ALAMEDA COUNTY FLOOD CONTROL
AND WATER CONSERVATION DISTRICT

ZONE 7 WATER AGENCY
100 N. CANYONS PARKWAY
LIVERMORE, CA 94551
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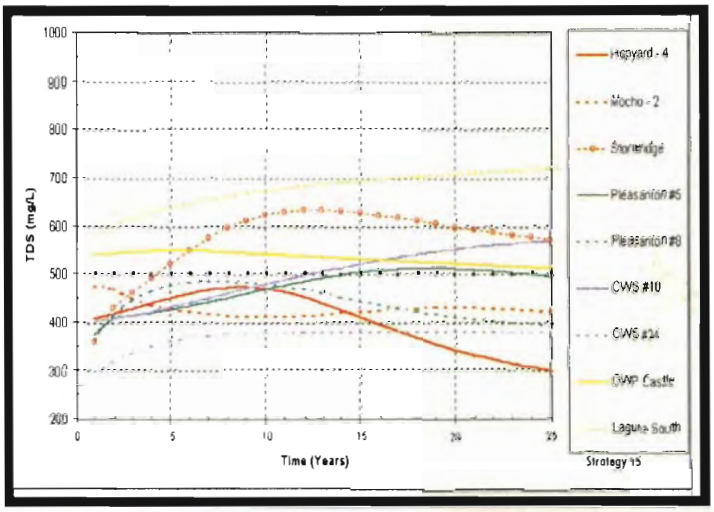
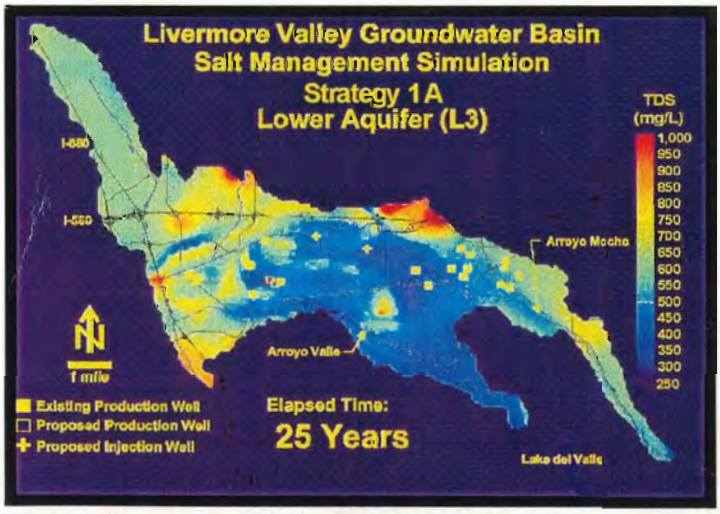
Salt Management Plan





May 2004

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Salt Management Plan

Prepared for
Zone 7 Water Agency

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EOA, Inc. / Zone 7—Water Resources

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Salt Management Plan Report

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Table of Contents

Table of Contents

Executive Summary

1. Salt Management Plan History and Overview
- 1.1. Introduction
- 1.2. SMP History and Regulatory Framework
- 1.3. Valley-Wide Water Recycling Study and Master Permit
- 1.4. SMP Chapters Overview

2. Water Supply and Resource Management
- 2.1. Existing Water Facilities and Demands
- 2.2. Historic Water Operations Plan
- 2.3. Proposed Water Operations Plans
- 2.4. Proposed Treated Water Facilities and Demands
- 2.5. Proposed Untreated Water Facilities and Demands
- 2.6. Water System Operations Model

3. Groundwater Basin Characteristics
- 3.1. Introduction
- 3.2. Previous Groundwater Basin Studies
- 3.3. Groundwater Basin Overview
  - *3.3.1 Physiographic Description*
  - *3.3.2 Geologic Description*
  - *3.3.3 Hydrologic Inventory*
- 3.4. Occurrence and Movement of Groundwater
  - *3.4.1 Definitions*
  - *3.4.2 Basin Boundaries*
  - *3.4.3 Subsurface Inflow into the Main Basin*
  - *3.4.4 Main Basin Groundwater Mixing and Movement*
  - *3.4.5 Horizontal Mixing and Movement (Intra-Aquifer Movement)*
  - *3.4.6 Vertical Mixing and Movement (Inter-Aquifer Movement)*
- 3.5 Vadose Zone Attenuation
- 3.6. Hydrogeologic Information Collection
- 3.7 Groundwater Model
  - *3.7.1 Model Grid and Properties*
  - *3.7.2 Model Fluxes*
  - *3.7.3 Initial Conditions*
  - *3.7.4 Model Flow Calibration*
  - *3.7.5 Solute Transport Calibration (Non-Reactive)*

4. Mineral Water Quality
- 4.1. Introduction
- 4.2. Imported Water
- 4.3. Local Surface Water
- 4.4. Groundwater
- 4.5. Production Wells
- 4.6. Delivered Water Quality and Variability
- 4.7. Tertiary and RO Recycled Water Quality

5. Zone 7 Salt Balance Calculations
- 5.1. Introduction
- 5.2. Salt Loading Calculation Assumptions
- 5.3. Explanation of Salt Balance Summary Tables
- 5.4. Actual 1998 Water Year Salt Balance Results
- 5.5. Steady State Results at 1998 Land Use Conditions
- 5.6. Historic Annual Average Salt Loading
- 5.7. Projected Year 2010 Salt Loading

6. Watershed Salt Management Monitoring Program (SMMP)
- 6.1. Introduction
- 6.2. Existing Monitoring Programs
- 6.3. Watershed Approach to Characterize Existing and Expected New Salt Loading
- 6.4. Recommended Near Term Salt Management Monitoring Program
- 6.5. Costs Associated with SMP Monitoring Program
- 6.6. Future Recycled and Untreated Water Use Related Monitoring
- 6.7. Reporting and Refinement of the SMMP

7. Salt Management Plan Policy Issues and Options
- 7.1. Introduction
- 7.2. Four Fundamental Salt Management Options
- 7.3. Options in Balancing Salt Management and Delivered Water Quality Goals
- 7.4. East-West Delivered Water Quality Equivalency Options
- 7.5. TDS Concentration Effects on Consumer Acceptability and Costs
- 7.6. RO Recycled Water Blending and Ownership

8. Individual Salt Management Strategies
- 8.1. Introduction
- 8.2. Water Conservation Impacts on Salt Loading
- 8.3. Historic Groundwater Basin Management
- 8.4. Maximum Stream Recharge Conjunctive Use Strategy
- 8.5. Paired Injection/Extraction Well Conjunctive Use
- 8.6. Zone 7 ASR Well Operation Strategy
- 8.7. Wellhead Demineralization

8.8. RO Recycled Water Injection
8.9. RO Recycled Water Stream Recharge and Phased Injection
8.10. Seasonal Groundwater Export
8.11. Chain of Lakes
8.12. Delta Fix
8.13. Composite Projects
8.14. Preliminary Unit O&M Cost Estimates for Salt Management Strategies

9. Year 2010 Salt Management Strategies and Screening
9.1. Introduction
9.2. Definitions and Assumptions
9.3. Assumptions Common to Year 2010 Salt Balance Studies
9.4. Individual Salt Balance Study Results
9.5. Discussion of Results
9.6. Feasibility Screening of Year 2010 Studies

10. Key 2010 Salt Management Strategies Modeling
10.1. Introduction
10.2. Baseline and Key Strategy Assumptions and Descriptions
10.2.1 Common Assumption for All Strategies (Baseline 1998 Conditions)
10.2.2 Strategy 1A—Status Quo (Without RO Recycled Water Injection)
10.2.3 Strategy 1—Status Quo Plus 6 TAF/Y RO Recycled Water Injection
10.2.4 Strategy 11B—Increased Conjunctive Use and Demineralization of High TDS Groundwater
10.2.5 Strategy 15—Increased Conjunctive Use and Demineralization of High TDS Groundwater
10.3. Groundwater Modeling Evaluations
10.3.1 Initial Groundwater Quality Conditions
10.3.2 GW Model Results for Strategy 1A—Status Quo (Without RO Recycled Water Injection)
10.3.3 GW Model Results for Strategy 1—Status Quo Plus 6 TAF/Y RO Recycled Water Injection
10.3.4 GW Model Results for Strategy 11B—Increased Conjunctive Use and Demineralization of High TDS Groundwater
10.3.5 GW Model Results for Strategy 15—Increased Conjunctive Use and Demineralization of High TDS Groundwater
10.4. Water System Operations Model Evaluations (WRMI)
10.4.1 Water System Operations Model Results for Strategy 1
10.4.2 Water System Operations Model Results for Strategy 11B
10.4.3 Water System Operations Model Results for Strategy 15
10.5. Modeling Results Comparison of Key Strategies
10.5.1 Groundwater Model Results Comparison of Strategies 1A, 1, 11B and 15

10.5.2 Water System Operations Model (WRMI) Results Comparison of Strategies 1, 11B and 15
10.6. Apparent Best Year 2010 Strategy

11. Salt Management Cost Allocation
11.1 Introduction
11.2 Livermore Valley Land Use and Salt Impact Zones
11.3 Current 2,200 Tons/Year Salt Management Cost Allocation
11.4 New Urban Development (M&I) Salt Loading
11.5 New Agricultural Development (Untreated Water) Salt Loading
11.6 Recycled Water Irrigation Salt Loading
11.7 Future Individual Project Salt Loading Impact and Cost Calculation Method

12. Near-Term Salt Management Strategies and Implementation Plan
12.1. Introduction
12.2. Near-Term Salt Management Strategies
12.3. Potential Near-Term Strategies
12.4. Adaptive Salt Management Via Annual Operations Plan
12.5. Phased Near-Term SMP Implementation
12.6. Future Salt Loading and SMP Next Steps

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A. Master Water Recycling Permit (Ch. 1)
B. Basin Plan Livermore-Amador Valley Excerpt (Ch. 1)
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F. Annual Groundwater Report (Ch. 4)
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H. Hydrochemographs (Ch. 4)
I. Groundwater and Surface Water Quality Data (Ch. 4 / 6)
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K. Program Design Reports (Ch. 6)
L. TDS and Consumer Acceptability Memorandum (Ch. 7 / 8)
M. Year 2010 Screening Studies 75 Year Data Summaries (Ch. 9)
N. *Phase 4 Groundwater Modeling: Salt Management Plan Simulations*—CH2M Hill (Ch. 10)
O. WRMI Delivered Water Quality Model Output (Ch. 10)
P. 1998 Water Year Land Use memorandum (Ch. 11)
Q. Meeting Notes of SMP Workshop For Senior Managers (9/03/98) (Ch. 11&12)
R. Zone 7's Water Resources Report List
S. SMP Submittal Letter to Regional Water Quality Control Board

List of Tables

Chapter 2

Table 2.1 Groundwater Basin Artificial Recharge Capacity
Table 2.2 ,Treated Water Production Capacities—2004
Table 2.3 Retailer's Municipal Supply Wells—2004
Table 2.4 Water Supply Forecast 2004 Calendar Year
Table 2.5 2004 Water Operations Plan
Table 2.6 Recommended Near-Term Treated Water Facilities
Table 2.7 Node 120 Demand Projected for Year 2010

Chapter 3

Table 3.1 Subsurface Inflow and TDS with Respect to Urban Development
Table 3.2 Summary of Recent Aquifer Test Results
Table 3.3 Description of Records in "recharge.dbf" File for Groundwater Model
Table 3.4 Description of Records in "wellpro2.dbf" File for Groundwater Model
Table 3.5 Description of Records in "rechg_e.dbf" File for Groundwater Model
Table 3.6 Recharge Water TDS in mg/l for Groundwater Model
Table 3.6A Blended TDS for Each Node for Groundwater Model

Chapter 4

Table 4.1 1997 Water Year Monthly Conductivity Sampling –Surface Water
Table 4.2 Surface Water Quality Monitoring 1997 Water Year
Table 4.3 Groundwater Quality by Basin—Major Mineral Summary, 1997 WY
Table 4.4 Municipal Supply Wells Data
Table 4.5 Municipal Groundwater Pumping and TDS in 2003
Table 4.6 Typical Delivered Water TDS Under Historic Basin Management Strategy
Table 4.7 Comparison of Water Quality Parameters

Chapter 5

Table 5.1 Main Basin Salt Balance—1998 Water Year
Table 5.2 Main Basin Salt Balance—Current Steady State Conditions at 1998 Land Use
Table 5.3 Main Basin Water Balance & Salt Balance—2010 Steady State Conditions
Table 5.4 Main Basin Salt Loading Major Changes from 1998-2010

Chapter 6

Table 6.1	Summary of Salt Management Monitoring Program
Table 6.2	Estimated Annual Costs for Salt management Monitoring Program
Table 6.3	Salt Management Monitoring Program Estimated Total Costs
Table 6.4	Proposed Water Supply to Meet Existing and Future Untreated Water Demands

Chapter 7

Table 7.1	Recommended TDS Standards Based on Pooled CMTS Data
Table 7.2	Summary of TDS and the Percentage of Customers Rating their Water Below Neutral on the Taste Quality Rating Scale

Chapter 8

Table 8.1	Main Basin Relative Salt Loading Sources 1998 Water Year
Table 8.2	Typical Delivered Water TDS Under Historic Basin Management Strategy
Table 8.3	Potential Zone 7 Delivered Water TDS Under Basin Management Strategy of 70% Annual Groundwater Pumpage
Table 8.4	Individual Salt Management Strategies Unit O&M Costs and Removals per 1,000 AF

Chapter 9

Table 9.1	Summary of Salt Balance Studies at 2010 Conditions
Table 9.2	Preliminary Cost Estimate for Salt Balance Studies at 2010 Conditions
Table 9.3	Summary of Assumed Costs for 2010 Salt Balance Studies
Table 9.4	Main Basin Water and Salt Balance 2010 Steady State Conditions–Study1
Table 9.4A	Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 1A
Table 9.4B	Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 1B
Table 9.5	Main Basin Water Balance and Salt Balance 2010 Steady State Conditions, With 100 SBA Water—Study 2
Table 9.6	Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 3
Table 9.7	Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 4
Table 9.8	Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 5
Table 9.9	Main Basin Water Balance and Salt Valance 1020 Steady State Conditions—Study 6
Table 9.10	Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 7

Table 9.11 Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 8
Table 9.12 Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 9
Table 9.13 Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 10
Table 9.14 Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study11
Table 9.14A Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 11A
Table 9.15 Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 11B
Table 9.16 Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 12
Table 9.17 Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 13
Table 9.17A Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 13A
Table 9.18 Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 14
Table 9.19 Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 14A
Table 9.20 Main Basin Water Balance and Salt Balance 2010 Steady State Conditions—Study 15

Chapter 10

Table 10.1 Summary of Key Salt Balance Strategies at 2010 Conditions
Table 10.1A Initial GW Conditions—Groundwater TDS at Well Locations
Table 10.2 Strategy 1A vs. Initial Conditions Groundwater Model Simulation Results
Table 10.3 Strategy 1 vs. Strategy 1A Groundwater Model Simulation Results
Table 10.4 Strategy 11B vs. 1A Groundwater Model Simulation Results
Table 10.5 RO Recycled Water as Percentage of Total Turnout Delivery
Table 10.6 Strategy 15 vs. Strategy 1A Groundwater Model Simulation Results
Table 10.7 Projected Annual Average TDS Delivered To Retailers Under Strategy 1
Table 10.8 Projected Annual Average TDS Delivered to Retailers Under Strategy 11B and Net Change from Strategy 1
Table 10.9 Projected Annual Average TDS Delivered to Retailers Under Strategy 15 and Net Change from Strategy 1
Table 10.10 Overall Average Zone 7 Delivered Water Quality Variability with Hydrologic Conditions under Strategy 1, 11B and 15
Table 10.11 Comparing Delivered Water TDS Variability Among Retailers Under Strategy 1, 11B, 15

Chapter 11

Table 11.1	Treated (Potable) and Untreated (Non-Potable) Water Rates for 1998 – 2003
Table 11.2	Existing Salt Loading Distribution Urban Applied salt Loading by Water Purveyor
Table 11.3	Summary of Zone 7 Expenses as a Function of Treated Delivered Water Rate
Table 11.4	TAG Recommended Funding Strategy for Zone 7 Salt Management Projects by Source of Salt Loading
Table 11.5	Future Individual Project Salt Loading Impact and Cost Calculation Method.
Table 11.6	Example Main Basin Salt Loading Assessment Calculations

Chapter 12

Table 12.1	Individual Salt Management Strategies Unit O&M Costs and Removals Per 1,000 AF
Table 12.2	Near-Term Salt Management Strategies
Table 12.3	Potential Near-Term Salt Management Strategies
Table 12.4	Meeting Highlights for Salt Management Plan Senior Managers' Briefing September 3, 1998

List of Figures

Chapter 2

Fig. 2.1 Zone 7 Water Facilities and Retail Service Areas
Fig. 2.2 2004 Water Supply Forecast
Fig. 2.3 Recommended Near-Term Facilities
Fig. 2.4 Recommended Mid-Term and Long-Term Facilities
Fig. 2.5 Candidate Well Sites
Fig. 2.6 Existing and Future Untreated Demand Areas
Fig. 2.7 Recommended Conveyance Alternative
Fig. 2.8 Zone 7 Main System Schematic
Fig. 2.9 Service Areas by WRMI Demand Nodes
Fig. 2.10 Schematic of Zone 7 Deliveries for WRMI
Fig. 2.11 Waste and Reclamation Components of System Schematic

Chapter 3

Fig. 3.7 Trends in Shallow Aquifer Inflow
Fig. 3.1 Vicinity Map
Fig. 3.2 Basin Overview
Fig. 3.3 Stream Recharge Rates and TDS
Fig. 3.4 East-West Main Basin Cross Section
Fig. 3.5 SP-SP' Cross Section
Fig. 3.6 Hydrologic Inflow
Fig. 3.8 Groundwater Level Contours—1996
Fig. 3.9 Bernal Sub-Basin Groundwater Elevation Map 1975-2000
Fig. 3.10 Amador Sub-Basin Groundwater Elevation Map 1975-2000
Fig. 3.11 Mocho-II Sub-Basin Groundwater Elevation Map 1975-2000
Fig. 3.12 Groundwater Model Grid
Fig. 3.13 Groundwater Cross Section B-B'
Fig. 3.14 Groundwater Cross Section A-A'
Fig. 3.15 K Values for Layer 1 of Groundwater Model
Fig. 3.16 K Values for Layer 2 of Groundwater Model
Fig. 3.17 K Values for Layer 3 of Groundwater Model
Fig. 3.18 Sy Values for Layer 1 of Groundwater Model
Fig. 3.19 Ss Values for Layer 3 of Groundwater Model
Fig. 3.20 Location of Faults in the Deep Aquifer
Fig. 3.21 1974-95 Areal Recharge for Groundwater model
Fig. 3.22 Hopyard-4 Well Hydrograph: Layer 3
Fig. 3.23 Well 3S/1E 9P5 Hydrograph: Layer 1
Fig. 3.24 Mocho-2 Well Hydrograph: Layer 3
Fig. 3.25 Hagemann Well Hydrograph: Layer 3

Fig. 3.26 Spring 1994 Actual Groundwater Level Contours
Fig. 3.27 Layer 1 Groundwater Level Spring 1994 from Groundwater Model
Fig. 3.28 Layer 3 Groundwater Level Spring 1994 from Groundwater Model
Fig. 3.29 Hopyard-4 & 6 Well Chemograph: Layer3
Fig. 3.30 Mocho-2 Well Chemograph: Layer 3
Fig. 3.31 Well 3S/1E 9P5 Chemograph: Layer 1
Fig. 3.32 Hagemann Well Chemograph: Layer 3
Fig. 3.33 Upper Aquifer TDS Contour Map
Fig. 3.34 Layer 1 TDS Fall 1995 Map from Groundwater Model
Fig. 3.35 Main Basin Lower Aquifer TDS Contours
Fig. 3.36 Layer 3 TDS Fall 1996 from Groundwater Model

Chapter 4

Fig. 4.1 Artificial Groundwater Recharge Water Quality, Historic Record
Fig. 4.2 Artificial Groundwater Recharge Water Quality, 1993-1998
Fig. 4.3 Monitoring Well Program Network
Fig. 4.4 Upper Aquifer TDS Contour Map
Fig. 4.5 Main Basin Lower Aquifer TDS Contour Map
Fig. 4.6 Average TDS of Monitored Wells, 1997 Water Year
Fig. 4.6A Average Hardness of Monitored Wells, 1997 Water Year
Fig. 4.7 Average Chlorides of Monitored Wells, 1997 Water Year
Fig. 4.8 Average Nitrates of Monitored Wells, 1997 Water Year
Fig. 4.9 Groundwater Hydrochemograph, Bernal Key Well
Fig. 4.10 Groundwater Hydrochemograph, 3S/2E 8P2
Fig. 4.11 Distribution System Water Quality Map - September 2003
Fig. 4.12 Typical Municipal Delivered Water SW/GW
Fig. 4.13 Treated Water Deliveries & Water Quality 1974-97 Water Years
Fig. 4.14 Treated Water Deliveries & Water Quality 1997 Water Year
Fig. 4.15 LWRP Reclaimed Irrigation Water Amount in Acre-feet 1976-99

Chapter 5

Fig. 5.1 1998 Groundwater Main Basin Salt Load
Fig. 5.2 1998 Groundwater Main Basin Salt Removal
Fig. 5.3 1998 Water Year Net Salt Loading
Fig. 5.4 Main Basin Salt Load Steady—State Conditions at 1998 Land Use
Fig. 5.5 Main Basin Salt Removal—Steady State Conditions at 1998 Land Use
Fig. 5.6 Main Basin Salt Balance—Steady State Conditions at 1998 Land Use
Fig. 5.7 Main Groundwater Basin 1974—98 Salt Loading
Fig. 5.8 Main Groundwater Basin Calculated Basin TDS Due to Salt Loading at Land Surface
Fig. 5.9 Groundwater TDS from SFWD O-Line—Bernal Sub-basin
Fig. 5.10 Groundwater TDS from Well 3S/2E 8P2 (CWS#03): Mocho 2 Sub-basin
Fig. 5.11 Main Basin Salt Balance—2010 Water Year Net Salt Loading

Chapter 6

Fig. 6.1	1997 Surface and Groundwater Monitoring Sites
Fig. 6.2	Livermore–Amador Valley Watersheds
Fig. 6.3	Existing and Proposed SMMP Surface and Groundwater Monitoring Sites
Fig. 6.4	Integrated Water System March 2000, Proposed Water Supplies
Fig. 6.5	Livermore Water Reclamation Plant Ground Water Monitoring Sites

Chapter 7

Fig. 7.1	Fundamental Salt Management Policy Options and Resultant Main Basin Groundwater Quality

Chapter 8

Fig. 8.1	Main Basin Salt Balance Schematic
Fig. 8.2	Projected Delivered Water Quality Under Various Basin Use Strategies
Fig. 8.3	Resultant Groundwater Quality: Use of ASR wells to Create "Bubbles" of High Quality Zone 7 Groundwater
Fig. 8.4	Livermore Treated Water Injection Demonstration Project
Fig. 8.5	Individual Salt Management Strategies
Fig. 8.6	Salt Removal Strategies and O&M Cost

Chapter 9

Fig. 9.1	Individual and Composite Salt Management Studies at 2010 Conditions: Option 1—Maintain Historic Delivered WQ and Improve Groundwater TDS
Fig. 9.2	Individual and Composite Salt Management Studies at 2010 Conditions: Option 2—Improve Delivered and Groundwater Quality
Fig. 9.3	Feasibility Screening of Year 2010 Salt Management Studies

Chapter 10

Fig. 10.1	Groundwater TDS Initial Conditions—Upper Aquifer
Fig. 10.2	Groundwater TDS Initial Conditions—Lower Aquifer
Fig. 10.2A	Chemograph Wells Location Map
Fig. 10.3	Scenario1A: Chemograph (Groundwater TDS) 50-Year
Fig. 10.4	Scenario 1A: Chemograph (Groundwater TDS) 25-Year
Fig. 10.5	Scenario 1A: Upper Aquifer Groundwater TDS Map at Time = 50 Years
Fig 10.6	Scenario 1A: Lower Aquifer Groundwater TDS Map at Time = 50 Years
Fig. 10.7	Scenario 1: Chemograph (Groundwater TDS) 50-Year
Fig. 10.8	Scenario 1: Chemograph (Groundwater TDS) – 25-Year
Fig. 10.9	Scenario 1: Upper Aquifer Groundwater TDS Map at Time = 50 Years

Fig 10.10 Scenario 1: Lower Aquifer Groundwater TDS Map at Time = 50 Years
Fig. 10.11 Scenario 11B: Chemograph (Groundwater TDS) 50-Year
Fig. 10.12 Scenario 11B: Chemograph (Groundwater TDS) 25-Year
Fig. 10.13 Scenario 11B: Upper Aquifer Groundwater TDS Map at Time = 50 Years
Fig. 10.14 Scenario 11B: Lower Aquifer Groundwater TDS Map at Time = 50 Years
Fig. 10.15 Groundwater Model Particle Tracking of Injected RO Recycled Water for Strategy 11B
Fig. 10.16 Percentage Distribution of RO Recycled Water in Deep Aquifer Map after 50-Years for Strategy 11B
Fig. 10.17 Scenario 11B: Percentage of RO Recycled Water in Deep Aquifer at Well Sites Graph
Fig. 10.18 RO Recycled Water Percentage in Zone 7 Delivery to Retailers
Fig. 10.19 Summer Operation—Ro Percentage at Zone 7 Turnouts
Fig. 10.20 Scenario 15: Chemograph (Groundwater TDS) 50-Year
Fig. 10.21 Scenario 15: Chemograph (Groundwater TDS) 25-Year
Fig. 10.22 Scenario 15: Upper Aquifer Groundwater TDS Map at Time = 50 Years
Fig. 10.23 Scenario 15: Lower Aquifer Groundwater TDS Map at Time = 50 Years
Fig. 10.24 Average Annual Zone 7 TDS Delivered to Retailers Under 2010 Demands—Strategy 1
Fig. 10.25 Average Annual Zone 7 TDS Delivered to Retailers Under 2010 Demands—Strategy 11B
Fig. 10.26 Average Annual Zone 7 TDS Delivered to Retailers Under 2010 Demands—Strategy 15
Fig. 10.27 Comparison of Groundwater TDS at Stoneridge Well Under Strategy 1, 1A, 11B and 15
Fig. 10.28 Comparison of Groundwater TDS at Hopyard Wellfield Under Strategy 1, 1A, 11B and 15
Fig. 10.29 Comparison of Groundwater TDS at Pleasanton #8 Well Under Strategy 1, 1A, 11B and 15
Fig. 10.30 Comparison of Groundwater TDS at GWP Castlewood (SFWD) Under Strategy 1, 1A, 11B and 15
Fig. 10.31 Comparison of SMP Study 1, 11B, 15 in Average Annual Zone 7 Delivered Water TDS
Fig. 10.32 Scenario 1A: Lower Aquifer Groundwater TDS Map at Time = 10 Years
Fig. 10.33 Scenario 1A: Lower Aquifer Groundwater TDS Map at Time = 25 Years
Fig. 10.34 Scenario 15: Lower Aquifer Groundwater TDS Map at Time = 10 Years
Fig. 10.35 Scenario 15: Lower Aquifer Groundwater TDS Map at Time = 25 Years

Chapter 11

Fig. 11.1 Livermore Valley Land Use Map
Fig. 11.2 Livermore Valley Salt Impact Zone

Chapter 12

Fig. 12.1 Salt Removal Strategies and O&M Cost
Fig. 12.2 Comparison of Strategies for 2000-2002 Implementation
Fig. 12.3 Annual Average TDS Delivered to Retailers Under Historic and Proposed 2000-2002 Operating Conditions
Fig. 12.4 Potential Near-Term Salt Management Strategies
Fig. 12.5 Arroyo De La Laguna TDS as a Function of Flow With and Without Groundwater Pumpage
Fig. 12.6 Schematic of Salt Management Annual Operations Plan
Fig 12.7 Amount and TDS of Zone 7 Deliveries Under—Well Head Demineralization 1.5 TAF and Conjunctive Use 3 TAF Demineralization Production Evenly Distributed for 12 Months.
Fig 12.8 Amount and TDS of Zone 7 Deliveries Under—Well Head Demineralization 1.5 TAF and Conjunctive Use 3 TA in Apr-Oct, Variable Demineralization Production April-October
Fig 12.9 Proposed Salt Management Plan for 2000-02 and O&M Cost
Fig. 12.10 Future Annual Salt Load & Removal Cost

Executive Summary

Zone 7 Salt Management Plan

Executive Summary

Zone 7 Salt Management Plan

Introduction

Contents at a Glance...

Introduction 1
Background 3
Water Quality and Variability 5
Salt Loading, Sources, and Sinks 6
Salt Management Monitoring Plan 9
Salt Loading Calculations 9
Recycled Water 10
Salt Management Plan Goals 10
Year 2010 Salt Management Strategies 11
Cost Allocation 14
Near-Term Salt Management Strategies 14
Adaptive Management 17
Zone 7 Board's Near-Term Implementation Plan Approval 18
Future Salt Loading 18
SMP Next Steps 19

The Salt Management Plan (SMP) is a cooperative effort developed to address the increasing level of total dissolved solids in the main groundwater basin. It was developed in partnership by Zone 7 staff and consultants, a technical advisory group (TAG) composed of local water retailers, and a Zone 7 citizens committee—the Groundwater Management Advisory Committee (GMAC). In-house data compilation work began in 1994, with technical analyses and presentations continuing through 1999. This SMP report provides the technical information and analyses that support the August 1999 Zone 7 Board approved salt management strategy of using increased conjunctive use combined with shallow groundwater demineralization in the western portion of the service area to fully offset current and future sources of salt loading to the main groundwater basin (Main Basin). This strategy was designed to also maintain or improve delivered water quality and to facilitate increased use of recycled water using planned Zone 7 facilities to offset salt loading. Annual Salt Management decisions are to be made via an adaptive management process integrated into Zone 7's annual water operations plan.

Chapter 1 provides a brief history of the SMP process and the regulatory framework that initiated and guided its development. It includes a summary of water recycling investigations and proposed projects in the Livermore-Amador Valley and how such projects could be implemented under the Master Water Recycling Permit and the SMP.

Chapter 2 provides an overview of both current and future Zone 7 facilities, water demands, and operations. It describes the key role of the annual operations plan in maintaining a sustainable water supply. The water system operations computer model used to project delivered water quality under alternative operating strategies is also described.

Chapter 3 provides a condensed summary of historic information and ongoing data collection on the hydrogeology of the fringe and main groundwater basins. Connectivity and mixing, fringe to Main Basin and upper to lower aquifer are addressed. Supporting information is presented from the enhanced Visual Modflow computer groundwater flow and MT3D solute transport model developed for the SMP.

Chapter 4 summarizes the extensive database of surface and groundwater quantity and quality information collected and maintained by Zone 7 as part of its management of water resources in the Livermore-Amador Valley. Issues of seasonal and spatial variability are addressed in addition to the major influence that imported South Bay Aqueduct water quality has on delivered water quality.

Chapter 5 describes the methodology and extensive data required by Zone 7 to calculate the annual and steady state-based water and salt balances for the main groundwater basin. Historic and projected year 2010 salt loadings are discussed. Variations of these salt balance calculations are used in the SMP to evaluate the impacts of alternative salt management strategies.

Chapter 6 presents Zone 7's existing monitoring programs, as well as additional surface and groundwater monitoring implemented to track current and future sources of salt loading in the watershed and to address areas of hydrogeological uncertainties. The surface and groundwater monitoring networks for each drainage basin are described.

Chapter 7 presents the key salt management plan policy issues and options developed through consultation with the TAG and GMAC. Key recommendations include: (1) fully offset current and future net salt loading and (2) maintaining and, where feasible, improving delivered water mineral quality. Background information is presented on consumer acceptability of varying TDS concentrations of delivered water.

Chapter 8 describes the range of individual and composite salt management strategies that are evaluated in more detail in the remaining chapters of the SMP. The focus is on strategies that use previously planned and budgeted Zone 7 facilities such as wells and groundwater demineralization facilities. Preliminary unit operations and maintenance (O&M) costs are also presented.

Chapter 9 presents the results of the salt loading calculations for 20 salt management strategies under projected year 2010 conditions. The strategies are based on the policies and options described in Chapter 7. Estimated costs and impacts on groundwater and delivered water quality TDS are included. A screening process is presented to identify the most feasible strategies for further analysis.

Chapter 10 presents the computer modeling results for four of the most promising strategies identified in the screening analysis discussed in Chapter 9. Included are computer model generated maps and graphics depicting impacts on groundwater, individual wells, and retailer turnouts under status quo operations versus SMP strategies.

Projected impacts of potential strategies using demineralized recycled water injection also are included.

Chapter 11 presents alternatives and recommended approaches for allocating the costs of salt management as a function of the salt source: existing municipal and industrial (M&I), future M&I, untreated water, or recycled water. TAG recommendations to fund capital costs through connection fees and O&M costs through water rates, similar to other Zone 7 facilities, are summarized.

Chapter 12 presents the SMP near-term implementation plan, including the most feasible salt management strategies identified in Chapter 10 scaled down to offset the current 2,200 tons/year salt loading versus the 5,400 tons/year loading projected for year 2010. These strategies include increased conjunctive use, shallow groundwater demineralization, and potential future demonstration scale stream recharge with demineralized recycled water. Chapter 12 describes the specific near-term (2000-2002) SMP implementation plan that was approved by the Zone 7 Board in August 1999 and two implementation options for 2004-08. The SMP concludes with recommended next steps to address future salt loading sources and to further investigate potential lower cost salt management strategies such as seasonal groundwater export.

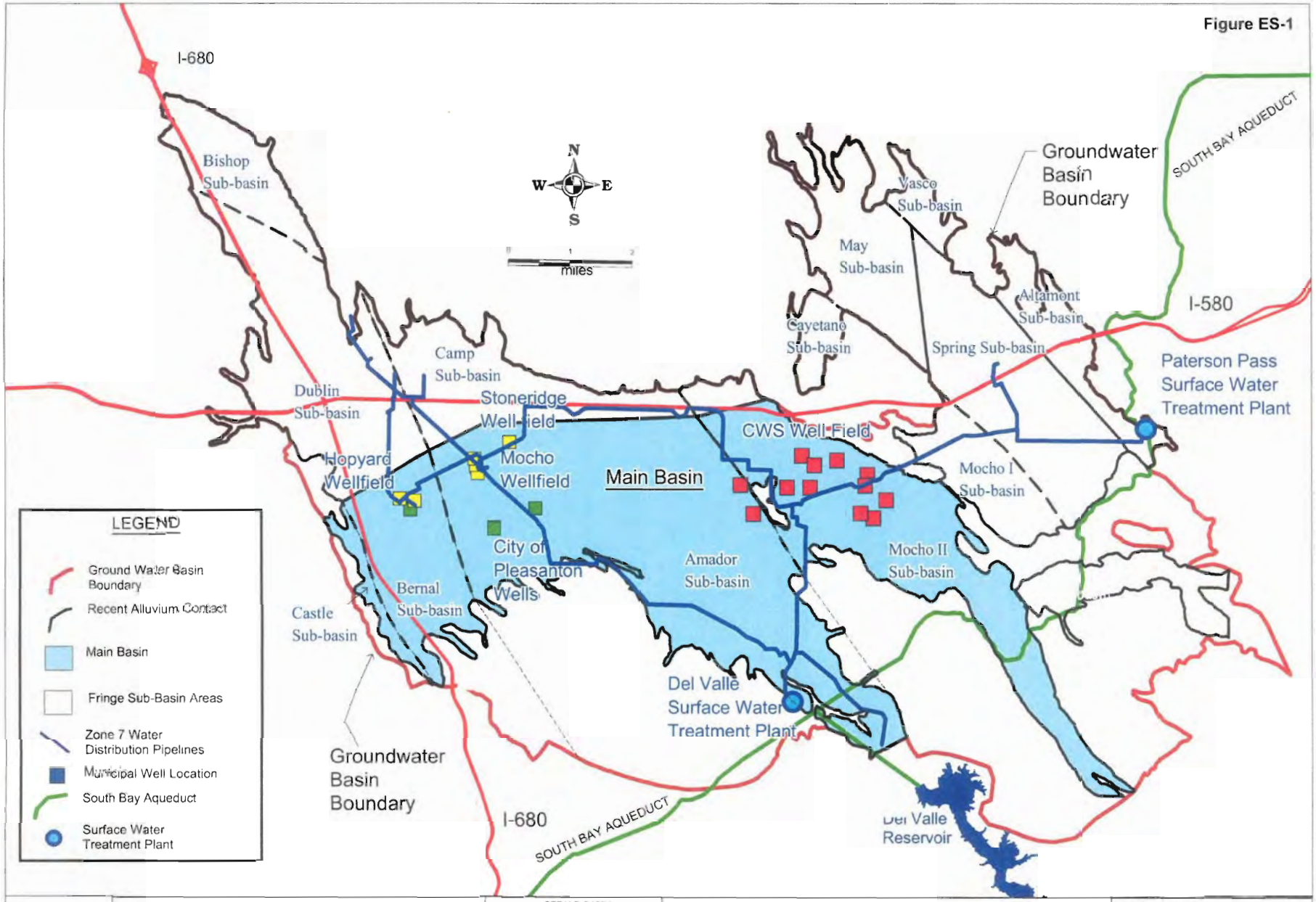
Background

Zone 7 of Alameda County Flood Control and Water Conservation District, locally known as Zone 7 Water Agency, serves as the overall water quality management agency for the Alameda Creek Watershed above Niles. Zone 7 has the primary responsibility of managing the Livermore-Amador Valley surface and groundwater resources. It has historically managed the 250,000 acre-foot capacity main groundwater basin (Figure ES-1) by maximizing lower TDS surface water deliveries, artificially recharging the Main Basin with low total dissolved solids (TDS) imported surface water, restricting groundwater pumping, and restricting wastewater disposal and water recycling within the watershed.

Studies relating to the groundwater supply of the Livermore Amador Valley were first conducted in the early 1900's. Since that time, a number of studies have been completed by entities, including the California Department of Water Resources, the U.S. Geological Survey, as well as Zone 7. To signify the area of the groundwater basin that had long been recognized as containing the majority of usable groundwater storage, the concept of a central or "main" basin was developed in the 1980's.

The Livermore-Amador groundwater basin is located in the heart of the Livermore-Amador Valley and extends into the hills south of Pleasanton and Livermore. The basin includes the areas occupied by both the Livermore Valley and Livermore uplands. The principal water-bearing units are the unconsolidated recent alluvium sands and gravels, and the tilted, semi-consolidated beds of sandstones and conglomerates of the Livermore Formation. Groundwater occurs in the aquifers under unconfined, semi-confined and

Figure ES-1



ZONE 7 WATER AGENCY
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APPROVED	DAVID LUNN

SALT MANAGEMENT PLAN

GROUNDWATER BASIN AND WATER FACILITIES MAP

SCALE	1" = 2 Miles
DATE	31 July 2002
FILE NO.	E:\projects\smp\SMP report summary\fig\ES1.wor

confined conditions, depending on depth and location in the basin. Several geologic faults or linear groundwater anomalies cut across the groundwater basin. Based in large part on these fairly linear fault-related groundwater impediments, the basin has been divided into 13 sub-basins: Altamont, Amador, Bernal, Bishop, Camp, Castle, Cayetano, Dublin, May, Mocho I, Mocho II, Spring, and Vasco. Together, portions of the Castle, Bernal, Amador, and Mocho II sub-basins overlain by recent alluvium are considered the "main" basin because of their large capacity to store and transmit groundwater and their significance to the local groundwater supply. The other sub-basins are collectively called the "fringe" basins.

Groundwater in the Livermore Valley exists in a multi-layered aquifer system with the upper aquifer being unconfined and the subsequent deeper aquifers being semi-confined or leaky. Flow generally follows a westerly pattern, like the surface water streams, along the structural central axis of the valley. The majority of subsurface inflow, however, occurs across the northern boundaries of the Main Basin, in particular from the Dublin and western Camp sub-basins, and flows in a southerly direction. These sources of groundwater co-mingle in the Bernal and Amador sub-basins and generally flow towards groundwater pumping facilities in Pleasanton.

It is a common misconception that the groundwater basin is a "totally closed" basin suggesting that minerals or contaminants that enter the groundwater basin have no way of leaving the basin. In the late 1800s, pre-development groundwater levels in the basin created a gradient causing groundwater to flow from east to west and naturally exit the basin as surface flow (rising groundwater) in the Arroyo de la Laguna. In the early to mid-1900s, groundwater began to be extracted in appreciable amounts causing groundwater levels to drop throughout the basin, below the level where it would naturally rise into the Arroyo de la Laguna and exit the basin through stream flow. This was the closest the Main Basin came to being, by definition, a "closed" basin. At present, the basin cannot be considered "totally closed" since water is recharged into and exported from the basin through various means. On average, approximately 8% of the total groundwater storage exits the basin each year.

Treated water production facilities in the valley include two surface water treatment plants owned and operated by Zone 7, as well as groundwater production wells owned and operated by Zone 7, the City of Pleasanton, and California Water Service Company (CWS). Total surface water treatment design capacity is 55 mgd. Actual capacity can vary with South Bay Aqueduct flow (water elevation). Zone 7 has seven existing active production wells with a total peak production capacity of 32 million gallons per day (mgd). Pleasanton has three existing active wells with a production capacity of 11 mgd and CWS has 12 existing active wells with a production capacity of 10 mgd. Total combined groundwater capacity for Zone 7 and its retailers is approximately 53 mgd.

Zone 7's treated water distribution system conveys treated water to retailer turnouts. The system includes booster pump stations and distribution pipelines, and 13.5 million gallons of total storage capacity in three storage reservoirs that help meet hourly demand fluctuations. Water retailers own and operate their own water distribution system to serve

their customers. Pleasanton and CWS both pump directly into their distribution systems to meet hourly and daily peak demands. Annual total groundwater pumping by Pleasanton and CWS is limited to their groundwater pumping quotas.

Water Quality and Variability

The historic management approach implemented by Zone 7 (i.e., maximizing surface water deliveries, artificially recharging the Main Basin with low total dissolved solids (TDS) imported surface water, restricting groundwater pumping, and restricting wastewater disposal and water recycling within the watershed) has been successful in maintaining a sustainable and reliable water supply. The valley-wide annual average delivered water blend during an average year is about 85% surface water and 15% groundwater. TDS is used as an indicator of overall mineral (salt) content in this SMP. However, Zone 7 monitors for a large suite of mineral constituents in surface and groundwater in addition to TDS. These more detailed data and TDS data are used to track sources of water and analyze water quality trends, as well as to calculate salt loading of the Main Basin.

The quality of Zone 7 potable deliveries varies seasonally as a function of both source water quality and the blend ratio of surface water to groundwater. The TDS concentrations of source water from the South Bay Aqueduct (SBA) can vary from 100 to 700 mg/l on an annual average basis depending on the wetness of the water year (climatic conditions) and seasonally, month to month depending on reservoir releases into the Delta and Delta pumping patterns. Groundwater quality changes slowly and is generally more consistent, ranging from 400 to 550 mg/L TDS. Hence, actual delivered water TDS varies from month to month and year to year. The ratio of groundwater to surface water can vary by season, by day, and by turnout depending on demand. Table ES-1 shows typical winter and summer source water quality, delivered water blend, and resultant delivered water TDS of Zone 7 deliveries under three climatic conditions: dry, average and wet years.

Table ES-1
Typical Delivered Water TDS
Under Historic Basin Management Strategy

	Source water Quality (TDS)		
Climatic	SBA TDS (mg/L)		GW
Conditions	Winter	Summer	TDS
Dry	500	500	450
Average	270	220	450
Wet	170	150	450

	Delivered Water Blend	
Climatic	%Surface Water Delivered	
Conditions	Winter	Summer
Dry	30%	30%
Average	100%	90%
Wet	100%	90%

Climatic	Delivered Water Quality, TDS (mg/L)	
Conditions	Winter	Summer
Dry	**470**	**470**
Average	**270**	**240**
Wet	**170**	**180**

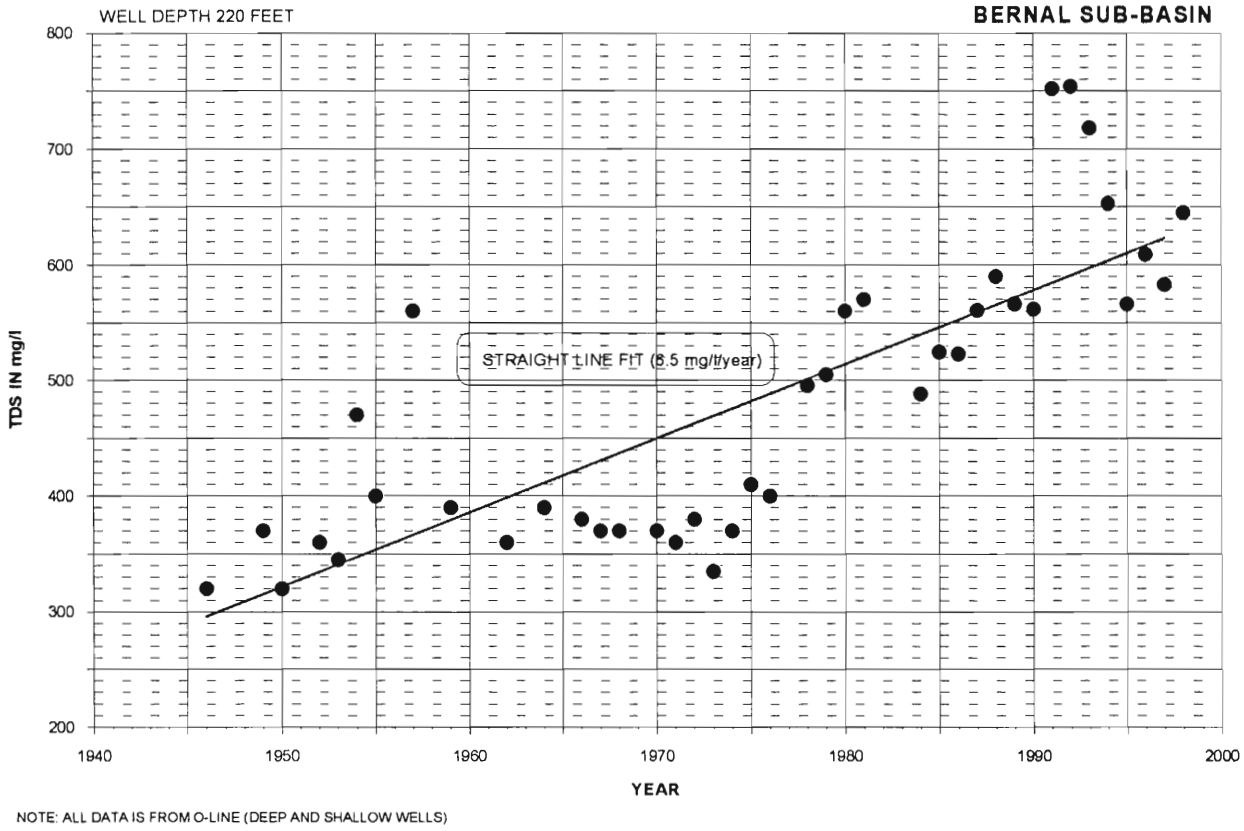
Delivered water TDS also varies from east to west in the valley. The blend of surface to groundwater varies between turnouts because of the locations of the wells relative to the turnouts and because of their intermittent use. The Livermore and CWS service areas, which are closer to surface water treatment plants, typically receive a higher percentage of treated surface water, while Pleasanton and DSRSD service areas, which are closer to Zone 7 wells, receive higher percentages of groundwater (see Figure ES-1). CWS and Pleasanton also operate their own wells and blend groundwater with their Zone 7 deliveries, adding to the variability of water quality delivered to their customers.

Salt Loading, Sources, and Sinks

As in other arid areas that rely on imported water for a significant portion (75-85%) of the local supply, the historic groundwater management approach has allowed a gradual but continual degradation in groundwater mineral (salts) quality. Annual net loadings varied from about 11,800 to a negative 4,800 tons, with a 25-year average of about 2,550 tons/year. The cumulative salt loading to the Main Basin during that time period was approximately 63,500 tons and there were only six years in which there was a negative salt accumulation in the Main Basin, three of them being 1996-1998. The net steady state salt loading to the Main Basin under 1998 conditions was 2,200 tons. The 2,200 tons per

year is equivalent to a TDS increase of about 10 mg/L per year in the groundwater. Figure ES-2 presents the groundwater TDS changes with time in the Bernal Sub-basin.

Figure ES-2



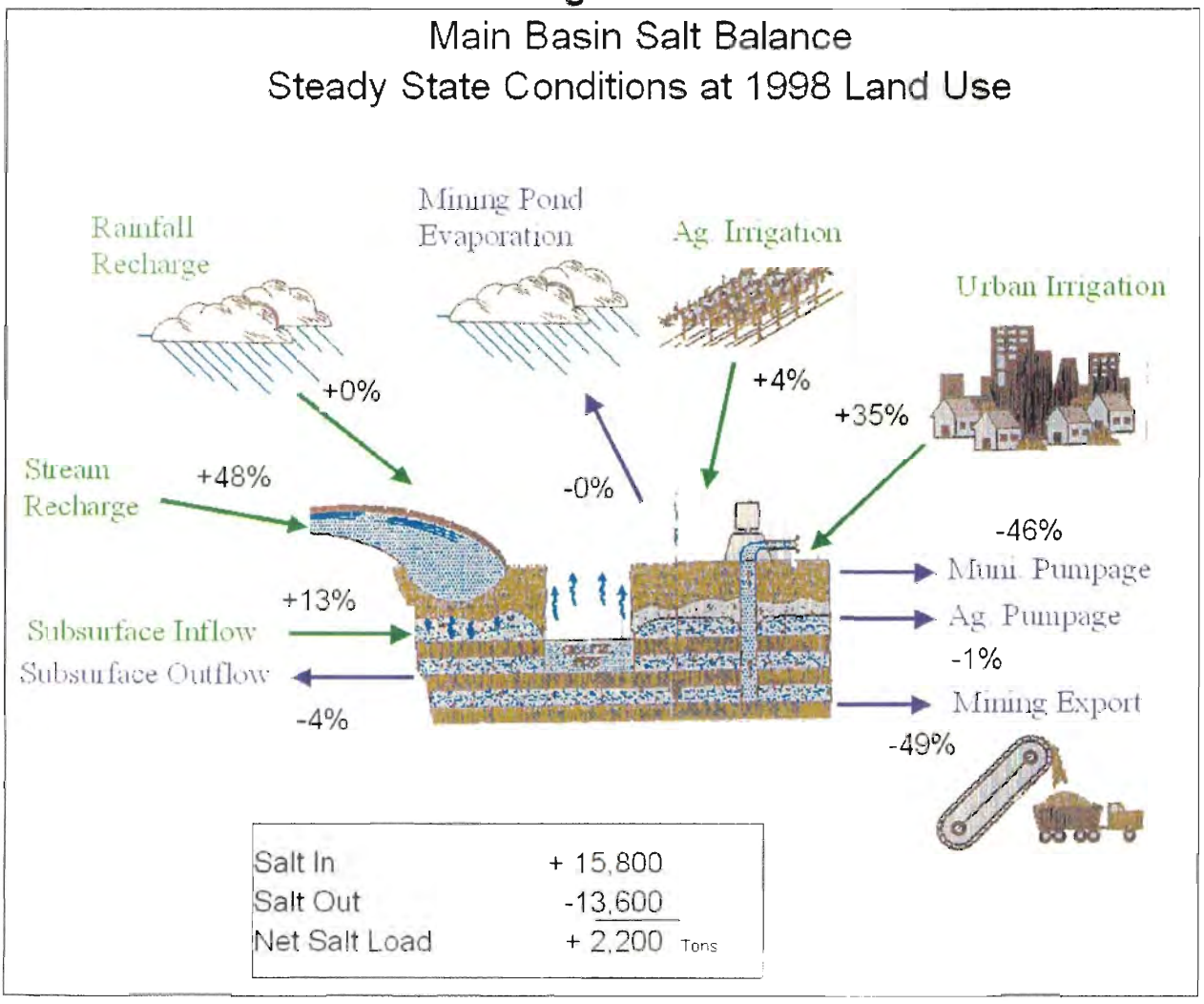
NOTE: ALL DATA IS FROM O-LINE (DEEP AND SHALLOW WELLS)

The main sources and removal mechanisms of salts from the groundwater basin under 1998 land use are shown schematically in Figure ES-3. The main salt sources are conveyed through natural and artificial surface water flow when the water is percolated or recharged into the Main Basin aquifers (48%). Deep percolation of urban irrigation water contributes 35% of total salt loading. Subsurface inflow of high salinity (1,000 mg/L TDS) fringe basin groundwater contributes about 13% of salt loading. Rainfall does not contribute any salt but it dilutes and transports the salts added through urban and agricultural irrigation down to the water table. Salts are removed from the Main Basin primarily as water is pumped from wells (46%) or from gravel mining pits (49%). Zone 7 manages the basin levels so that there is little or no loss of water (and salts) via subsurface outflow. However, the basin is not truly "closed" since, through recharge and pumpage, annually approximately 8% of the total basin storage and more than half of the pumped water and associated salts leave the basin.

Some of the extracted municipal pumpage and associated salts (25-30%) are returned to the basin in areas where irrigation over the Main Basin takes place. The remainder of the pumpage and salts is either used inside the home and then exported as wastewater through the LAVWMA pipeline or used for irrigation in fringe basin areas where the applied salts do not impact the Main Basin. Some of the mining pumpage is returned to the Main Basin through stream recharge but most of this water, along with the salts, leaves the basin and valley via stream outflow.

The annual salt loading under 2003 land use conditions is 5,000 tons per year, an increase of 2,800 tons over the 1998 salt loading. The major cause for the increase in annual salt loading is the cessation of the majority of the gravel mining pumpage and associated salt export from the valley. Salt loading is projected to increase to 5,400 tons per year by year 2010.

Figure ES-3



Salt Management Monitoring Plan

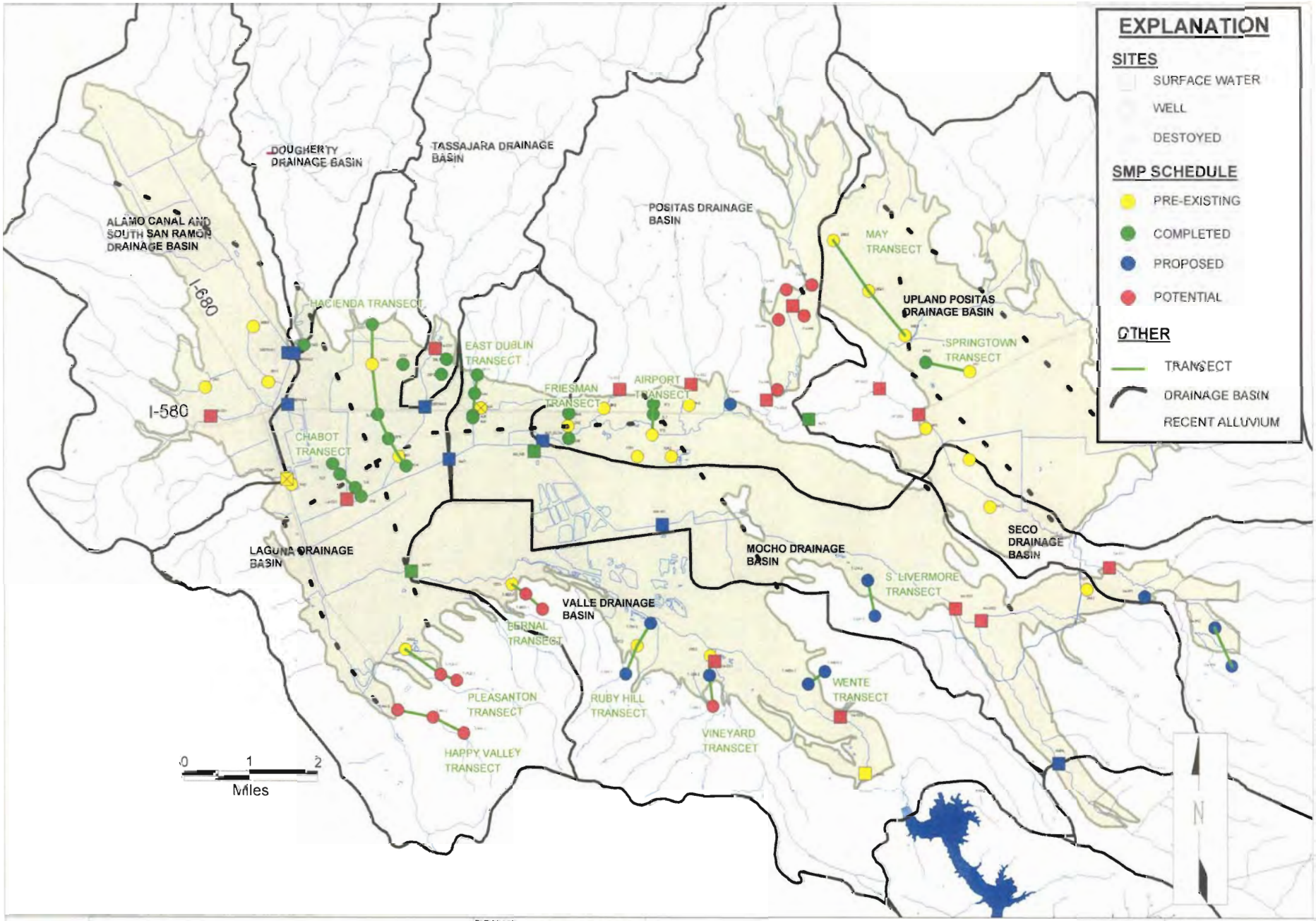
The SMP includes a Salt Management Monitoring Plan (SMMP) designed to help refine the baseline salt loading estimates, particularly from new urban and agricultural irrigation in the fringe basins. Seventeen additional monitoring wells and upgraded continuous recording surface water monitoring facilities have been identified to supplement information provided by existing monitoring program sites. Figure ES-4 shows the locations of the existing and new Salt Management Monitoring Plan monitoring sites.

Salt Loading Calculations

Since 1974, Zone 7 has computed both an annual and a long-term steady state salt balance using a fundamental salt balance equation: inflow of salts dissolved in water minus outflow of salts dissolved in water equals the change in dissolved salts in the groundwater basin. The actual balance in any one year is not indicative of long-term trends since there can be significant storage changes due to change in recharge (e.g., rainfall) and extraction components in a given year. The steady state salt balance equations are used in this SMP to track long-term expected TDS impacts on the Main Basin. They are also adjusted for future land use and operational conditions to evaluate the impacts of alternative salt management strategies under year 2010 conditions.

Supply and demand components each have associated TDS concentrations based on the given year's monitoring data, some historic data, and a few assumed (immeasurable) values. The salt balance calculations include several fundamental and intentionally simplifying assumptions as part of the screening level "spreadsheet" model of the Main Basin. Perhaps the most important simplifying assumption is that all salts applied through irrigation eventually make their way to the underlying groundwater (while in actuality vadose zone processes can delay salt transport for decades). Salts removed by plant uptake and by the application of fertilizers are considered negligible. Percolate quality is assumed to be primarily a function of the differing percentage of applied water that recharges throughout the area due to site specific variations in soil characteristics.

The calculations of main basin water quality assume that the main groundwater basin is well mixed. Monitoring and modeling information developed for and presented in this SMP support the conclusion that there is significant long-term movement from the upper to the lower aquifers in the Main Basin. High TDS (700-2,000 mg/L) irrigation percolate that accumulates in the upper (0-150 foot) aquifer and then "leaks" and mixes into the lower aquifer is a key source of the Main Basin TDS increases. This upper/lower connectivity explains in part why extraction and demineralization (or export) of this high TDS shallow groundwater can provide significant long-term salt management benefits. The same benefits would also result from extraction of high TDS shallow groundwater (e.g., Dublin Sub-basin) that would otherwise enter the Main Basin as subsurface inflow.



ZONE 7 WATER AGENCY
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SALT MANAGEMENT PROGRAM

SURFACE WATER AND GROUNDWATER MONITORING SITES

SCALE: 1" = 2 miles
DATE: APRIL 8, 2004
FIGURE: Fig ES-4

Recycled Water

Numerous studies of potential recycled water use have been conducted but relatively little recycled water has been used directly to date in the valley. This is due in part to concerns about potential impacts from the elevated TDS levels in recycled water (versus potable water) on groundwater TDS concentrations. Zone 7, Livermore, and Dublin San Ramon Services District (DSRSD) conducted a valley-wide water recycling study (*Livermore-Amador Valley Water Recycling Study—May 1992*) and found that properly treated recycled water can provide a safe and cost effective new source of additional water supply and wastewater disposal capacity for the valley. The study also found that use of demineralized recycled water could help improve the salt balance and groundwater quality. Zone 7 subsequently adopted Resolution No. 1548, which affirmed the conclusions of the May 1992 Water Recycling Study and stated Zone 7's intent to work cooperatively with Livermore, DSRSD, and other entities to encourage the proper and orderly development of water recycling projects in a manner that would avoid degradation of groundwater quality.

In December 1993, the Regional Water Quality Control Board (RWQCB) issued a Master Water Recycling Permit (Order No. 93-159) to Zone 7, DSRSD, and Livermore. A key permit requirement was the development and implementation of a Salt Management Plan to fully offset both current salt loading from natural sources and operations, and any future salt loading associated with new recycled water use. The permit, through the SMP, provided the framework within which local decisions could thereafter be made determining the quality, quantity and location of permitted recycled water use.

Furthermore, the RWQCB 1995 Basin Plan Implementation Plan acknowledged the balancing of uses that needs to occur in managing the Livermore-Amador Valley groundwater basin:

"*... The Regional Board supports efforts to concurrently improve the salt balance in the Main Basin, to improve the local water supply, and to reduce the need for wastewater export through recycled water irrigation, groundwater recharge, and other basin management practices.*"

The Basin Plan supported the use of a "*mass-balance approach in assessing cumulative impacts*" for the SMP. This mass-balance approach has more commonly been called the "salt bubble" approach and was fundamental to the SMP and its salt management strategies. The salt balance calculation is the mass balance calculation that determines the long-term impacts.

Salt Management Plan Goals

The SMP was developed during 1994-1999 through a cooperative effort involving Zone 7 staff, Zone 7 consultants, the Technical Advisory Group (TAG) comprised of local water retailers, and the Zone 7 Groundwater Management Advisory Committee (GMAC)

comprised of local citizens. In consultation with the above advisory groups, a series of policy goals were developed for the SMP to help guide the development and refinement of various salt management strategies. The policy goals were also recommended for Zone 7 adoption and inclusion in the annual operations plan to help guide the use of available surface and groundwater supplies and treatment facilities (e.g., demineralization).

The SMP 1999 policy goals are as follows:

- Offset the current (1999) 2,200 tons per year of salt loading plus the approximately 50 tons per year of projected annual increase.
- Maintain or improve groundwater mineral quality.
- Maintain or improve delivered water quality.
- Provide comparable delivered water quality to all water retailers.
- Provide a mechanism for full mitigation of all salt loading associated with recycled water use.
- Minimize total operations and maintenance costs through an adaptive management process.

Over several years during which the SMP was being developed, the scope broadened beyond that outlined in the Master Permit. The resultant effort and product in many ways more closely resemble an overall watershed water resource management plan than simply a Main Basin salt management plan. In particular, at the request of the retailers, a considerable effort was devoted to evaluating the impacts of the salt management strategies on delivered water quality. The Visual Modflow computer groundwater model was further refined to compute future water quality at each production well. The water system operations model (WRMI) was developed and calibrated to provide better estimates of impacts on individual wells and delivered water quality at each Zone 7 turnout under alternative operational and salt management strategies. The WRMI model calculated monthly water quality at each turnout over an extensive 75-year hydrologic period.

Year 2010 Salt Management Strategies

Reducing net salt loading requires reducing the import of salts and/or increasing the export of salts. The SMP evaluates over twenty alternative individual and composite salt management strategies based on their compliance with the SMP policy goals. These include their ability to fully offset the projected year 2010 salt loading of 5,400 tons/year, operational costs, and impacts on delivered water quality.

The SMP focuses primarily on strategies that would only require use, or increased use of, existing and already planned Zone 7 facilities. Among the key individual conceptual salt management strategies are:

- **Conjunctive use via stream recharge**—Contrary to historic basin management, this strategy would maximize the amount of groundwater delivered to customers

and, to the extent practicable, allocate more local and imported surface water for stream recharge, thereby "flushing" the basin with lower TDS water.

- **Conjunctive use with ASR wells**—Aquifer storage and recovery (ASR) wells are capable of pumping groundwater from and injecting surface water into the groundwater basin. Under this strategy, low TDS treated surface water would be injected for about six months (winter) and subsequently extracted for six months (summer). This strategy would maintain and, in average to wet years, improve delivered water quality by creating bubbles of low TDS water around Zone 7's wells. This strategy, however, does not directly impact the salt balance. Zone 7 testing has identified potential clogging problems that may limit the feasibility of ASR operation.
- **Seasonal groundwater export**—This strategy consists of pumping high TDS shallow groundwater to the creeks during wet season periods if it did not adversely impact in-stream and downstream beneficial uses. To implement this strategy, various agency approvals and close coordination with Alameda County Water District operations would be required. Additional water would need to be procured to replace the water "lost" due to export.
- **Wellhead demineralization** — This strategy consists of groundwater demineralization at the point of extraction. For the SMP, demineralization is assumed to include a reverse osmosis membrane-based treatment system producing water in the 100 mg/L TDS range. The product water would be blended with non-demineralized groundwater and/or surface water prior to delivery to achieve a target delivered water TDS or hardness and to reduce aggressiveness to distribution pipelines. Demineralizing shallow high TDS water that could otherwise migrate vertically over time and degrade the lower aquifer would maximize salt removal benefits and minimize costs.
- **Demineralized recycled water injection**—This strategy is based on the City of Livermore's and DSRSD's potential projects as originally designed to inject demineralized recyled water into the groundwater basin. Both projects were designed to produce product water that meets all drinking water requirements and have less than 100 mg/L TDS prior to injection.
- **Conjunctive use with Chain of Lakes (2005)**—Similar to conjunctive use via stream recharge, this strategy consists of allocating local and imported surface water for recharge in the Chain of Lakes.
- **Delta fix (future)**—This strategy refers to the State and Federally sponsored CalFed Bay-Delta Program's proposed projects to solve multiple Bay-Delta water quality, quantity, resource, and environmental problems. Of interest for the SMP are options which, if implemented, would result in higher quality (lower TDS) Delta water being conveyed to the State Water Project and thus to Zone 7 and other municipalities throughout California.

A composite strategy that includes more than one strategy offers a more flexible and potentially cost-effective approach. For example, a composite strategy could be comprised of a blend of seasonal groundwater export, conjunctive use and demineralized recycled water recharge. Initially, all SMP strategies included the use of 6 TAF of Reverse Osmosis (RO) recycled water injection. Following public concerns in 1998 about the acceptability

of RO recycled water injection, an additional subset of strategies was developed without RO recycled component. The current recommended strategy does not include RO recycled water injection.

Table ES-2 presents the salt management strategies evaluated for projected year 2010 land and water use conditions. Baseline conditions are established by Strategy 1A. If implemented, Strategy 1A would continue Zone 7's historical operational practice of maximizing surface water deliveries and pumping groundwater only for peaking and drought conditions. Under this "status quo" strategy and year 2010 conditions, an average salt loading of 5,400 tons/year and delivered water TDS of 275 mg/L would result.

A screening for technical feasibility, timeline, economics, delivered water quality, including public and institutional acceptance, showed that only Strategy 15 could successfully pass all feasibility screening criteria (Section 9.6). Strategy 15 consists of a combination of conjunctive use and 5,000 AF of high TDS shallow groundwater wellhead demineralization (WHD). Detailed modeling analyses (Chapter 10) confirmed that Strategy 15 would provide the projected benefits to municipal groundwater and delivered water quality, and would eliminate the positive net salt loading in the Main Basin. Delivered water quality would be maintained at the baseline level of 275 mg/L.

Table ES-3 shows the difference in municipal groundwater quality (TDS) from using Strategy 15 versus Strategy 1A. It is clear that after 25 and 50 years of operation under Strategy 15, groundwater TDS would be improved at all listed locations except at well CWS#10, which is located in the Mocho II Sub-basin. This happens because recharge and pumping conditions in the Mocho II Sub-basin remain the same under both strategies. The modeled groundwater TDS for the lower aquifer after 25 years of operating under strategies 1A and 15 are mapped in figures ES-7 and ES-8, respectively. When comparing the figures, it is clear that the area of the basin with groundwater TDS below 500 mg/L would be significantly larger under Strategy 15. The Bernal Sub-basin lower aquifer and western portion of the Amador aquifer would benefit most under Strategy 15. Most of the Main Basin lower aquifer would stabilize near or below 500 mg/L.

Table ES-2

SUMMARY OF SALT BALANCE STUDIES AT 2010 CONDITIONS

Study No.	Name	LONG TERM AVERAGE									
		Vadose Zone Attenuation Credit	Demineralized Municipal Pumpage TAF	Salt Mgt. Conj. Use GW Pumpage TAF	Total Zone 7 GW Pumpage TAF	Net Salt Loading Tons/Yr	Net Increase In TDS mg/l/year	Projected GW TDS After 10 Years, mg/l	TDS of Zone 7 Deliveries mg/l	Incremental Operational Cost	
										Per year	Per Acre-foot of TW Delivery
1	Status Quo 6 TAF RO RW INJECTION (1)	NONE	NONE	NONE	12	3100	10	Currently 450 550	300	$0	$0
1A	Status Quo NO RO RW INJECTION	NONE	NONE	NONE	7.5	5400	18	630	275	$0	$0
1B	Status Quo 3640 AF RO RW INJECTED PLUS 20% MORE GW PUMPED FOR AG	NONE	NONE	NONE	10.4	5000	17	620	270	$0	$0
2	DELTA FIX 100mg/l SBA water quality	NONE	NONE	NONE	12	0	0	450	180	$0	$0
3	15% ATTENUATION	15%	NONE	NONE	12	2000	7	520	300	$0	$0
4	30% ATTENUATION	30%	NONE	NONE	12	1000	3	480	300	$0	$0
5	INCREASED GW PUMPING FOR CONJUNCTIVE USE	NONE	NONE	16	28	800	3	480	360	$760,000	$10
6		NONE	NONE	22	34	0	0	450	390	$1,100,000	$20
7	DEMINERALIZE ZONE 7 GW PUMPAGE	NONE	13	NONE	12	1700	6	510	210	$5,473,000	$100
8	DEMINERALIZE ZONE 7, CWS & PLEASANTON GW PUMPAGE	NONE	20	NONE	12	900	3	480	210	$8,420,000	$160
9	COMPOSITE OF CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE	NONE	19	7	19	100	0	450	212	$8,333,000	$160
10		NONE	10	16	28	-100	0	450	250	$4,968,000	$90

Table ES-2

SUMMARY OF SALT BALANCE STUDIES AT 2010 CONDITIONS

Study No.	Name	LONG TERM AVERAGE: Vadose Zone Attenuation Credit	Demineralized Municipal Pumpage TAF	Salt Mgt. Conj. Use GW Pumpage TAF	Total Zone 7 GW Pumpage TAF	Net Salt Loading Tons/Yr	Net Increase In TDS mg/l/year	Projected GW TDS After 10 Years, mg/l	TDS of Zone 7 Deliveries mg/l	Incremental Operational Cost: Per year	Incremental Operational Cost: Per Acre-foot of TW Delivery
11	COMPOSITE OF CONJUNCTIVE USE & DEMINERALIZATION OF SHALLOW GW PUMPAGE	NONE	5 (Demin 1000 mg/l GW pumpage to 100 mg/l)	5	17	-2200	-7	380	270	$2,351,000	$40
11A		NONE	1.5 (Demin 1000 mg/l GW pumpage to 100 mg/l)	10	22	0	0	450	320	$1,091,500	$20
11B		NONE	3 (Demin 1000 mg/l GW pumpage to 100 mg/l)	3	15	0	0	450	277	$1,383,000	$30
12	COMPOSITE OF ATTENUATION, CONJUNCTIVE USE & GW DEMINERALIZATION	15%	1.5 (Demin 1000 mg/l GW pumpage to 100 mg/l)	10	22	-1200	-4	410	320	$1,077,500	$20
13	ZONE 7 GW (1000TDS) PUMPAGE TO ARROYO MOCHO (EXPORT) WHEN GW STORAGE IS ABOVE 200 TAF	NONE	NONE	Average 3.6 TAF Seasonal GW Export	15.6	0	0	450	300	$404,000	$8
13A	ZONE 7 GW (1000TDS) PUMPAGE TO ARROYO MOCHO (EXPORT) WHEN GW STORAGE IS ABOVE 200 TAF	NONE	NONE	Average 1.5 TAF Seasonal GW Export	13.5	1730	6	510	300	$169,000	$0
14	COMPOSITE OF RO RW, ASR CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE **ASR RO RW PUMPAGE FOR AG USE**	NONE	4.6 (Demin 1000 mg/l GW pumpage to 100 mg/l)	4	14.3	0	0	450	250	$2,096,600	$40
14A	COMPOSITE OF RO RW ASR CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE **ASR RO RW PUMPAGE FOR URBAN IRRI.**	NONE	3.8 (Demin 1000 mg/l GW pumpage to 100 mg/l)	4	14.3	0	0	450	255	$1,759,800	$30
15	COMPOSITE OF CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE **NO RECYCLED WATER INJECTION**	NONE	5 (Demin 1000 mg/l GW pumpage to 100 mg/l)	8.5	16	0	0	450	270	$2,607,000	$50

Assumptions:

1. *All studies include 6 TAF/YEAR of RO recycled water (RW) injection except Study 1a & 15 have no RO RW water injection and studies 14 & 14a have 3640 af of demineralized RW injection.*
2. *All studies do not include salt loading due to future development outside the main basin or new recycled water irrigation water use*
3. *Incremental operational cost is based upon total treated water deliveries (45,100 AF Zone 7 plus 7,214 AF GPQ pumpage)*

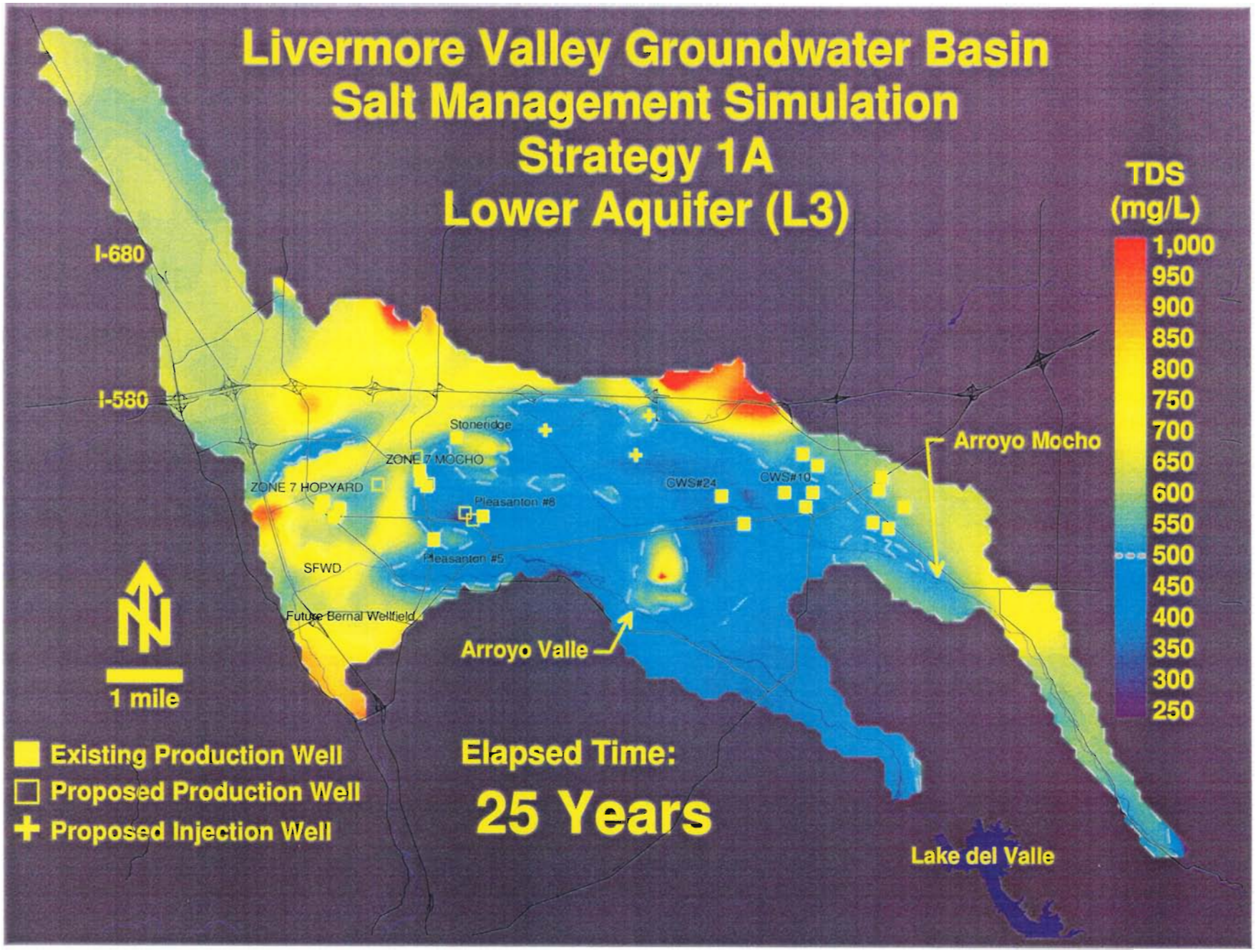

Livermore Valley Groundwater Basin
Salt Management Simulation
Strategy 1A
Lower Aquifer (L3)
TDS
(mg/L)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
I-680
I-580
Stoneridge
ZONE 7 MOCHO
ZONE 7 HOPYARD
Pleasanton #8
Pleasanton #5
SFWD
Future Bernal Wellfield
CWS#24
CWS#10
Arroyo Mocho
Arroyo Valle
Lake del Valle
1 mile
Existing Production Well
Proposed Production Well
Proposed Injection Well
Elapsed Time:
25 Years

Figure ES-7

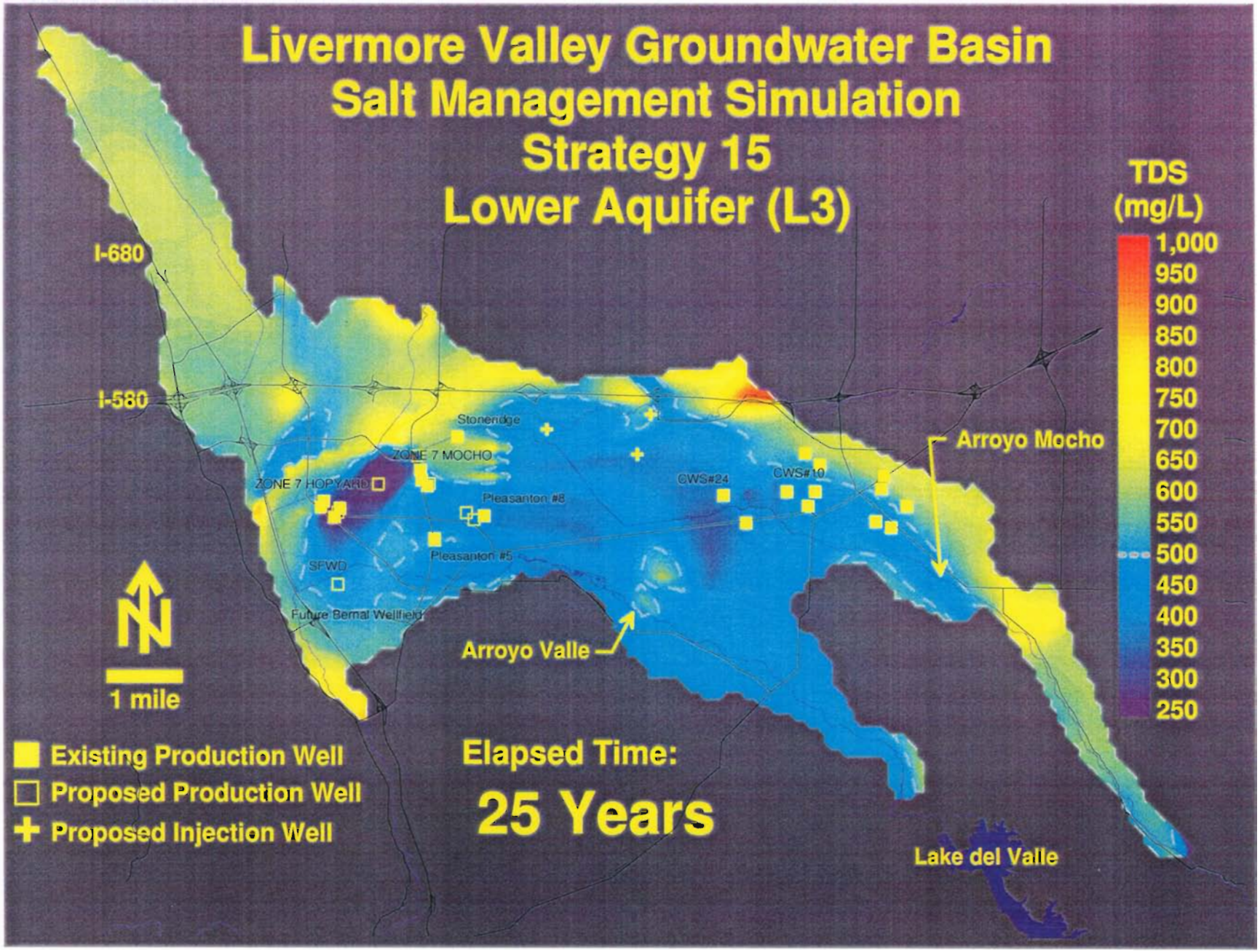

Livermore Valley Groundwater Basin
Salt Management Simulation
Strategy 15
Lower Aquifer (L3)
TDS
(mg/L)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
I-680
I-580
Stoneridge
ZONE 7 MOCHO
ZONE 7 HOPYARD
Pleasanton #8
Pleasanton #5
CWS#24
CWS#10
Arroyo Mocho
SFWD
Future Bernal Wellfield
Arroyo Valle
Lake del Valle
1 mile
Existing Production Well
Proposed Production Well
Proposed Injection Well
Elapsed Time:
25 Years

Figure ES-8

Table ES-3: Strategy 15 Versus Strategy 1A Groundwater Model Simulation Results Municipal Wellfield Groundwater Quality (TDS) at Select Locations

	Groundwater TDS and Change from Strategy 1A, mg/L			
Wellfield or Well Name	After 25 Years	Change	After 50 Years	Change
Zone 7 Hopyard Welfield (Hop-9)	300	-250	260	-410
Zone 7 Mocho Wellfield (Mocho 2)	420	-60	400	-80
Zone 7 Stoneridge Wellfield	570	-10	550	-50
Pleasanton # 5	490	-10	430	-50
Pleasanton # 8	390	-50	390	-60
CWS # 10	570	50	550	10
CWS # 24	380	-20	390	-20
SFWD Wellfield	510	-130	490	-320
Future Bernal Wellfield (Laguna South - Shallow Aquifer)	720	-160	760	-220

Cost Allocation

By late 1998, the TAG and GMAC agreed to support the cost allocation approach of having Zone 7 fund annual salt management O&M costs via the treated water rates to offset the existing 2,200 tons/year salt loading (Section 11.3). The majority recommended that it made the most sense economically and administratively to not attempt to differentiate between sources of salts and let Zone 7 manage future salt loading by expanding the approach adopted to manage current salt loading. A methodology for calculating individual project salt loading was developed in the SMP. This provides the framework under which future salt loading could be determined on a project-by-project basis and/or where salt management projects can be conducted by agencies other than Zone 7 and generate salt "credits".

Near-Term Salt Management Strategies

Zone 7 staff, in consultation with the TAG and GMAC, decided in early 1999 to develop a revised set of salt management strategies that could be implemented in the near term (i.e., in 2000-2002) rather than in year 2010. These near-term strategies were the strategies previously identified and screened for year 2010 conditions (Section 9.6), but scaled down for the current 2,200-tons/year loading conditions. Letter suffixes (e.g., 15A) are variations of the same basic year 2010 strategy. The near-term salt management strategies and implementation plan are detailed in Chapter 12.

From among the 2010 strategies, seven near-term salt management strategies believed to be feasible were identified. These are listed in Table ES-4. The values in the table were

calculated as if the strategies were to be implemented under year 2000 loadings, treated water deliveries, and costs. The unit O&M costs and salt removal capability assumptions used to develop these near-term strategies were the same as described in detail in Section 8.14. As previously indicated, the TAG and GMAC agreed to support the cost allocation approach of having Zone 7 fund annual salt management O&M costs via the treated water rates to offset the existing 2,200 tons/year salt loading (Section 11.3). Therefore, incremental operational costs in Table ES-4 are also expressed as a percentage increase in treated water rates, based on an assumed annual water usage of 1/2 acre-foot per household.

Table ES-4
NEAR TERM SALT MANAGEMENT STRATEGIES

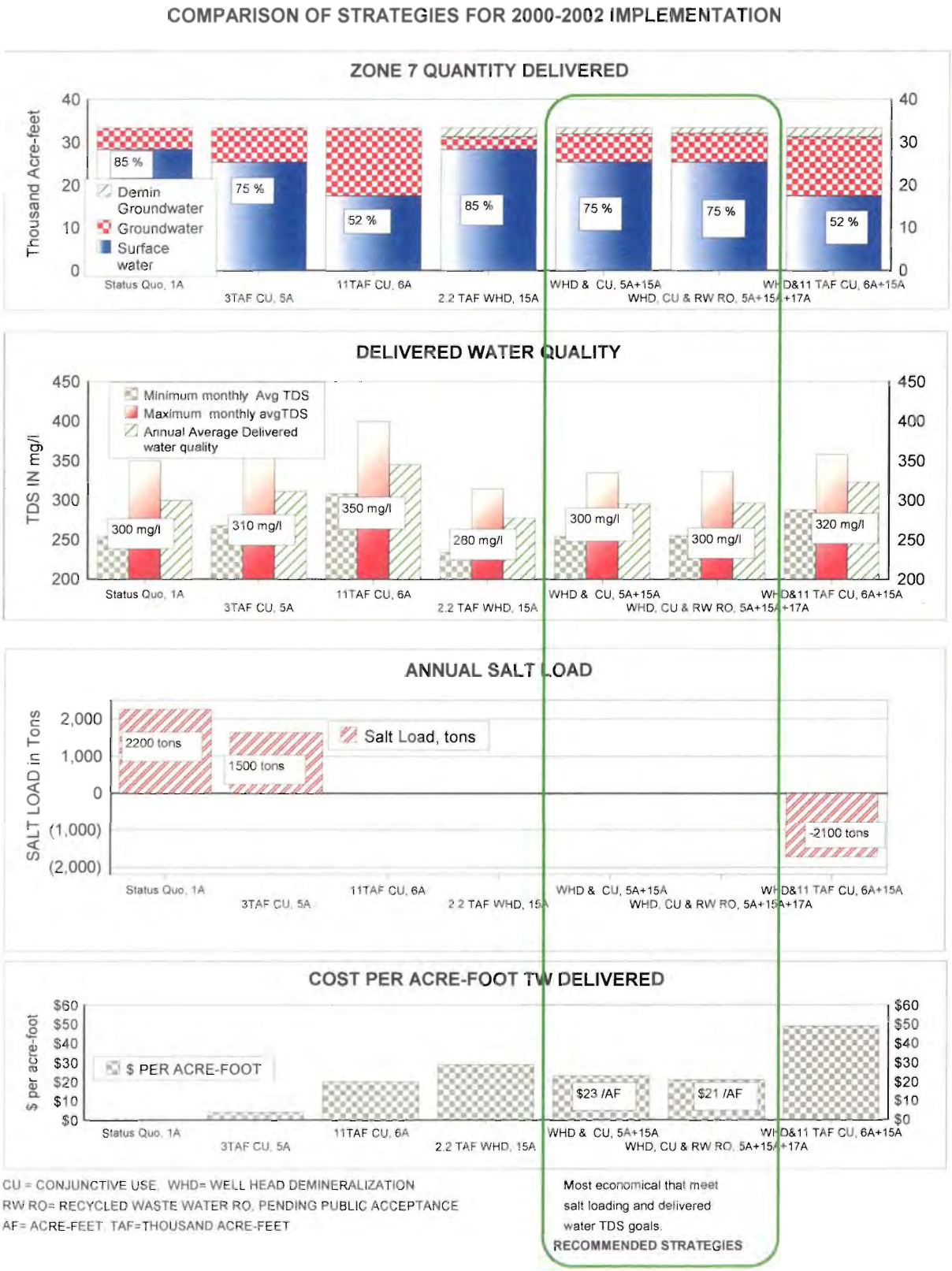
		Long - Term Average							
			NET SALT	NET INCREASE	Projected GW TDS	TDS OF ZONE 7	ZONE 7 INCREMENTAL OPERATIONAL COSTS		
STRATEGY NO	NAME	POLICY OPTION	LOADING TONS/YR	IN GW TDS mg/l/year	after 10yrs mg/l	DELIVERIES mg/l	PER YEAR	PER ACRE-FOOT OF TW DELIVERY	% Rate Increase
Status Quo 1A	Year 2000 Status Quo (no demineralized RW injection)	I	2200	7	520	300	$0	$0	0.0%
Conj. Use 5A	Minimum Conjunctive Use 3000 AF (Stoneridge well - no GW demin)	II	1600	5	500	310	$120,000	$4	0.8%
6A	Major Conjunctive Use 11,000 AF (zero out salt balance)	III	0	0	450	350	$680,000	$20	3.8%
Wellhead Demin 15A	2200 AF Demin GW Pumpage (1000 mg/L to 100 mg/L)	III	0	0	450	280	$976,800	$29	5.5%
COMPOSITE OF 5A AND 15A	Minimum Conjunctive Use (3000 AF/Y) and 1600 AF/Y Demin GW PUMPAGE	III	0	0	450	300	$786,000	$24	4.4%
COMPOSITE OF 5A, 15 A AND 17A (17A Rev. Table 12.2)	Minimum Conjunctive Use (3000 AF/Y) and 1300 AF/Y Demin GW PUMPAGE 840 AF (Livermore) RW RO Stream Recharge	II	0	0	450	300	$714,000	$21	4.0%
5A PLUS 15A	Major Conjunctive Use (11000 AF/Y) and 2200 AF/Y Demin GW PUMPAGE	IV	-2100	-7	380	330	$1,656,000	$49	9.3%

Assumptions:

1) *Zone 7 TW delivery of 33,500 AF and UTW of 7300 AF (Year 2000)*
2) *Base TW rate of $528/ AF for year 1999*
3) *Incremental cost spread only to Zone 7 Treated water deliveries*
4) *GW TDS of 450 mg/l and SW TDS 270 mg/l (Historic average at PPWTP)*
5) *GW Demin capacity at 2200 AF/Y (180 af/month for 12 months)*

The above (seven) individual and composite year 2000 strategies are compared in figures ES-9 and ES-10. Figure ES-9 presents four parallel bar charts. The first (uppermost) bar chart series presents the ratio of surface water to total groundwater delivered by Zone 7 under each of the seven strategies. The second graph presents every strategy's resultant minimum and maximum monthly average TDS (12 month average), and the overall annual average TDS of Zone 7 deliveries (i.e., three bars per strategy). The third graph presents the annual average salt loading (in tons) remaining after implementation of each strategy. The fourth (bottom) graph presents the incremental O&M cost per acre-foot of

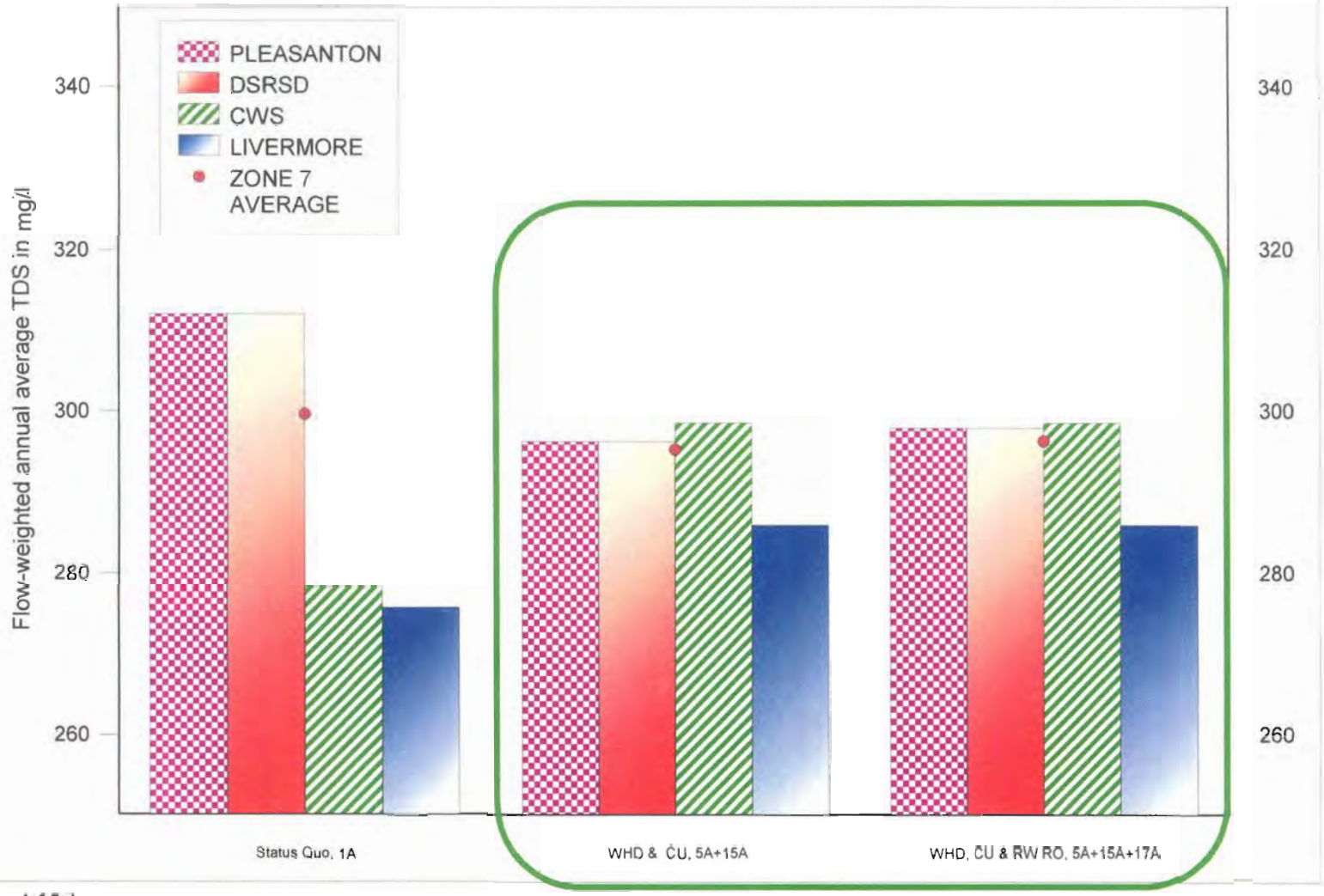
Figure ES-9



CU = CONJUNCTIVE USE, WHD= WELL HEAD DEMINERALIZATION
RW RO= RECYCLED WASTE WATER RO, PENDING PUBLIC ACCEPTANCE
AF= ACRE-FEET, TAF=THOUSAND ACRE-FEET

Figure ES-10

Annual Average TDS Delivered to Retailers
Under Historic and Proposed 2000-2002 Operating Conditions



NOTE:

1) Assuming that 75% of the time the Stoneridge pumpage will be diverted to East (to CWS & Livermore) by closing rate control valve in X-valley pipeline.

2) Assuming that all the other GW pumpage (GW, WHD & ASR) is delivered to Pleasanton and DSRSD (prorated by delivery amount).

3) Assumes Stoneridge pumpage at 400 mg/l and all other Zone 7 pumpage at 450 mg/l. Well Head Demineralization to 100 mg/l.

Figure ES-10

Zone 7 deliveries (i.e., increase in treated water rates attributable to salt management). Figure ES-10 compares the annual average TDS of Zone 7 deliveries to individual retailers between status quo operation (i.e., Strategy 1A) and two composite strategies.

Comparison of the strategies indicates the following:

- Strategy 1A (Status Quo)—This strategy minimizes operational costs but fails to achieve any other SMP goals. Under this strategy, treated water rates would not increase.
- Strategy 5A (Minimum Conjunctive Use)—This reduces salt loading by about 600 tons/year (28%), but it increases the annual average TDS of Zone 7 delivered water by about 3%. Under this strategy, treated water rates would increase by 0.8%.
- Strategy 6A (Major Conjunctive Use)—This is minimum cost strategy and is salt neutral. However, it would significantly increase the TDS of Zone 7 deliveries, particularly to the west side of the valley, which contradict SMP goals. Under this strategy, treated water rates would increase by 3.8%.
- Strategy 15A (Wellhead Demineralization)—This salt neutral strategy would decrease the TDS of blended Zone 7 deliveries, particularly to the west side of the valley. However, it is the highest cost near-term salt neutral strategy. Under this strategy, treated water rates would increase by 5.5%.
- Composite of 5A and 15A (Minimum Conjunctive Use and Wellhead Demineralization)—This is the most economical near-term strategy that satisfies all salt management criteria. Under this strategy, treated water rates would increase by 4.4%.
- Composite 5A, 15A and 17A (Minimum Conjunctive Use, Wellhead Demineralization, and RO Recycled Water Stream Recharge)—This strategy could satisfy all salt management criteria and would be slightly less expensive than the composite 5A/15A strategy. Under this strategy, treated water rates would increase by 4%. If the RO recycled water stream recharge component did not occur or were postponed, wellhead demineralization would need to be increased, and it would effectively make this strategy the same as the composite 5A/15A strategy.
- Composite 6A and 15A (Major Conjunctive Use and Wellhead Demineralization)—Groundwater quality would improve most rapidly under this strategy but delivered water quality would degrade. This is the highest cost near-term strategy. Under this strategy, treated water rates would increase by 9.3%.

Several of the 2010 strategies passed the feasibility screens (technical, timeline and water quality), except for public and institutional acceptability. If regulatory and/or perception barriers are overcome, at least some of these strategies could also potentially be implemented before 2010. A select group of what appeared to be the more promising of these other strategies were scaled down to current 2,200 tons/year loading and were named potential near-term strategies. Eleven potential near-term salt management strategies were identified based on a Delta fix, RO recycled water injection, seasonal

groundwater export, Lake G recycled water storage and irrigation, and RO recycled water stream recharge. These strategies are discussed in Section 12.3.

Zone 7 staff, in consultation with the TAG and GMAC, developed a recommended near-term implementation plan (Section 12.4) out of the near-term strategies evaluated. The plan included recommended policy goals and a three-year phased implementation of increased conjunctive use, wellhead demineralization with brine export, and potential demonstration scale RO recycled water stream recharge. The plan also identified how annual salt management decisions would be made via an adaptive management process and integrated into Zone 7's annual operations plans.

Adaptive Management

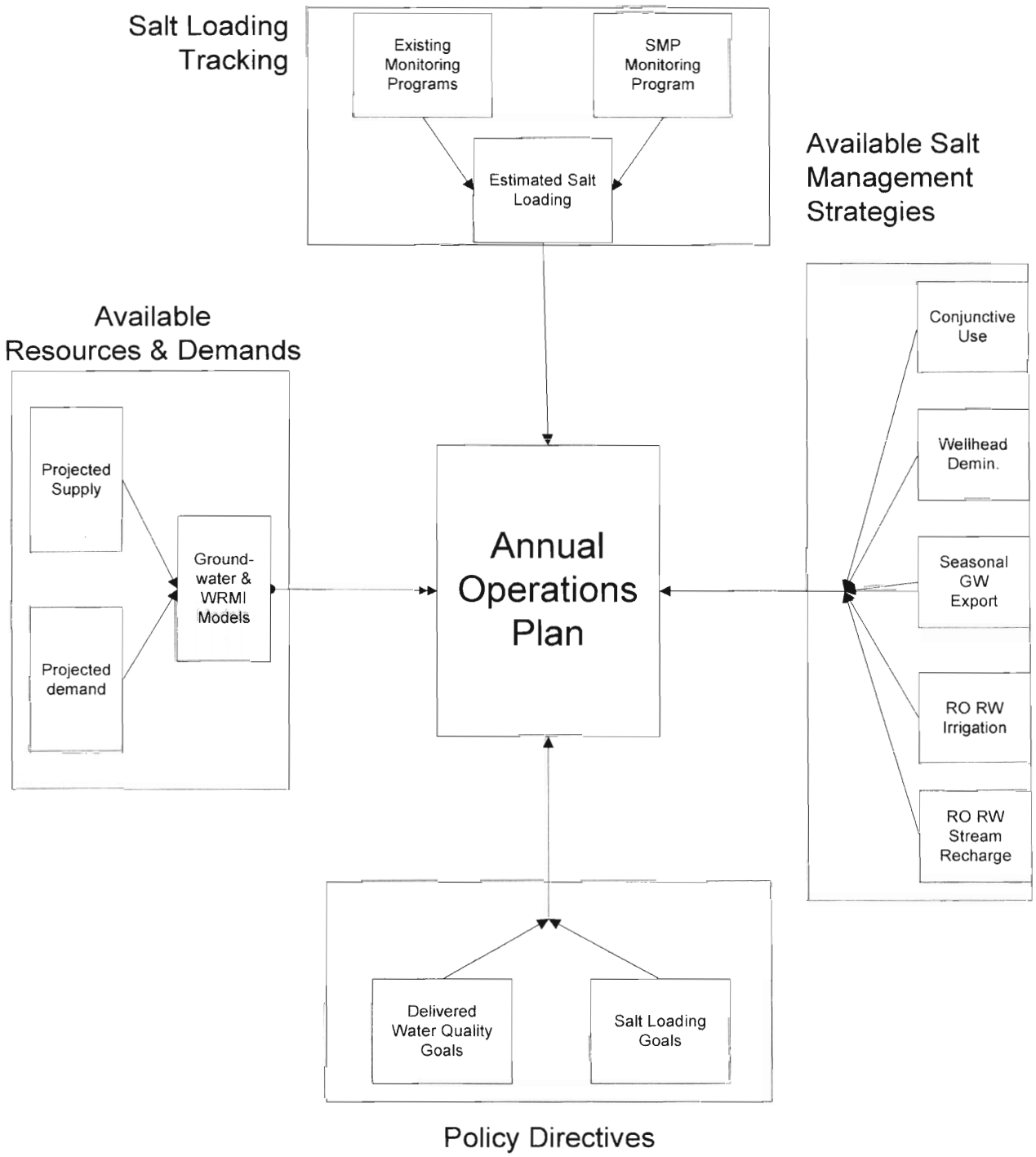
Zone 7's annual operations plan has been expanded to incorporate the SMP goals and an adaptive management process. This means that when all the facilities are in place to fully implement the SMP, each year staff will review the projected water supply forecast, retailer water demands and adopted salt management goals to select the most cost-effective combination of available salt management tools to be used during the upcoming year. Annual operational costs will be estimated and allocated as appropriate during the annual water rate setting process. Over time, it is expected that additional strategies may become available (e.g., seasonal groundwater export) and Zone 7 will re-evaluate the optimum combination of strategies for any given year. Figure ES-11 illustrates Zone 7's proposed adaptive management process through which multiple changing variables will be balanced annually to arrive at an optimal operational decision.

The adaptive management approach requires input in four major areas: policy directives, available resources and demands, salt loading tracking, and available salt management strategies.

- Policy directives include items such as Zone 7 Board decisions/guidance that there be no long-term average net salt loading to the groundwater basin and that delivered water mineral quality be maintained or improved.
- Available water resources and demands involve assessing the new water supply, demand and groundwater storage conditions at the beginning of each year. This basically represents the information tracked and processed by the historic operations plan.
- Salt loading tracking involve collection of data and information from the various monitoring programs. The existing monitoring program is sufficient for tracking salt loading from existing sources and for existing land use conditions. Future land use changes and any increased use of recycled water will require additional monitoring to track the resultant salt loading. The Salt Management Monitoring Program will provide this new salt loading source information, facilitate tracking of salt removal, and provide the information needed to calculate the annual salt removal targets for inclusion in the annual operations plan.

Figure ES-11

Schematic of Salt Management Annual Operations Plan



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- Available salt management strategies include all the available salt removal strategies and their relative removal capacities. The number and type of strategies are expected to increase over time with the facilities owned and operated by Zone 7 and others (see tables 12.2 and 12.3).

With adaptive management, factors such as current and projected salt loading, relative salt removal costs ($/ton removed), impacts on delivered water quality, and water supply conditions, will be evaluated together and the best possible solution that balances the competing salt management goals will be incorporated into the annual operations plan. In some years, the decision-making may require groundwater modeling or other sophisticated prediction methods.

An example of a possible outcome of the adaptive management process is a decision to not implement any salt removal measures in a given year and to accrue a salt deficit recognizing that it would need to be offset in future years. This may be the case in the early years of implementing the SMP when there will be few salt management strategies to choose from (e.g., conjunctive use). This outcome could also result during a drought when demineralization facilities may not be operated to conserve the water that would otherwise be lost as salt concentrate. A similar decision to limit or not operate demineralization facilities may be made during periods of limited power supply and/or high power cost. Conversely, under very favorable water supply and water quality conditions, Zone 7 could choose to implement extra salt removal measures and thereby accrue salt credits.

Zone 7 Board's Near-Term Implementation Plan Approval

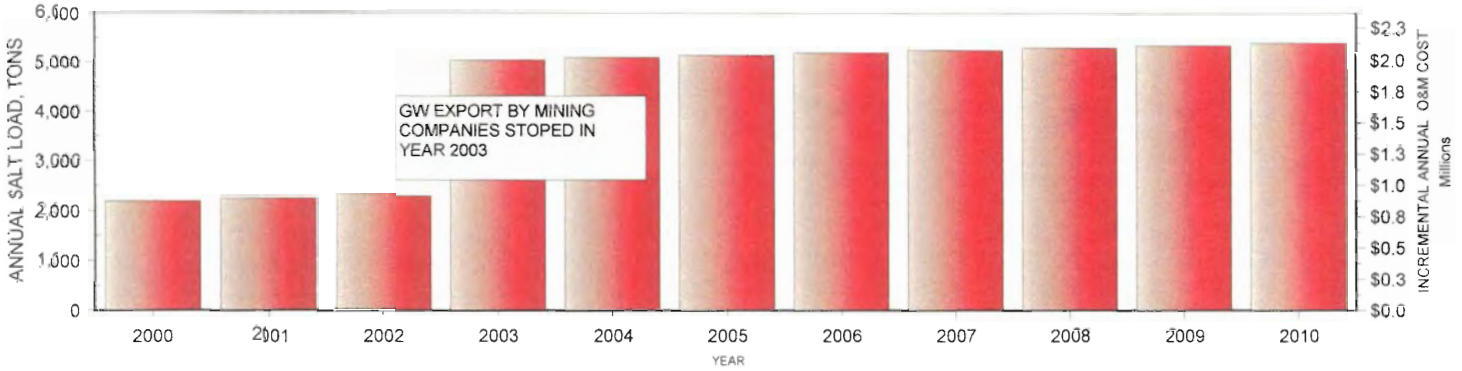
The above phased near-term implementation plan was presented to and approved by the Zone 7 Board of Directors on August 18, 1999 by Resolution No. 99-2068. The tables and figures illustrating the plan contained in Chapter 12 (ES 9-12) are essentially the same as those presented to the Board. The Resolution stated the Board's support for the proposed Salt Management Program Implementation Plan and for inclusion of the six policy goals in the Zone 7 annual operations plan. The Resolution also authorized the Zone 7 General Manager to proceed with the recommended year 2000-2002 Salt Management Implementation Plan.

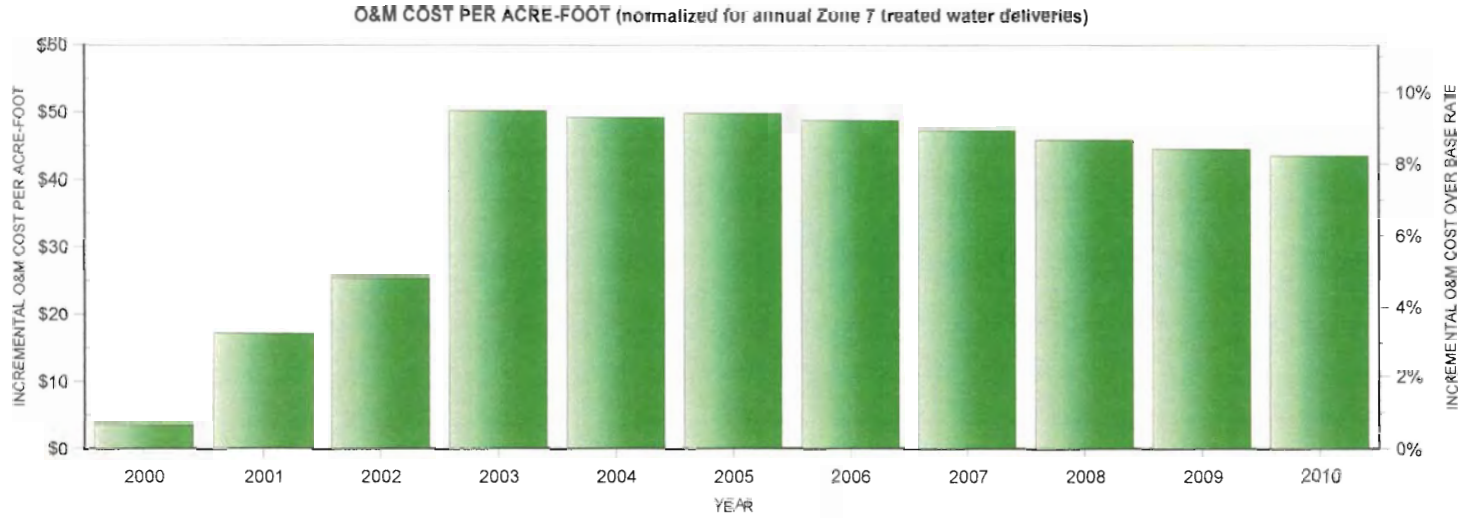
Future Salt Loading

Main Basin salt loading has been projected to increase from the current (1999) 2,200 tons/year to 5,400 tons/year by year 2010 (Section 8.9). The upper graph in Figure ES-12 presents projected future annual salt loading from year 2000 through 2010. This graph shows the salt load in tons on the left y-axis and incremental annual O&M cost on the right y-axis. The costs shown are based on one strategy and reflect the potential annual operation and maintenance (O&M) costs to fully offset each year's loading, assuming the

Figure ES-12

FUTURE ANNUAL SALT LOAD & REMOVAL COST (2)





NOTE: 1) *Salt load calculation does not include.*

a) The impacts of increased future subsurface inflows due to increased agricultural irrigation outside the main basin.

b) The incremental increase in salt loading due to recycled water irrigation over the main basin.

2) *Salt removal cost is based upon removal by Shallow Well GW Demin (1 - 4 TAF/Y) and Conjunctive use (3 - 7 TAF/Y) For any other strategy or combination of strategies, the cost will change.*

Figure ES-12

use of shallow well demineralization (1 to 4 TAF/Y) and conjunctive use (3 to 7 TAF/Y). Under any other strategy or composite strategies, the costs would differ.

The lower graph shows the incremental O&M cost per acre-foot of Zone 7 treated water deliveries on the left y-axis. The right y-axis shows this cost as a percentage over the base treated water rate. For years 2000–2002, the incremental cost would increase from about $3/AF/year (first bar on lower graph of Figure ES-12) or $1.50/houseold/year to about $25/AF/year (left y-axis) or $12.50/household/year. That would be an increase of about 5% (right y-axis) over the Zone 7 1998 base treated water rate ($528/AF).

A major change occurred in year 2003 with the cessation of the majority of the water and salt exports by the gravel-mining companies. To remain salt neutral, the SMP will have to be expanded to offset an additional 2,800 tons/year of salts. This will cause the incremental operational costs to increase by about $50/AF of Zone 7 treated water deliveries over base treated water rates. After 2003, the increase in salt loading is projected to be gradual, about 50 tons/year or 500 tons by 2010 primarily due to increased urban and agricultural development-related irrigation.

Zone 7 treated water deliveries are projected to increase each year successively at least through year 2010, increasing the base volume over which to distribute the increased O&M costs. Therefore, the incremental operational cost for salt management in 2010 would stabilize at around $45/AF/year. This represents about an 8% incremental cost over the Zone 7 1998 base treated water rate. If any of the other lower-cost salt removal strategies become feasible in the future, they will be integrated into the annual operations plan as part of the SMP adaptive management process and operational costs will be reduced.

These future salt loading estimates do not include impacts of potential increased future subsurface inflow or surface water runoff due to increased agricultural irrigation outside the Main Basin (to be tracked via the Salt Management Monitoring Plan). However, the potential loadings due to increases in subsurface flow are believed to be minimal and the effects of these impacts would not be seen for many decades due to the various geologic barriers between the fringe and the Main Basin (as documented in Chapter 3). The estimates shown also do not include any incremental increase in salt loading due to new or retrofit recycled water irrigation projects impacting the Main Basin. New and/or expanded salt management strategies and facilities will need to be implemented to offset these future potential salt sources to comply with the SMP goal of fully offsetting net salt loading.

SMP Next Steps

Zone 7 began implementing the SMP in the year 2000 by increasing conjunctive use (Strategy 5A). Zone 7 has wellhead demineralization facilities scheduled within its Capital Improvement Program (CIP). Further planning studies have been conducted that verified the feasibility of shallow groundwater demineralization as described in this SMP. Those studies also investigated, in more detail, alternative sites for the demineralization facilities.

A well master plan is being prepared that will in part also evaluate sites for shallow groundwater wells. Negotiations are continuing with DSRSD and Livermore on use of the LAVWMA facilities for RO concentrate disposal. Zone 7 has completed a Water Quality Master Plan. The SMP goals and operations have been integrated into and coordinated with the Water Quality Master Plan goals.

Given enough public support, Zone 7 and Livermore could begin exploring in more detail, summertime stream recharge with demineralized recycled water in the Arroyo Mocho near Isabel Avenue (strategies 17A and 17B). Zone 7 will continue discussions with Alameda County Water District on possible operational agreements that would identify conditions under which it would be acceptable for Zone 7 to conduct seasonal high TDS groundwater export (strategies 13B, 13C, and 13D). Zone 7 will contact the RWQCB to determine what type of permit, if any, is required to carry out this activity.

Zone 7's submittal of this SMP (Reference S) to RWQCB staff documents Zone 7's long-term plan and strategy for managing salts and mineral water quality within the Livermore-Amador Valley groundwater basin to promote the wise use of all water resources and to protect the long-term sustainable quality of potable water delivered within the valley.

Chapter 1

Salt Management Plan History and Overview

1.1 Introduction

Zone 7 has prepared this Salt Management Plan to serve as a cornerstone of Zone 7's overall groundwater management efforts. This Salt Management Plan (SMP) identifies and evaluates all significant salt loading to, and removal from, the groundwater basin. This plan is intended to be used by Zone 7, other local agencies and regulators to determine the anticipated effects of various actual and proposed projects on the water quality of the Livermore-Amador Valley surface water and groundwater resources.

This SMP was developed over a period of several years through a cooperative effort involving Zone 7 staff, Zone 7 consultants, a Technical Advisory Group (TAG) comprised of local potable water retailers, and the Groundwater Management Advisory Committee (GMAC). This SMP was developed in accordance with the Master Water Recycling Permit and Basin Plan guidance and requirements. As part of the SMP effort, Zone 7 staff developed additional surface and groundwater monitoring and modeling tools that validated prior methodologies for calculating salt loading inputs to, and exports from, the main groundwater basin. The models also provided the capability to more accurately project potential impacts on both groundwater at municipal well sites and delivered water quality for alternative operational strategies.

This chapter presents a brief history of the SMP and the regulatory framework behind it. This is followed by a summary of the 1992 Water Recycling Study that identified the basic SMP concept in the context of maintaining sustainable groundwater quality while facilitating recycled water projects. The chapter concludes with a brief description of the contents of the remaining eleven chapters in this SMP.

1.2 SMP History and Regulatory Framework

The Zone 7 Water Agency serves as the overall water quality management agency for the Alameda Creek Watershed above Niles. Zone 7 has the primary responsibility for managing the Livermore-Amador Valley surface and groundwater resources. It has historically managed the main groundwater basin (main basin) by maximizing surface water deliveries, artificially recharging the Main Basin with low total dissolved solids (TDS) imported surface water, restricting groundwater pumping, and restricting wastewater disposal and water recycling within the watershed. This historic management strategy, implemented by Zone 7 staff through the annual water operations plan, has been successful in maintaining a sustainable and reliable water supply.

However, as in other arid areas that rely on imported water for a significant portion (75-85%) of the local supply, this strategy has allowed a gradual, but continuing degradation in groundwater mineral (salts) quality. Salts have been accumulating in the Main Basin due to these management practices, irrigation, and natural sources at a long-term average net salt loading rate of approximately 2,200 tons/year. The 2,200 tons per year, which is projected to increase to 5,400 tons per year by the year 2010 or sooner, is equivalent to about a 10 mg/L per year increase in TDS in the groundwater. The 5,400 tons per year does not include potential loadings from new agricultural irrigation projects or recycled water irrigation projects.

Recycled water represents a significant potential resource for the Valley. While opportunities for such beneficial reuse have been studied extensively over the past 30 years, few projects have been implemented. This is due in large part to the fact that recycled water contains two to three times the amount of salts (TDS) as does typical Zone 7 treated water and concerns about the additional salt loading impacts on the Main Basin.

Zone 7, Livermore, and Dublin San Ramon Services District (DSRSD) conducted a Valley-wide water recycling study (*Livermore-Amador Valley Water Recycling Study - May 1992*) that found that properly treated recycled water can provide a safe and cost effective source of additional water supply and wastewater disposal for the Valley. The study also found that use of demineralized recycled water could also help improve the salt balance and groundwater quality.

Zone 7 subsequently adopted Resolution No. 1548 which affirmed the conclusions of the May 1992 Water Recycling Study and stated Zone 7's intent to work cooperatively with Livermore, DSRSD, and other entities to encourage the proper and orderly development of water recycling projects and thereby avoid degradation of groundwater quality.

The Regional Water Quality Control Board (RWQCB) in December 1993 issued the Master Water Recycling Permit (Order No. 93-159) to Zone 7, DSRSD, and Livermore. The Master Permit specifies the requirements to be met prior to implementation of additional recycled water irrigation or recycled water groundwater recharge projects in the Valley. The key Permit requirement is for development and implementation of a Salt Management Plan to fully offset both current salt loading and any future salt loading associated with recycled water use. SMP requirements include defining basin characteristics, refining salt balance calculations, identifying water quality objectives, developing a SMP monitoring program, evaluating alternative salt management tools and strategies, and developing a SMP implementation plan and schedule.

The RWQCB Water Quality Control Plan (Basin Plan) contains water quality objectives (WQO) for the surface water and groundwater in the Valley. Water quality objectives are set by the RWQCB to protect beneficial uses of water of the State. The groundwater TDS objective is defined as ambient or 500 mg/L, whichever is lower. The 500 mg/L WQO is based on the USEPA and California Department of Health Services (DHS) drinking water

secondary Maximum Contaminant Level (SMCL) value for potable supplies. Ambient conditions are defined as the water-bearing zone with the highest quality water.

The Basin Plan Implementation Plan describes in detail the RWQCB's programs and specific plans of action for meeting WQOs. The Basin Plan has a specific section devoted to the Livermore-Amador Valley (p. 4-21 to 4-23). That section summarizes the conclusions of the 1992 Master Water Recycling Study and the content and requirements of the 1993 Master Water Reuse Permit. General policy guidance regarding the SMP is provided in the Basin Plan where it is noted that the SMP will be developed "*based on the concept that the effect of each individual project is best assessed in the context of the cumulative effects of all such projects, as well as the effects of groundwater management policies and natural conditions.*" The Basin Plan also supports the SMP use of a "*mass-balance approach for assessing cumulative impacts.*" This has commonly been called the "salt bubble" approach. A small area of salty water above "ambient" would be acceptable if offset by areas of non-salty water.

Additional Basin Plan guidance (p. 4-23) states that the SMP define "*a project or set of projects that will:*

- *Minimize the current trend toward increasing Main Basin groundwater salinity due to subsurface groundwater inflow or natural recharge;*
- *Fully mitigate the effects of salt loading due to water recycling on the Main Basin groundwater resource;*
- *Ensure that water imports and water recycling will not contribute to the degradation of groundwater quality; and*
- *Protect groundwater beneficial uses.*"

The Basin Plan Implementation Plan (p. 4-21) acknowledges the balancing of uses that needs to occur in managing the Livermore-Amador Valley groundwater basin:

"*... The Regional Board supports efforts to concurrently improve the salt balance in the Main Basin, to improve the local water supply, and to reduce the need for wastewater export through recycled water irrigation, groundwater recharge, and other basin management practices.*"

Other policy guidance relative to salt management is provided in the State's non-degradation policy, SWRCB Resolution 68-16. This Resolution independently requires that existing water quality not be degraded so as to unreasonably impact beneficial uses. As excerpted below:

"..existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies." Controllable sources and discharges including recycled water use are to be controlled to assure that *"the highest*

water quality consistent with maximum benefit to the people of the State will be maintained."

Irrigation related impacts on groundwater quality are recognized as different from impacts of other constituents. A separate section of the Basin Plan (p. 4-35) provides additional guidance on interpreting the non-degradation policy relative to irrigation impacts where it notes:

"An increase in the concentration of soluble salts contained in percolation irrigation water is an unavoidable result of consumptive use of water." ...

"Maintenance of a favorable salt balance, that being a reasonable balance between the import and export of salts from individual basins, must be considered to control increases in mineral content. This is especially applicable for the Livermore and Santa Clara Valley groundwater basins."

"The ultimate consequences of regulatory action for irrigation operations must be carefully assessed. The "no-degradation" concept in connection with salt levels is not appropriate in all circumstances."

"A concept of minimal degradation might be considered in some areas. It would need to be coupled with management of the surface and underground water supplies in order to assure acceptable degradation effects."

1.3 Valley-Wide Water Recycling Study and Master Permit

Since the 1960's both the water and wastewater agencies in the Livermore-Amador Valley independently studied water recycling, focusing on landscape and agricultural irrigation. The volume of water recycling at that time was limited, primarily because of concerns over its impact on groundwater in the Valley's Main Basin. Of particular concern were soluble constituents such as TDS and nitrate. The Valley's interest in protecting the groundwater also dates back to the 1970's, when in-basin disposal of secondary-treated wastewater was practiced. Until 1980, the City of Pleasanton used spray-irrigation to dispose of treated effluent, the City of Livermore discharged filtered secondary effluent to Arroyo Las Positas and used percolation ponds and spray irrigation, and the Dublin San Ramon Services District (DSRSD) discharged treated effluent to the Alamo Canal which subsequently flows into the Arroyo de la Laguna and Alameda Creek.

Numerous studies of alternative wastewater treatment and disposal alternatives were conducted during the 1970's given concerns over impacts of on-going and proposed future wastewater discharges on the groundwater basin and on downstream (Niles Cone) beneficial uses. These studies and related investigations led to the San Francisco Regional Water Quality Control Board (RWQCB) to include in the 1975 Basin Plan TDS and chloride water quality objectives for the surface waters of the Alameda Creek watershed above Niles to protect the waters from degradation by controllable sources. A 250 mg/L

90-day arithmetic mean TDS objective was set based on the calculated long-term average concentration of the imported surface water brought into the Valley and released into the Arroyos to recharge the Main Basin and the Niles Cone. It was also set to serve as basis for prohibiting wastewater discharges to surface waters.

These objectives could not be achieved most months of the year in surface waters that were impacted by wastewater discharges. These objectives led the various disposal and reuse studies to focus on options for advanced treatment (demineralization) or export to San Francisco Bay. The 1970's studies and Basin Plan objectives led to construction of the Livermore Amador Valley Water Management Agency (LAVWMA) export pipeline that transported all treated municipal effluent from Livermore and DSRSD to a deepwater outfall in San Francisco Bay south of the Oakland airport. Export of the Valley's treated effluent to San Francisco Bay via LAVWMA began in 1981.

During the 1970's, increasing development was occurring and developers were proposing to build packaged wastewater treatment plants with onsite effluent disposal. Concerns over the adverse water quality impacts, particularly from salts and nitrates resulting from such practices, led to development of the Zone 7 *Wastewater Management Plan*. This 1982 plan prohibited the use of packaged treatment plants and required effluent applied above the Livermore-Amador Valley Main Groundwater Basin to have no more than 250 milligrams per liter total dissolved solids and less than 10 mg/L nitrates. The plan also included groundwater quality objectives of ambient or 500 mg/L, whichever is lower for the Main Basin based on non-degradation and compliance with the secondary Maximum Contaminant Level (MCL). The San Francisco Bay Regional Water Quality Control Board incorporated these plan objectives and policies into the *1984 Basin Plan*.

The 1975 Basin Plan, and subsequent Basin Plans, contained the following statement: "*Wastewater discharges that cause the above surface water limits to be exceeded may be allowed if part of an overall water-wastewater resource operational program developed by those agencies affected and approved by the Regional Board.*" The Regional Board considered the 1982 *Wastewater Management Plan* to fulfill in part the requirement for a "*water-wastewater resource operational program.*" This SMP was developed in part to fulfill this requirement.

In 1989, recognizing the limit to water resources, Zone 7, DSRSD and the City of Livermore formed an ad hoc Tri-Valley Task Force on Water Recycling. The task force had a broad-based membership that included business, development and community leaders. Review of water recycling projects already being conducted elsewhere led to the acknowledgment and acceptance of water recycling as a viable water resource component for the Valley. The task force concluded that a regional water recycling study was needed and recognized the value of a "master water reuse permit."

In early 1991, to implement the recommendations of the Tri-Valley Task Force, the Zone 7 Water Agency initiated a wide-ranging water recycling feasibility study in conjunction with DSRSD and Livermore. The study identified a feasible water-recycling

program for the entire Livermore-Amador Valley that had the potential to meet future water demands as well as enhance groundwater quality.

The comprehensive *Livermore-Amador Valley Water Recycling Study* was completed in May 1992. It is a planning level study that looked at the prior 20 years of effort and looked at how agency or project linkages could be made to facilitate a Valley-wide recycling program. The study noted that two principal changes had occurred to make water recycling in the Valley potentially more attractive than in the past. The first was the acknowledgment that water resources in California were becoming increasingly scarce. Opportunities to implement major water resources development projects were viewed as limited. Even during non-drought periods, water supplies are stressed. During periods of drought, Zone 7 does not receive its contractually committed allocation of water from the State Water Project. Potential shortfalls in water supply early in the next century were identified.

The second reason for increased interest in water recycling was that reverse-osmosis treatment was no longer considered an innovative or experimental treatment process but a "conventional" one. The cost of operating reverse osmosis (RO) treatment facilities also had improved, making it a potentially economically viable option for water supply in the Livermore-Amador Valley. The improved technology and economy of advanced treatment processes provided additional water recycling options for the Livermore-Amador Valley in the 1992 study.

Two advisory groups reviewed the work products during the study and provided suggestions and recommendations at key milestones. The Technical Advisory Group (TAG) consisted of staff members from the County of Alameda, Alameda County Water District, DSRSD, the cities of Livermore and Pleasanton, the Regional Water Quality Control Board and Zone 7. The Policy Advisory Group (PAG) consisted of the TAG and members of the governing boards or councils from sponsoring agencies (DSRSD, City of Livermore, RWQCB and Zone 7).

Study Objective

The primary objective of the study was to "investigate the feasibility of water recycling in the Livermore-Amador Valley while continuing to protect and enhance the water resources in the Main Groundwater Basin." To meet this objective, the *Livermore-Amador Valley Water Recycling Study* consisted of a number of major tasks:

- The water recycling investigations in the Valley that were completed since the 1970's were reviewed and documented in technical appendices.
- The potential role of recycled water in meeting water supply needs was identified. Potential groundwater recharge methods were investigated and identified. Groundwater management and maintenance of groundwater quality were also addressed.

- An assessment of the market for direct non-potable reuse of recycled water was made. Specific water recycling alternatives were developed and evaluated. Key potential projects were identified.
- The permitting requirements and institutional/policy considerations were identified and reviewed. An implementation "plan" was developed.

The study "determined that water recycling--through groundwater recharge and direct (non-potable) reuse--is a viable method of supplementing limited water supplies in the Valley and that it can assist in meeting wastewater disposal needs as well. The steps for project implementation have now been identified." The Executive Summary of study report provides the key findings. Chapter 10 of the study report outlines the implementation "plan."

Project Alternatives

Two main water reuse categories were studied:

- Landscape irrigation through direct reuse
- Groundwater recharge for municipal use, including indirect potable reuse

Eleven separate projects were initially identified. Seven of the project alternatives were evaluated in detail and three were recommended as "key" projects that would be the basis for developing a long-term water recycling program for the Valley. Capital and operation and maintenance costs were estimated to be near $1,000 acre-feet in 1992 dollars. Although cost was considered a major criterion for recommending projects for implementation, the study identified other considerations. These included long-term impacts on groundwater quality, ability to meet current and probable future regulatory requirements, risk to public health, institutional (implementation) issues, public acceptance and environmental impacts. Following a review of cost and non-cost factors, the study concluded that cost remained as the most important selection criterion for the seven identified projects.

Program Implementation

The study included discussions of program implementation, permitting requirements, policy considerations and financing and cost-sharing options. For large-scale projects involving two or more agencies, it was anticipated that institutional arrangements for carrying out the projects would be determined by the agencies themselves. The study recommended an implementation plan that included three non-technical and three technical elements:

Non-Technical Elements:

1) Development of a policy framework for implementation of the Water Recycling Program and specific water recycling projects.
2) Selection of institutional arrangements to define the roles and responsibilities of the Valley agencies that will participate in the Water Recycling Program.
3) Determination of the financing and funding mechanisms to pay for construction and operation of the reclamation projects, and the selection of cost-sharing arrangements to pay for each agency's appropriate share of the cost.

Technical Elements:

4) Acquisition of a permit from the San Francisco Regional Water Quality Control Board to begin implementation of the Water Recycling Program. A "blanket" permit, which will allow a variety of individual projects to be constructed by the Valley agencies, will provide the most flexible approach.
5) Development of a Salt Management Plan which will (1) identify specific water quality goals (for total dissolved solids) for the Main Groundwater Basin, and (2) provide a framework for selection of water recycling projects (and other salt management techniques) to attain these goals. The Salt Management Plan will be required as part of the permitting process.
6) Implementation of an improved groundwater monitoring program to provide the data that will be needed for implementation of water recycling projects in accordance with proposed regulations, Basin Plan and Zone 7 policies, and the (to be developed) Salt Management Plan.

Permitting and Regulatory Considerations

Permitting requirements were determined through discussions with San Francisco Regional Water Quality Control Board staff. The Regional Board staff indicated support for a blanket or master permit, provided a salt management plan was developed to ensure that all projects are undertaken in a manner that ensures the long-term protection and enhancement of the groundwater quality. The master permit would allow phased implementation of all potential uses identified as part of the overall program adopted by the responsible agencies. New projects could be implemented subject to Agency approval instead of requiring new permits or permit amendments as each project in the recycling is brought on-line. The production of demineralized and non-demineralized recycled water would be authorized under one permit for distribution to appropriate agencies and projects. Flexibility would be allowed in determining which discharger supplies which users. Table 6-8 in the study report outlined how water-recycling projects could be accommodated within the Basin Plan and Zone 7 Policies and Guidelines. The study concluded that well-established technologies and procedures exist to comply with the policies and guidelines.

Institutional Arrangements

The study indicated that the water-recycling program would require participation by several entities. It was expected that any large-scale project would require two or more of the Valley water and wastewater agencies. At the time of the study, it was anticipated that institutional arrangements for carrying out recycling projects among the agencies would be determined by the agencies themselves. The following was concluded:

- The three principal agencies, Zone 7, DSRSD and City of Livermore, would seek a Valley-wide "blanket" permit for implementing a Water Recycling Program. Zone 7 was identified as the "lead" agency with principal responsibility for obtaining the permit and enforcing its terms and conditions.
- A memorandum of understanding would be negotiated to develop the permit application.
- The agencies would develop a salt management plan to ensure the water recycling projects are undertaken within a framework that provides for maintenance and enhancement of Valley groundwater resources.
- Each agency would adopt a Resolution of Intent that commits the agency to seek advancement of water recycling programs and projects.
- Following acquisition of the blanket permit, the agencies would develop an agreement to implement the Water Recycling Program. Key elements of the agreement would be cost-sharing arrangements, responsibility for ownership and operation of facilities, and implementation of the Salt Management Plan.
- Each agency would develop policies with respect to its own interests in water recycling projects, e.g. policies that encourage or mandate water reuse and development of pricing structures for recycled water.

Master Water Recycling Permit with Salt Management Plan Requirement

Following completion of the May 1992 *Livermore-Amador Valley Water Recycling Study*, the Valley agencies worked together with RWQCB staff to develop language for the recommended Master Water Recycling Permit. The Regional Water Quality Control Board (RWQCB) issued the permit, Order No. 93-159, to Zone 7, DSRSD and Livermore on December 15, 1993. The permit language captured the findings and recommendations of the 1992 Study. The permit was issued in conformance with California Water Code Section 13523.1 governing Master Reclamation Permits. A Master Permit, issued to the recycled water purveyors, eliminates the requirement that the RWQCB issue individual permits to all users. Users are regulated instead in accordance with rules and regulations developed and enforced by the permittee(s).

The Master Permit specifies requirements to be met prior to implementation of additional recycled water irrigation or groundwater recharge projects in the Valley. The permit was connected to the SMP, which would provide the framework within which local decisions

could thereafter be made determining the qualities, quantities and locations of permitted recycled water use. The SMP was to fully offset the current salt loading, as well as any future salt loading associated with new recycled water use. The SMP requirements, as specified in the Master Permit, include defining basin characteristics, refining salt balance calculations, identifying water quality objectives, developing a SMP monitoring program, evaluating alternative salt management tools and strategies, and developing a SMP implementation plan and schedule.

A key issue identified to successfully implementing a regional water-recycling program was the development and enforcement of a SMP that ensures that water-recycling projects were carried out to protect and enhance the Main Basin groundwater quality. The 1992 water recycling study concluded, and the Regional Water Quality Control Board staff concurred, that Zone 7 would be the most appropriate agency to develop and implement the SMP.

In accordance with the Master Permit, this SMP was developed through a cooperative effort involving Zone 7 staff and consultants; a technical advisory group composed of local potable water retailers; and the Zone 7's citizens committee, the Groundwater Management Advisory Committee (GMAC). In-house data compilation work began in 1994 with the majority of the technical analyses conducted in the 1997 through mid-1999 time frame.

1.4 SMP Chapters Overview

Over the several years that the SMP was being developed, the scope broadened beyond that outlined in the Master Permit. The resultant effort and product could perhaps more accurately be described as approaching the complexity and breadth of a watershed water resource management plan than simply a Main Basin salt management plan. At the request of the potable water retailers, considerable effort was devoted to evaluating impacts of the salt management strategies on delivered water quality. The groundwater model was further refined and the water system operations model (WRMI) developed and calibrated to provide better estimates of impacts on individual wells and delivered water quality at each of Zone 7's turnouts. Greater effort was invested in investigating fringe and Main Basin connectivity given the potential for much larger urban and agricultural development. Efforts were also made to involve ACWD staff in the SMP process even though SMP impacts were believed negligible on ACWD water quality. Great effort was also invested in incorporating the methods, information and policy decisions into Zone 7's water operations practice.

Chapter 2 provides an overview of Zone 7 facilities, demands, and operations, both current and proposed. The water system operations computer model is also described. Chapter 3 provides a condensed summary of Zone 7's current understanding of the hydrogeology of the fringe and Main Basin. The issue of basin connectivity and mixing is addressed in detail along with a description of and output from the groundwater flow and solute transport model. Chapter 4 summarizes the extensive water quality information

collected by Zone 7. Issues of seasonal and spatial variability are addresses. Chapter 5 presents the methodology used by Zone 7 in calculating the water and salt balances. Historic and projected year 2010 salt loadings are discussed. Chapter 6 presents Zone 7's existing monitoring programs and the additions that are intended to be made to even more accurately track salt loading in the future. The surface and groundwater monitoring networks for each drainage basin are described.

Chapter 7 presents the key salt management plan policy issues and options developed through consultation with the TAG and GMAC. Background information is presented on consumer acceptability of different TDS concentrations in delivered water. Chapter 8 describes the range of individual and composite salt management strategies that are evaluated in more detail in the remaining chapters of the SMP. Preliminary Unit Operations and Maintenance (O&M) costs are also presented. Chapter 9 presents the results of the spreadsheet based salt loading calculations under projected year 2010 conditions for the 20 salt management strategies investigated at the screening level. Estimated costs and impacts on delivered water quality are included.

Chapter 10 presents the computer modeling results for four of the most promising strategies identified in the Chapter 9 screening analysis. Projected impacts of potential strategies using demineralized recycled water injection are included. Numerous maps and graphics depicting impacts on groundwater, individual wells, and on retailer turnouts are included. Chapter 11 presents alternatives and recommended approaches for allocating the costs of salt management as a function of the source of the salt: existing M&I, future M&I, untreated, or recycled water. Chapter 12 presents the near-term implementation plan including the most feasible strategies, scaled down to offset current loadings versus the 2010 loadings in prior chapters. The chapter concludes with the specific "2000-2002" implementation plan presented to and approved by the Zone 7 Board in August 1999 and recommended next steps to address future salt loading.

The Report and Study was conducted from an operations standpoint. The goal was to incorporate all recommendations into Zone 7's routine operations. To a large extent this has been accomplished by incorporating the methods, reports and procedures developed in the Salt Management Plan into Zone 7's water resource management.

Chapter 2

Water Supply and Resource Management

2.1 Existing Water Facilities and Demands

Zone 7 serves a population of about 183,000 as the wholesaler of treated potable water to its retail contractors for municipal and industrial (M&I) uses. Zone 7 also supplies untreated water for agricultural, golf course and other uses. The four major retailers, which provide water for M&I use, are the City of Pleasanton, the Dublin San Ramon Services District (DSRSD), the City of Livermore and California Water Service Company (CWS). Zone 7's water supply comes from three sources: 1) Imported surface water from the State Water Project (SWP), 2) local runoff into Lake Del Valle (LDV), and 3) stored groundwater. Zone 7's major existing water facilities are shown in Figure 2.1.

Water Supply, Conveyance and Storage

Imported Surface Water—Zone 7 has a contract with the California Department of Water Resources (DWR) for water deliveries through State Water Project (SWP) facilities. This contract allows Zone 7 to import water from Lake Oroville via the Sacramento-San Joaquin Delta and the South Bay Aqueduct (SBA). The Zone 7 maximum annual entitlement for the year 2004 is 80,619 AF/year. The long-term average yield of SWP water is believed to be about 75% of the contractual entitlement (total SWP demand is 4.1 MAF/year). Zone 7 also has contracted with Byron-Bethany Irrigation District (BBID) and DWR for water transfer of 2,000 AF of BBID water for delivery through SWP facilities.

Zone 7 uses imported surface water by either delivering directly to untreated and (after treatment) treated water customers or after storage in the local groundwater basin through pumping during peak demand periods and during dry years. Untreated water deliveries, typically for agricultural irrigation, are made directly from the SBA turnouts. Treated water is produced at and then delivered from the Zone 7 Patterson Pass Water treatment plant (PPWTP) and Del Valle Water Treatment Plant (DVWTP). Zone 7 recharges water for storage in the local groundwater basin using the valley Arroyos.

Zone 7 has also purchased water storage rights (65 TAF) in the Semitropic Water Storage District groundwater basin located in south-central California near Bakersfield. Zone 7 is allowed by contract to store excess SWP water in the Semitropic groundwater basin in wet years and to then pump additional water from the delta during dry years in exchange for the water pumped from storage in Semitropic for use by downstream SWP contractors.

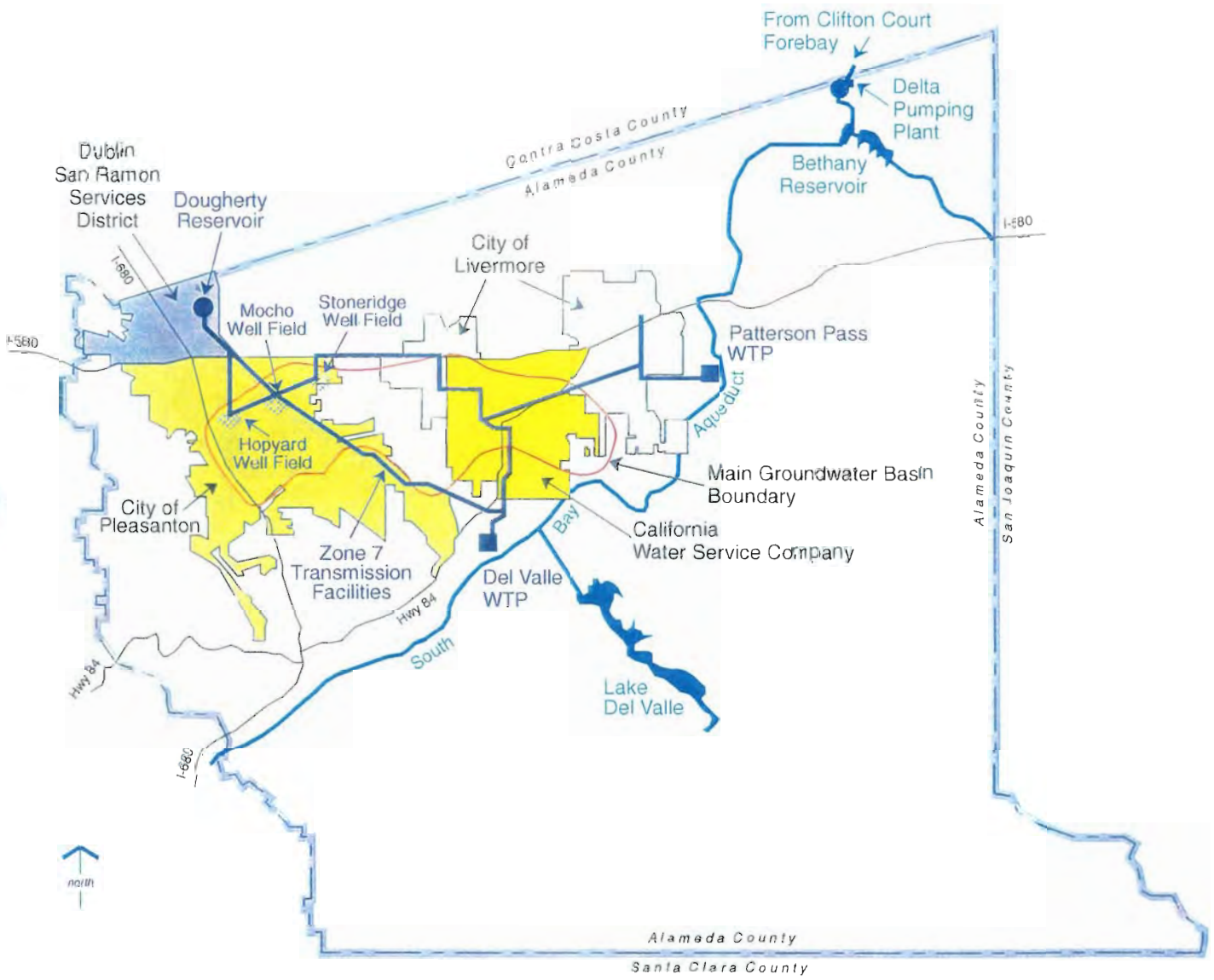


Figure 2.1
Zone 7 Water Facilities and Retail Service Areas

Local Runoff Into Lake Del Valle —Zone 7 shares the water rights with Alameda County Water District (ACWD) for the local runoff into Lake Del Valle. The average local runoff into Lake Del Valle is about 22 TAF/year. Some of this runoff during wet years is lost as flood releases. Zone 7's existing contract with DWR allows Zone 7 to store local water in the lake and use it in the following calendar year. The Zone 7 average yield from Lake Del Valle at current demand levels is about 8,000 AF/year. This is expected to increase to 9300 AF/year as the treated and untreated water demand during the wet season increases.

Zone 7's share of local runoff into Lake Del Valle can be delivered directly for untreated uses, treated at DVWTP and delivered for M&I uses, or stored for future use. Zone 7 can release available local water into the arroyos for groundwater basin recharge to the extent recharge capacity is available during dry conditions.

Local Groundwater Basin—The local groundwater basin has a storage capacity of over 240,000 AF. The annual average natural recharge into the groundwater basin is about 13,000 AF. The natural groundwater recharge sources include rainfall recharge, irrigation water recharge, natural stream recharge and net subsurface groundwater inflow. In addition to the natural recharge, Zone 7 artificially recharges the basin by making untreated water releases from the South Bay Aqueduct into Arroyo Mocho and Arroyo Valle. Zone 7's existing artificial recharge capacity ranges from 12,300 AF/Y in wet years to 20,000 AF/Y in dry years (Table 2.1).

Table 2.1, Artificial Groundwater Basin Recharge Capacity

	DRY YEAR	*AVERAGE YEAR*	*WET YEAR*
Arroyo Mocho	12,000	10,000	7,300
Arroyo Valle	8,000	7,000	5,000
Total Artificial Recharge Capacity	20,000	17,000	12,300

Surface Water Treatment and Groundwater Production Wells

The existing treated water production facilities include the two surface water treatment plants owned and operated by Zone 7 and the groundwater production wells owned and operated separately by Zone 7, the City of Pleasanton and CWS. The Del Valle water treatment has a maximum design capacity of 36 mgd and Patterson Pass has a maximum design capacity of 19.5 mgd. The total surface water treatment design capacity is 55.5 mgd. Actual current capacity is slightly less and varies with Del Valle Reservoir water blend in SBA flow (Table 2.2, 2004).

Zone 7 has seven existing active production wells with a total production capacity of 32 mgd. Pleasanton has three existing active wells with a production capacity of 11 mgd and CWS has 12 existing active wells with a production capacity of 10 mgd (Table 2.3, 2004). Pleasanton, CWS and DSRSD have annual groundwater pumping quotas of 3500, 3069

Table 2.2

ZONE 7 WATER AGENCY
WATER RESOURCES
TREATED WATER PRODUCTION CAPACITIES

2004

SURFACE WATER TREATMENT PLANTS

FACILITY		SUSTAINED CAPACITY FOR PLANNING*					PEAK CAPACITY
		MGD	GPM	CFS	AF/DAY	AF/MONTH	MGD
DEL VALLE	W/ LAKE DEL VALLE BLEND	36	25,000	55.8	110.5	3,370	36
	W/O LAKE DELL VALLE BLEND	25	17,360	38.8	76.8	2,340	26
PATTERSON PASS	TOTAL	18	12,500	27.9	55.3	1,685	19.5
	PPWTP CONVENTIONAL	12	8,330	18.6	36.8	1,123	13.5
	PPWTP UF	6	4,170	9.3	18.4	562	6.0
TOTAL	CURRENT W/ LDV BLEND	54	37,500	83.7	165.8	5,055	55.5
SURFACE	CURRENT W/O LDV BLEND	43	29,860	66.7	132.0	4,025	45.5

GROUNDWATER PRODUCTION WELLS

FACILITY	AVG.CAPACITY GPM	SUSTAINED CAPACITY FOR PLANNING*		3 Month Avg sust. Capacity	Power** consumption		PEAK CAPACITY
		MGD	AF/MONTH	MGD	KWH/AF	KWH/AF/FT	MGD
HOPYARD WELL FIELD	4,980	6.5	610	6.5			7.2
HOPYARD 9	1,240	1.6	152	1.6	619		1.8
HOPYARD 6	3,740	4.9	459	4.9	603	1.7	5.4
MOCHO 1&2 WELL FIELD	4,660	6.1	571				6.8
MOCHO 1	2,370	3.1	290		587		3.4
MOCHO 2	2,290	3	281		587		3.3
MOCHO 3&4 WELL FIELD	7,790	10.2	955	18.5			11.3
MOCHO 3	4,130	5.4	505		652	1.6	6.0
MOCHO 4	3,660	4.8	449		782	1.5	5.3
STONERIDGE	4,660	6.1	571		684	2.0	6.8
TOTAL GROUNDWATER	22,090	29	2,710	25			32.0

TOTAL CAPACITY W/ LAKE DEL VALLE BLEND	83	7,765	79			88
TOTAL CAPACITY W/O LAKE DEL VALLE BLEND	72	6,735	68			78

*10% average GPM capacityis reserved for daily peaking and outages. Sustained capacityused for monthly scheduling.
1 mgd = 1.55 cfs = 3.07 AF/Day = 93 AF/Month = 1120 AF/Year

TABLE 2.3

ZONE 7 WATER AGENCY
WATER RESOURCES
RETAILER'S MUNICIPAL SUPPLY WELLS
December 2003 WELL STATUS

PURVEYOR	WELL	STATE WELL	HP	GPM	MGD	AF/M	AF/Y	LONG TERM STATUS
City of Pleasanton	#5	3S/1E 16L 5	200	2000	2.9	269	3226	ACTIVE
	#6	3S/1E 16L 7	200	2150	3.1	289	3468	ACTIVE
	#7	3S/1E 18A 5	150	1900	2.7			INACTIVE
	#8	3S/1E 16A 2	450	3200	4.6	430	5162	ACTIVE
	TOTAL			9250	13.3	988.0	11856	
OPERATIONAL TOTAL Pleasanton				**7350**	**10.6**	**988.0**	**11856**	

California Water Service	004-01	3S/2E 8H 1	50			0	0	INACTIVE
	005-01	3S/2E 16B 1	25	70	0.1	9	113	ACTIVE
	008-01	3S/2E 8P 1	25	370	0.5	50	597	ACTIVE
	009-01	3S/2E 9Q 1	40	730	1.1	98	1177	ACTIVE-N
	010-01	3S/2E 8F 1	60	725	0.9	97	1169	ACTIVE-N - V
	012-01	3S/2E 9P 1	60	850	1.2	114	1371	ACTIVE
	014-01	3S/2E 8N 2	50	1000	1.4	134	1613	ACTIVE
	015-01	3S/2E 16C 1	60	975	1.4	131	1573	ACTIVE
	017-01	3S/2E 9L 1	50	460	0.7	62	742	ACTIVE-N
	019-01	3S/2E 8G 1	60	620	0.9	83	1000	ACTIVE-N
	020-01	3S/2E 18B 1	60	280	0.4	38	452	ACTIVE
	024-01	3S/2E 7P 3	100	450	0.6	60	726	ACTIVE
	031-01	3S/2E 7R3	125	750	1.1	101	1210	ACTIVE
						877.7	10533	
OPERATIONAL TOTAL CWS				**7280.0**	**10.3**	**506.1**	**6073**	

ACTIVE-N = High nitrate wells that require blending
ACTIVE-V = High VOC -Require blending.

New CWS Well 031-01 on line June 12, 2003.

and 645 AF, respectively. The total combined groundwater pumping capacity for Zone 7 and the retailers is about 53 mgd.

Distribution System

The Zone 7 treated water distribution system conveys treated water from the treatment plants and wells to the retailer turnouts. The Zone 7 distribution system includes treated water storage reservoirs, booster pump stations and distribution pipelines. Zone 7 has a treated water storage capacity of 2 MG at PPWTP, 7.5 MG at DVWTP and 4 MG in the Dougherty reservoir. The treated water storage reservoirs help meet hourly demand fluctuations. The water from the treatment plants flows into the system by gravity. The rate control stations along the transmission pipelines regulate the amount of flow from each plant. Treated water produced at the surface water treatment plants and by Zone 7 production wells is delivered to the retailer turnouts at various locations throughout the Zone 7 system.

The retailers own and operate their own water distribution systems serving their M&I customers. Pleasanton and CWS pump groundwater according to their groundwater pumping quotas (GPQ) directly into their retail distribution systems. The Zone 7 booster pump stations at Airway Blvd and at Silver Oaks Way are used only during extreme conditions to pump water from the wellfields to the higher elevation service areas in the east. Untreated deliveries are made directly from the aqueduct to untreated water turnouts.

Existing Demand

Zone 7's 2004 treated water demand is about 40,600 AF and the retailers groundwater pumping quota (GPQ) is about 7200 AF/year. The total treated water demand in the valley (Zone 7 plus GPQ) is therefore about 47,800 AF/year. Zone 7 water facilities are sized to meet 100% of the maximum day demand. The maximum day demand varies from 170% to 200% of the average day demand. For water facilities planning, the more conservative 200% of average day demand has been used. In year 2004, the Zone 7 treated water demand of 40,600 AF corresponds to a maximum day demand of 73 mgd. This maximum day demand is about 83% of Zone 7's existing production capacity (36 mgd DVWTP + 19.5 mgd PPWTP + 32 mgd wells). Zone 7 2004 untreated water demand is about 6,000 AF/year. Recycled water use in the valley is about 500 AF/year.

2.2 Historic Water Operations Plan

Prior to the most recent seven-year drought (1987-92), Zone 7 water operations planning served primarily to satisfy DWR contract requirements. From the lessons learned during the drought, Zone 7 instituted more comprehensive water operations planning efforts to help improve water supply reliability during dry years. The goals and major components of the subsequent water operations planning program developed and implemented during

the 1993-99 period (historic water operations plan) for managing Zone 7 water resources are described below.

Water Operations Planning Goals

The historic water operations planning effort was guided by the following major goals:

- Provide water delivery schedule information to DWR (contract requirements).
- Meet 100% of treated and untreated water demands for the current year.
- Maintain enough storage to meet 100% of demand through a typical historic six-year drought.
- Maximize delivery of surface water by minimizing groundwater pumpage.
- Minimize operational cost.

The historic water operations planning program consists of the following three major components:

1) Five-Year Demand Projections and DWR Delivery Schedule
2) Annual Water Supply and Storage Probability Analysis
3) Monthly Water Operations Plan (MWOP)

Five-Year Demand Projections and DWR Delivery Schedule

Each year Zone 7's treated and untreated water contractors submit their water demand estimates for the upcoming five years based upon projected land use developments. These demand estimates are analyzed for reasonableness and other contract requirements such as maximum day demand and for conformity to a DWR total contract amount maximum monthly limit of 11%. This five-year demand data is then used for water supply operations planning.

DWR requires all SWP contractors to submit a preliminary five-year delivery schedule by October 1 of each year that assumes 100% SWP entitlement delivery. DWR also requires that all contractors submit a one-year delivery schedule assuming 50% and 30% SWP entitlement delivery for the first of the five years. DWR uses this information to plan their water operations.

Based upon the amount of Zone 7 local water storage in LDV, local groundwater storage, Zone 7 storage in the Semitropic Water Storage District groundwater basin, and projected demands, a monthly five-year delivery schedule for each demand category is prepared assuming 100% SWP entitlement delivery. The first priority is to schedule surface water to meet 100% of the untreated (agricultural) water demands. The remaining Zone 7 SBA capacity is used to schedule surface water for the treatment plants up to plant capacities and demand limits.

If there is still SBA capacity available, then that capacity is used to schedule water for groundwater recharge through Arroyo Mocho and Arroyo Valle. Any remaining surface water supplies are scheduled for delivery to increase Zone 7's Semitropic water storage. The maximum amount of surface water is delivered directly to meet demands and groundwater is pumped only for daily peaking. This strategy minimizes cost and maximizes the delivery of low TDS surface water to customers.

For the 50% and 30% SWP entitlement delivery schedules for the first year, water operations planning becomes more complicated. For these two cases a detailed monthly water operations plan (discussed later in this section) is prepared. The surface water is first used to meet untreated demand and the remaining surface water is scheduled for the treatment plants. Groundwater is pumped as needed to supplement the surface water supply to meet 100% of the demand. Based upon groundwater pumping capacity, local groundwater basin storage and Zone 7 Semitropic storage, required Semitropic pump back is calculated. Typically a 30% SWP entitlement case would require some Semitropic pump back to meet 100% of demands.

In December of each year, DWR announces the approved deliveries as a percentage of entitlement based upon water year-to-date actual runoff and projected runoff and assuming that 90% probability of exceedence conditions (dry conditions) will occur during rest of the water year. With this announcement, DWR requests all contractors to submit a revised one-year delivery schedule. Zone 7 prepares a monthly operations plan based upon this announcement and submits the revised one-year delivery schedule.

Annual Water Supply and Storage Probability Analysis

In addition to the five-year DWR delivery schedule, the DWR process calls for the preparation of a Water Supply Forecast (which provides a range of contingent operational strategies on an annual basis) and for preparation of a detailed Monthly Water Operations Plan.

The Water Supply Forecast is prepared in December of each year for the following calendar year. The Water Supply Forecast shows how Zone 7 would operate to make full deliveries under a wide range of hydrologic conditions ranging from critically dry to extremely wet. The Water Supply Forecast is designed around the following elements and goals:

- Evaluate the beginning of year water storage in the local groundwater basin, local LDV storage and Zone 7 storage in Semitropic.
- Estimate available water supplies from various sources (i.e., natural groundwater recharge, local LDV water, SWP water, etc.) under various hydrologic conditions.
- Plan to meet 100% of demand under all conditions.
- Prioritize water utilization to conserve or increase storage to prepare Zone 7 to meet 100% of demand in a typical seven-year drought assuming the next year as the first year of a six-year drought.

- Prioritize the use of sources to minimize operational cost to meet 100% demand, while maintaining or increasing storage to prepare for a six-year drought.

As an example, Table 2.4 presents an annual summary of the Water Supply Forecast for 2004 under seven probability of exceedence conditions ranging from critically dry (99% exceedence, i.e., 99% probability that a subsequent year would be wetter) to extremely wet (1% exceedence). The Water Supply Forecast is divided into five sections: 1) Beginning of year storage; 2) New supply; 3) Demand; 4) Artificial recharge; and 5) End of year storage.

Figure 2.2 presents the variations in the key water supply forecast components under different hydrologic conditions (dry to wet). The first graph presents the forecasted variation in SWP entitlement water deliveries (the Zone 7 2004 maximum annual SWP entitlement is 80,619 AF). In a critically dry year, the SWP project deliveries could be as low as 10% of entitlements while in normal or wet years the SWP deliveries could be 100% of entitlement. Similarly, the second graph presents the potential variations in the local Lake Del Valle water supply.

The third graph presents the variations in required groundwater pumpage to meet 100% demand. Under dry conditions when the surface water supplies are not enough to meet 100% of demand, more groundwater pumpage is required. Under wet conditions, the groundwater pumpage has historically been required only for daily or seasonal peaking.

The fourth graph presents potential variations in available artificial groundwater recharge capacity and planned artificial recharge. Under dry conditions, the available artificial recharge capacity would be at its maximum but planned artificial recharge would be at its minimum due to the lack of water supplies with which to recharge. Under wet conditions, the planned artificial recharge is increased up to the available artificial recharge capacity and storage space limits. The "Water Supply Forecast for 2004, January 1, 2004" memorandum describes the Water Supply Forecast in more detail (Reference I).

Monthly Water Operations Plan (MWOP)

The Water Supply Forecast addresses water management decisions on an annual basis. The Monthly Water Operations Plan addresses water management decisions on a monthly basis. The Monthly Water Operations Plan includes a series of tables that indicate how Zone 7 proposes to operate its water system and meet water needs for the year on a monthly basis. Each year in July, Zone 7 prepares preliminary versions of the Monthly Water Operations Plans for the following three years. This July version of the Monthly Water Operations Plan is used to determine O&M costs for budgeting purposes.

In September of each year, these three-year Monthly Water Operations Plans are updated to reflect the latest demand requests from Zone 7 contractors and are used for preparing the DWR water delivery schedules. In January of each year, the Monthly Water Operations Plan for the current year is updated with more accurate DWR water supply projections for most probable conditions. As the year unfolds from January through April,

ZONE 7
WATER RESOURCES

WATER SUPPLY FORECAST
2004 CALENDAR YEAR

January 1, 2004
ACRE FEET

		PROBABILITY OF EXCEEDENCE						
		99%	90%	75%	50%	25%	10%	1%
	Hydrologic Year Type	CRITICALLY DRY	DRY	BELOW NORMAL	ABOVE NORMAL	WET	EXTREMELY WET	
BEGINNING OF YEAR STORAGE								
1) STATE WATER PROJECT CARRYOVER		35,000	30,000	11,400	6,200	2,000	0	0
2) ZONE 7 LAKE DEL VALLE		0	0	0	0	0	0	0
3) GROUNDWATER		203,000	203,000	203,000	203,000	203,000	203,000	203,000
4) SEMITROPIC		68,000	68,000	68,000	68,000	68,000	68,000	68,000
SUPPLY								
1) STATE WATER PROJECT								
PERCENT OF ANNUAL ENTITLEMENT		35%	40%	60%	80%	90%	95%	100%
AMOUNT	*	28,220	32,250	48,370	64,500	72,560	76,590	80,620
TURN BACK WATER		500	0	0	0	0	0	0
ARTICLE 21 WATER		0	0	0	0	0	0	0
2) ZONE 7 LAKE DEL VALLE		0	0	0	0	0	0	0
DIRECT USE OF INFLOW	*	0	230	3,740	6,450	10,340	11,980	14,140
PRIOR RIGHTS RELEASES		0	770	1,060	1,380	1,570	1,650	2,040
STORED INFLOW	*	0	0	0	630	2,680	2,740	5,640
STORED WATER USED FOR DELIVERIES		0	0	0	0	0	0	0
EVAPORATION		0	0	0	(80)	(220)	(230)	(430)
3) BBID		2,000	2,000	2,000	1,000	1,000	1,000	1,000
4) GROUNDWATER NATURAL RECHARGE		4,770	5,180	6,200	8,790	14,210	19,160	27,360
5) RECYCLED WATER (NON - DEMINERALIZED)		500	500	500	500	500	500	500
TOTAL SUPPLY		35,990	40,930	61,870	83,170	102,640	113,390	130,870
DEMAND								
1) ZONE 7 UNTREATED WATER DEMAND								
UNTREATED, SURFACE WATER		5,980	5,980	5,980	5,980	5,980	5,980	5,980
2) ZONE 7 TREATED WATER DEMAND								
TREATED, SURFACE WATER		35,160	35,160	35,160	35,160	35,160	35,160	35,160
SEMITROPIC RETURN (component of SW)	*	0	0	0	0	0	0	0
ZONE 7 GROUNDWATER PUMPING	*	8,800	8,800	8,800	8,800	8,800	8,800	8,800
TOTAL TREATED		43,960	43,960	43,960	43,960	43,960	43,960	43,960
ZONE 7 TOTAL DEMAND		49,940	49,940	49,940	49,940	49,940	49,940	49,940
3) PURVEYOR GROUNDWATER PUMPING								
CWS		3,070	3,070	3,070	3,070	3,070	3,070	3,070
PLEASANTON		3,500	3,500	3,500	3,500	3,500	3,500	3,500
4) MINING USE		3,470	3,210	2,960	2,690	2,500	2,300	2,210
5) OTHER M&I AND DOMESTIC GROUNDWATER		1,110	1,060	1,010	980	950	900	860
6) AGRICULTURE GROUNDWATER		1,210	1,200	1,190	1,180	1,170	1,160	1,150
7) RECYCLED WATER DEMAND		500	500	500	500	500	500	500
TOTAL DEMAND		62,800	62,480	62,170	61,860	61,630	61,370	61,230
ARTIFICIAL RECHARGE (Stream + COL)								
MAIN BASIN								
1) TOTAL ARTIFICIAL RECHARGE CAPACITY (including COL)	*	29,520	28,640	27,820	25,990	23,690	22,670	21,810
2) ZONE 7 SUPPLEMENTAL ARTIFICIAL RECHARGE	*	13,840	12,600	13,630	24,610	22,120	21,020	19,770
3) PRIOR RIGHTS RECHARGE		0	770	1,060	1,380	1,570	1,650	2,040
4) UNUSED ARTIFICIAL RECHARGE CAPACITY		15,680	15,270	13,130	0	0	0	0
SEMITROPIC								
1) ZONE 7 STORAGE TRANSFER CAPACITY TO SEMITROPIC		50,000	30,000	25,000	9,600	9,600	6,000	6,000
2) ZONE 7 ACTUAL STORAGE TRANSFER TO SEMITROPIC		5,740	5,740	5,740	5,740	5,740	5,740	5,740
END OF YEAR STORAGE								
1) SWP CARRYOVER		5,000	5,000	5,000	6,650	10,000	10,000	10,000
2) ZONE 7 LAKE DEL VALLE								
STORED WATER USED FOR DELIVERIES		0	0	0	0	0	0	0
STORAGE CHANGE		0	0	0	550	2,460	2,510	5,210
END OF YEAR STORAGE		0	0	0	550	2,460	2,510	5,210
3) MAIN GROUNDWATER BASIN								
STORAGE CHANGE		(2,550)	(2,290)	360	14,560	17,900	22,100	29,580
END OF YEAR GROUNDWATER STORAGE		200,450	200,710	203,360	217,560	220,900	225,100	232,580
4) SEMITROPIC								
STORAGE TRANSFER LOSSES (10%)		574	574	574	574	574	574	574
STORAGE CHANGE		5,166	5,166	5,166	5,166	5,166	5,166	5,166
END OF YEAR SEMITROPIC STORAGE		73,166	73,166	73,166	73,166	73,166	73,166	73,166
SAN BENITO COUNTY POTENTIAL OBLIGATION		3,000	3,000	3,000	3,000	3,000	3,000	3,000
UNUSED SWP ENTITLEMENT		0	0	0	0	6,900	11,670	19,110

* DATA PLOTTED IN FIGURE 1

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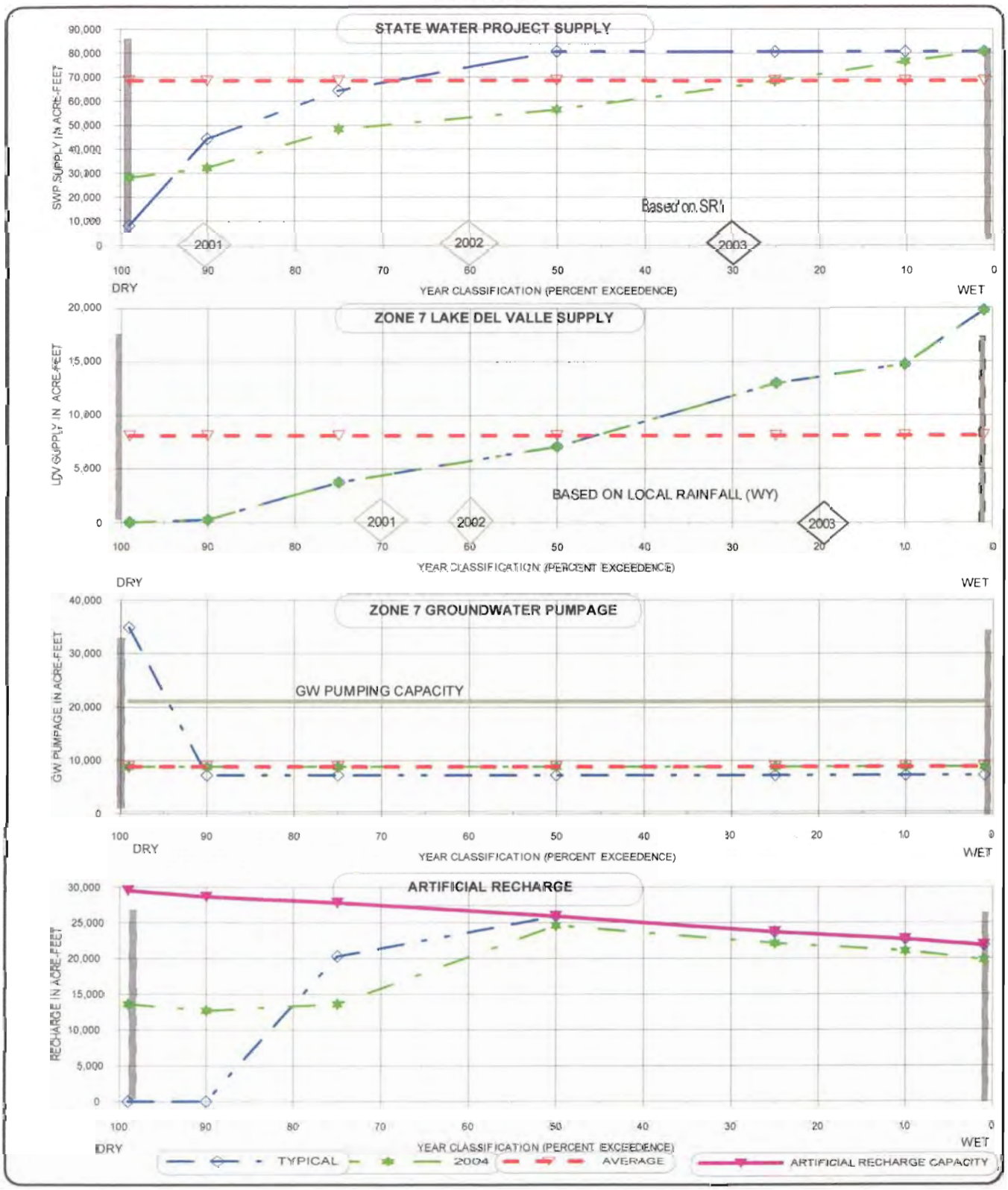
ZONE 7
WATER RESOURCES

FIGURE 2.2

2004 WATER SUPPLY FORECAST

January 1, 2004



the amount of uncertainty in supply is reduced. In April of each year, after DWR has announced the firm rest-of-year deliveries, Zone 7 develops a Monthly Water Operations Working Plan. This monthly plan is then updated monthly for the rest of the year with actual year-to-date data and as such reflects adjustments made to meet water operational objectives.

An example of the Monthly Water Operations Plan is shown in Table 2.5. The Monthly Water Operations Plan is organized into seven categories. The first category in Table 2.5 is Treated Water Production. This shows what Zone 7's treatment plants and wellfields would need to produce each month to meet full deliveries. The second category displays surface water deliveries from SBA supplies to meet untreated water demands and deliveries for artificial stream recharge. The untreated water deliveries include Zone 7's agricultural customers and municipal demands for untreated water. The deliveries for artificial stream recharge include releases into Arroyo Mocho and Arroyo Valle for groundwater recharge.

The third category includes the possible use of the aquifer storage and recovery (ASR) wells. ASR recharge is the amount of treated water scheduled to be injected into the groundwater basin for storage. ASR storage is the total ASR storage available at the end of the month for operations use. The fourth category shows municipal pumping by retailers including scheduled pumpage and average historic pumpage for Pleasanton and CWS. Dublin San Ramon Service District's pumping quota is shown, but is accounted for in CWS' scheduled pumpage (since CWS purchased DSRSD's quota for 1999). The fifth category lists the South Bay Aqueduct deliveries scheduled by Zone 7, ACWD and SCVWD. The sixth category shows the estimated average TDS in mg/L of the composite Zone 7 production. The seventh category shows the monthly and annual total estimated costs for power and chemical usage for Zone 7's surface water treatment plants and wells.

2.3 Proposed Water Operations Plans

The historic water operations planning strategy prepared Zone 7 to make full deliveries each year and to accumulate enough water in storage reserves (local groundwater basin and Semitropic storage) to make full deliveries under typical six-year drought conditions (1987-92). This strategy minimized O&M costs by delivering the maximum amount of surface water and pumping groundwater as needed to supplement surface water supplies during peak demand and drought periods. This strategy provided sustainable water supply at minimum O&M cost but did not address groundwater basin water quality (TDS) impacts due to net salt loading on the basin.

Chapters 8 through 10 describe various alternative water operation strategies that would serve to sustain or improve groundwater basin water quality. To implement such strategies for sustainable water supply along with sustainable water quality, the historic Water Operations Plan goals would need to be revised. The details on how these goals would need to be revised to allow Zone 7 to address sustainable water quality along with water supply are discussed in Chapter 12.

Table 2.5

ZONE 7
WATER RESOURCES
2004 WATER OPERATIONS PLAN (65% SWP Allocation)
IN ACRE-FEET

		Actual			FORECAST									
1	***TREATED WATER PRODUCTION***	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
	DEL VALLE TREATMENT PLANT	0	0	1278	1491	2221	2181	2630	2573	2106	1656	1166	952	18254
	PATTERSON PASS TREATMENT PLANT (Total)	845	761	541	1492	1700	1700	1700	1700	1700	1657	1167	952	15915
	CONVENTIONAL	*830*	*544*	*254*	*932*	*1140*	*1140*	*1140*	*1140*	*1140*	*1097*	*607*	*392*	*10356*
	ULTRAFILTRATION	*15*	*217*	*287*	*560*	*560*	*560*	*560*	*560*	*560*	*560*	*560*	*560*	*5559*
	TOTAL TREATED SURFACE WATER	845	761	1819	2983	3921	3881	4330	4273	3806	3313	2333	1904	34169
	MOCHO 1 (capacity 290AF/MO)	104	89	0	0	0	27	50	50	25	25	0	0	370
	MOCHO 2 (Capacity 280 AF/MO)	136	159	152	0	0	27	50	50	25	25	0	0	624
	MOCHO 3 (Capacity 500 AF/MO)	45	138	170	0	25	170	150	200	110	144	0	0	1152
	MOCHO 4 (Capacity 450 AF/MO)	0	3	317	54	54	180	250	250	110	140	0	0	1358
	STONERIDGE WELLFIELD	453	275	50	50	50	300	550	500	450	275	150	150	3253
	HOPYARD WELLFIELD	300	217	212	0	50	250	270	250	250	0	0	0	1799
	HOP 6	300	217	211	0	50	200	220	200	200	0	0	0	1598
	HOP 9	0	0	1	0	0	50	50	50	50	0	0	0	201
	SHALLOW WELLFIELD (380 AF/M cap)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Future Wells (Deep) (120 AF/M CAP)	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL TREATED GROUNDWATER	1038	881	901	104	179	954	1320	1300	970	609	150	150	8556
	TOTAL TREATED WATER PRODUCTION	1883	1642	2720	3087	4100	4835	5650	5573	4776	3922	2483	2054	42725
2	**UNTREATED WATER DELIVERY FROM SBA**	4	35	83	434	819	968	1064	974	560	491	231	32	5695
3	**ARTIFICIAL RECHARGE OPERATIONS**													
	ARTIFICIAL STREAM RECHARGE RELEASES- Arroyo Valle -Sycamore Park	145	226	245	600	619	600	619	619	600	619	600	491	5983
	ARTIFICIAL STREAM RECHARGE RELEASES- Arroyo Valle -Vineyard Trib	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL ARROYO VALLE RELEASE	145	226	245	600	619	600	619	619	600	619	600	491	5983
	DIVERSION INTO SHADOWCLIFS	0	0	0	180	185	180	185	185	180	185	180	185	1645
	ARTIFICIAL STREAM RECHARGE RELEASES - Arroyo Mocho	724	657	860	930	1120	1200	930	930	1200	1240	800	720	11311
	DIVERSIONS INTO LAKE-I FOR ARTIFICIAL RECHARGE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL ARROYO MOCHO RELEASE	724	657	860	930	1120	1200	930	930	1200	1240	800	720	11311
	TOTAL ARTIFICIAL RECHARGE	869	883	1105	1530	1739	1800	1549	1549	1800	1859	1400	1211	17294
4	***MUNICIPAL PUMPING BY RETAILERS***													
	PLEASANTON PUMPING	76	89	167	224	364	475	524	486	396	277	193	161	3432
	PLEASANTON AVERAGE PUMPAGE IQ (Independent Quota) = 3500 AF/YR	137	119	144	224	364	475	524	486	396	277	193	161	3500
	CWS PUMPING	2	133	223	221	345	394	440	404	335	230	156	138	3021
	CWS AVERAGE PUMPAGE GPQ = 3069 AF/YR	123	128	155	221	345	394	440	404	335	230	156	138	3069
	DSRSD PUMPING GPQ = 645 AF/YR (Pumped by Zone 7 from Mocho)	54	54	54	54	54	54	54	54	54	53	53	53	645
5	***SOUTH BAY AQUEDUCT DELIVERIES***													
	ZONE 7 46TAF ENTITLEMENT (11%of40TAF+18% of 6TAF = 5480 AF/mo)	1718	1679	3007	4947	6479	6649	6943	6796	6166	5663	3964	3147	57158
	ACWD SBA DEMAND (11% = 4620 AF/mo)	1388	1379	1698	1643	3324	3811	3942	3938	3811	3719	1649	3704	34006
	SCVWD SBA DEMAND (11% = 11000 AF/mo)	3081	2677	6000	7000	8800	9100	9200	9800	8400	6300	6000	6000	82358
	TOTAL SBA DEMAND, AF	6187	5735	10705	13590	18603	19560	20085	20534	18377	15682	11613	12851	173522
	TOTAL SBA DEMAND, CFS	100	103	174	228	302	328	326	333	308	254	195	208	2857
	ACWD & SCVWD TOTAL, CFS	72	73	125	145	197	216	213	223	205	162	128	157	1916
6	***ZONE 7 DELIVERED TDS TO RETAILERS***	382	367	323	281	249	273	287	304	319	301	305	333	301
7	***TOTAL ESTIMATED ZONE 7 POWER AND CHEMICAL USAGE COST***	$30,954	$26,674	$64,295	$97,986	$130,632	$132,151	$149,961	$147,512	$130,298	$110,445	$77,069	$62,904	$1,160,881

2.4 Proposed Treated Water Facilities and Demands

The total 2004 treated water demand in the valley is about 47,800 (40.6 TAF Zone 7 and 7.2 TAF GPQ). This total demand is expected to increase to about 66,000 AF (59 TAF Zone 7 and 7.2 TAF GPQ) by the year 2020. The valley-wide maximum day demand is projected to increase to 118 mgd (105 mgd for Zone 7). To meet this projected treated water demand, Zone 7 is in the process of acquiring additional surface water supplies that would be delivered through the SWP/SBA system. Zone 7 is in the process of SBA expansion to to increase the conveyance capacity for the transmission of these additional supplies to the valley.

Zone 7 would also need to upgrade and expand its existing treatment and distribution facilities to meet projected treated water demands and future water quality regulatory requirements. In February 2000, Zone 7, with assistance from consultants Camp Dresser & McKee prepared a "Treated Water Facilities Master Plan." This master plan categorized the proposed facilities into three phases. Table 2.6 (ref. Table E-6, Treated Water Facilities Master Plan) lists the recommended treated water facilities for near-term (1999-2005), mid-term (2006-2010), and long-term (2011-2020). Figure 2.3 shows the recommended near-term treated water facilities and Figure 2.4 shows the recommended mid-term and long-term treated water facilities (ref. Figure E-5 and E-6 of Treated Water Facilities Master Plan).

The sizing of the surface water treatment plants in the Master Plan is based upon the assumption that 15% of the typical maximum day demand would be provided by groundwater production. The projected year 2020 groundwater production required to supplement surface water production on a typical maximum day would be 16 MGD. The Treated Water Facilities Master Plan also includes the construction of groundwater demineralization facilities. Zone 7 is also in the process of preparing a Well Master Plan (WMP) to construct new wells to meet Zone 7's goal of achieving a valley-wide groundwater production capacity equal to 75% of the maximum day demand for reliability purposes.

In year 2020, 75% of the valley-wide maximum day demand is projected to be 89 mgd. One of the WMP goals is to identify the locations for future wellfields and an implementation plan to increase the valley-wide production capacity to achieve 75% reliability goal. Figure 2.5 shows the potential wellfield locations to be studied under the WMP. The projected 88 MGD of groundwater production capacity would provide increased reliability and operational flexibility particularly if Zone 7 chose to increase the use of groundwater over the historic 85% SW to 15% GW ratio.

2.5 Proposed Untreated Water Facilities and Demands

The projected untreated water demand, consisting primarily of agricultural water demands, is expected to increase from 6,000 AF/year (year 2004) to approximately 26,800 AF/year by year 2020. The existing and projected future untreated water demand areas are shown in Figure 2.6 (Water Supply Planning Study Update, February 1999). The

TABLE 2.6

Recommended Near-Term Treated Water Facilities

Near-term Recommendations (1999 – 2005) [1]	*Year*	*Capital Cost ($1M)*
Use Existing Zone 7 wells to meet near-term water treatment plant capacity shortfalls	Immediate	-
Complete evaluation of AWTP sites to select a site, perform environmental evaluations, and purchase site	2000	-
Construct North Livermore Pipeline	2000-2001	2
Expand DVWTP to 40 mgd [2]	2001	15
Construct regulatory driven improvements at DVWTP	By 2005	14
Continue evaluation of use of Del Valle Reservoir storage (DWR negotiations) and feasibility of ASR operations	2000-2005	-
Continue groundwater monitoring and evaluation of feasibility of ASR operation	2000-2005	-
Construct East Dublin Pipeline Reaches I and II to Dougherty (Highway 580 Crossing)	2005	3
Construct regulatory driven improvements at PPWTP	By 2005	8
Add 6 to 8 mgd Membrane Capacity at PPWTP	2001-2002	14
Construct 3 mgd RO Demineralization Project [3]	2001	10
Construct new 24 mgd groundwater wells	2004-2006	14
Construct 24 mgd AWTP	2004-2006	50
Construct Treated Water Pipelines for AWTP (42 mgd ultimate capacity)	2004-2006	39
Subtotal		$169
Mid-term Recommendations (2006 – 2010) [1]		
Construct Livermore Dublin Connector – Required only if WTPs expanded and Mocho well field not used for maximum day peaking [4]	2006-2010	8
Subtotal		$8
Long-term Recommendation (2011 – 2020)		
Construct B4-A Pipeline as required [5]	2011	$21-26
Based on decisions on use of FCS and feasibility of using additional groundwater wells:	2011	
1. Expand DVWTP to 48 and AWTP to 34 mgd, or		31
2. Expand AWTP to 42, or		31
3. Increase ASR maximum day groundwater production to 42 mgd		11
Subtotal		$32-57
TOTAL		$209-234

[1] Recommendations based on maintaining 85 percent of maximum day production from water treatment plants.
[2] Does not include pump station improvements.
[3] Does not include transmission and concentrate disposal pipeline or pump station costs.
[4] If the new Mocho well field is not used for peaking, this parallel piping to serve East Dublin is required.
[5] Based on Water Transfer Associates cost estimate.

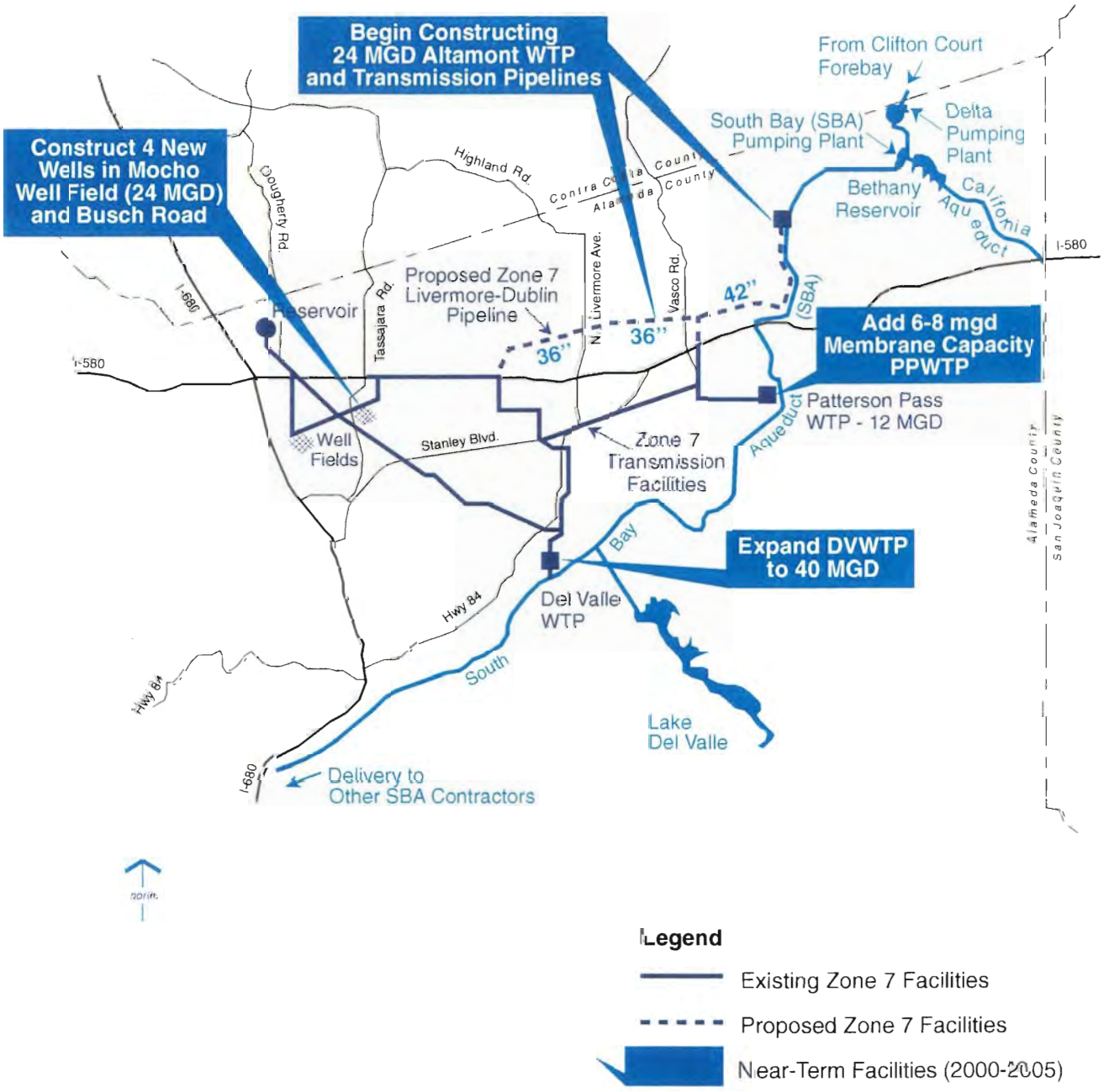


FIGURE 2.3
Recommended Near-Term Facilities

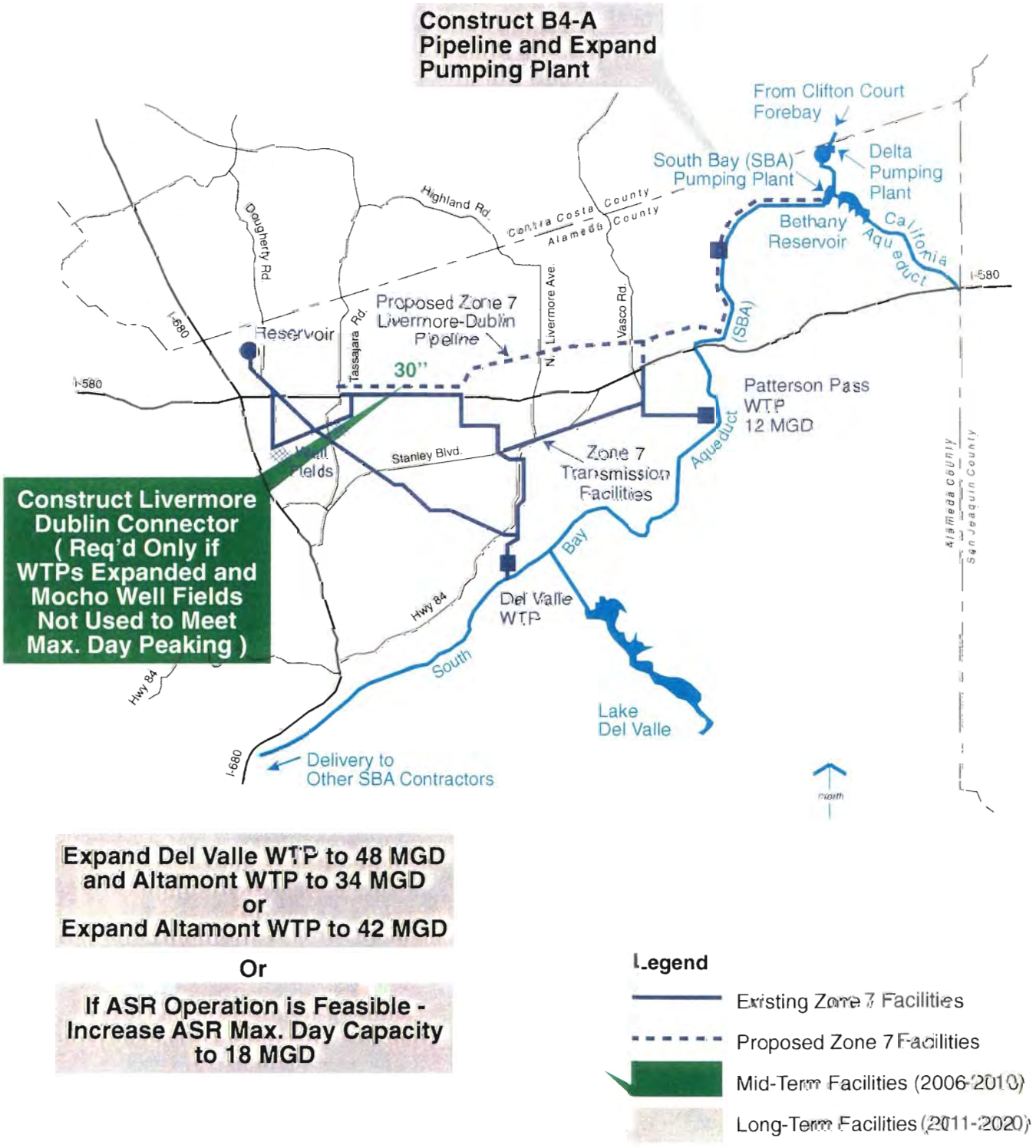


FIGURE 2.4
Recommended Mid-Term and Long-Term Facilities

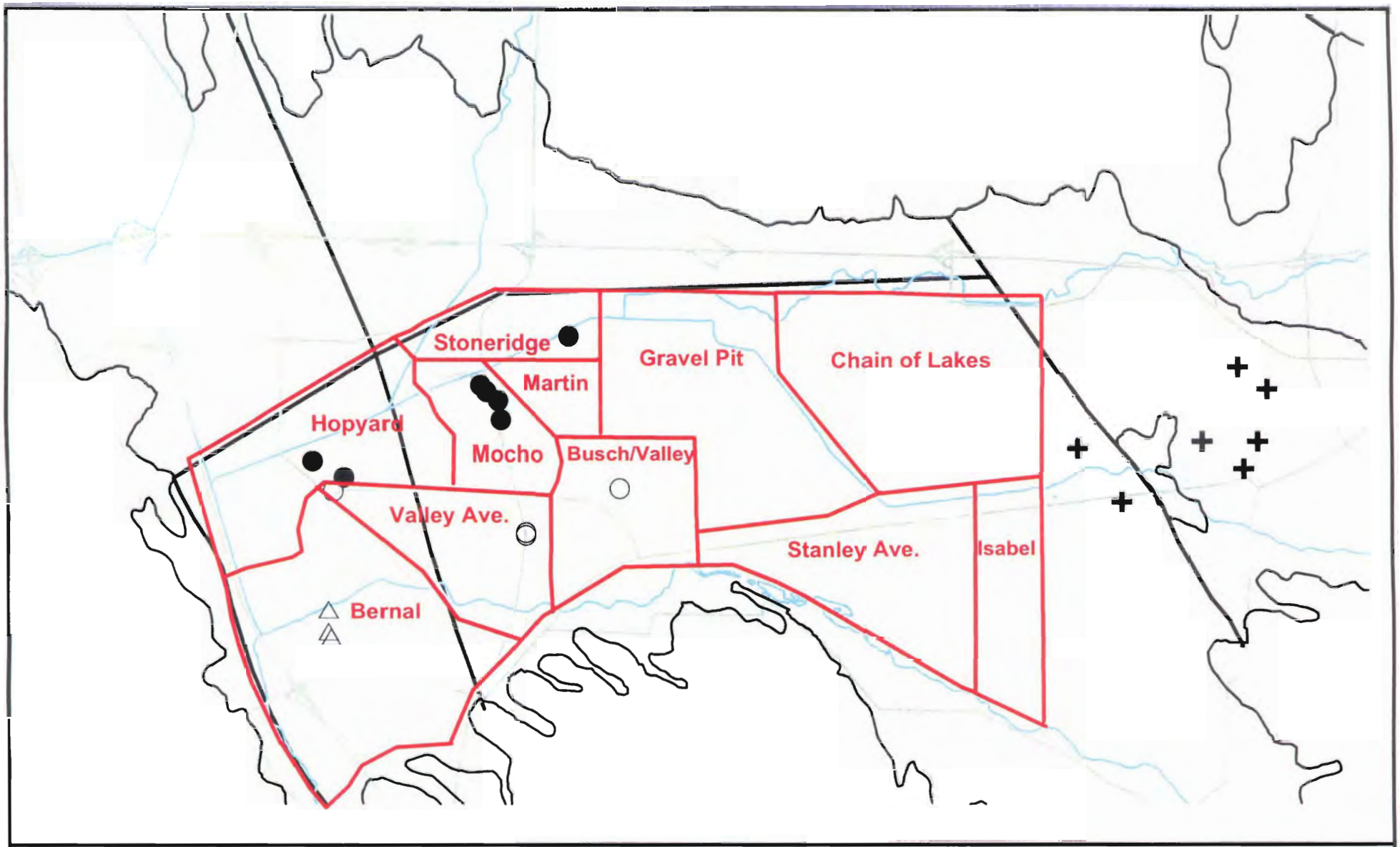


FIGURE 2.5
POTENTIAL NEW WELLFIELD LOCATION
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

projected future untreated demand areas can be generally divided into two major areas: South Livermore and North Livermore.

The South Livermore Valley Specific Plan (May 1997) defines 2000 acres of agricultural area to be developed by year 2020. In addition to the area included in the South Livermore Valley Specific Plan, field and map reviews of the South Livermore Valley indicate that 5,000 acres of additional land is suitable for development as vineyards and orchards (J. Koltz memorandum dated December 5, 1997 and modified on July 27, 1998). Based on a water application rate of 2 AF/acre, new water use in the South Livermore area could increase to approximately 16,000 AF/year by the year 2020.

The North Livermore Project which is currently under a comprehensive re-evaluation identifies two sub-areas with potential untreated water demands, Zone A and Zone B. Zone A is the urban area extending south from a buffer zone below May School Road to I-580. Untreated water demand areas within Zone A include approximately 490 acres of parks, schools, creek and drainage corridors, primary road medians, and a greenbelt that separates Zone A from Zone B. The estimated ultimate untreated demand for Zone A is approximately 1,590 AF/year.

Zone B is considered to be the 700 acres of land set aside as potential irrigable land, north of May School Road. The proposed breakdown for Zone B is 200 acres of golf course, 300 acres of grape production, and 200 acres of other crops. The estimated untreated water demand for this area is approximately 1,800 AF/year at buildout (year 2020). These untreated water demand areas in Zone A and Zone B are still in the planning stages and as such projected potential demands could change.

The above South Livermore and North Livermore areas have a combined projected untreated water demand of 26,800 AF/year by the year 2020. Compared to the treated water demand projections, the untreated demand projections are likely to be more variable due to issues related to the affordability of water for agricultural purposes. If the agricultural development in the South Livermore area and the North Livermore area does not occur as projected, then the untreated demand from other areas is projected to increase only to 10,300 AF/year by year 2020. The salt management studies developed in Chapter 9 assume an untreated demand of 8,500 AF/year by year 2010. The salt loading impacts of the additional untreated demand from the South Livermore and the North Livermore areas would be evaluated on a project-by-project basis as they occur (see Chapters 11 and 12).

Zone 7 is in the process of conducting various studies (such as Integrated Water Supply Plan) to determine the best possible water supply sources and conveyance facilities to meet potential untreated water demands. In February 1999, Zone 7 completed the Water Supply Planning Study Update (Water Transfer Associates). The study concluded that Zone 7 needs about 95 mgd of additional conveyance capacity. Existing capacity as of 1999 is 11% of 40,000 AF plus 18% of 6,000AF = 5,480 AF/mo or 58.5 mgd. Several potential options were identified to provide Zone 7 with additional conveyance capacity:

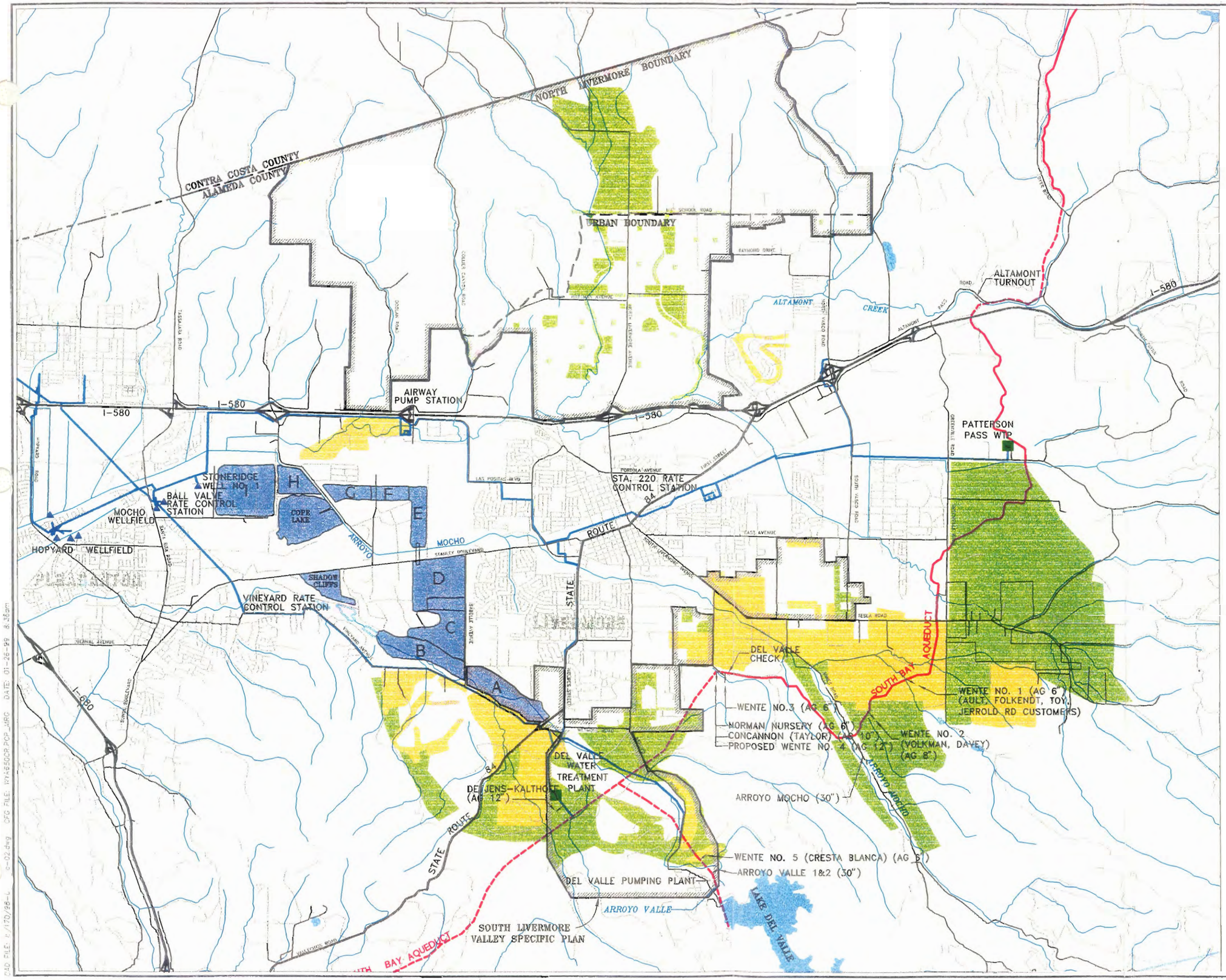


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FIGURE 2.6

Zone 7 Water Supply
Planning Study
February 1999

EXISTING AND FUTURE UNTREATED WATER DEMAND AREAS

N

0 3000 6000
SCALE IN FEET

NOTES:

1. MAPPING BASED ON USGS DIGITAL LINE GRAPHS, 1:100,000 SCALE AND MAPS PROVIDED BY ZONE 7. PIPING SCHEMATICS ARE APPROXIMATE.

LEGEND:

- SBA AQUEDUCT, CANAL
- SBA AQUEDUCT, PIPELINE
- ZONE 7 TRANSMISSION SYSTEM
- WENTE No. 2 — UNTREATED WATER CONTRACTOR AND TURNOUT LOCATIONS
- ZONE 7 WELL
- ZONE 7 WATER TREATMENT PLANT
- H — CHAIN-OF-LAKES
- EXISTING UNTREATED WATER DEMAND AREAS
- POTENTIAL FUTURE UNTREATED WATER DEMAND AREAS

Water Transfer Associates

- Acquisition of the Future Contractor's share of SBA. Zone 7 completed the acquisition in 1999 but the Water Supply Program EIR limits Zone 7 use of this new capacity for peaking to avoid impacts to Del Valle Reservoir levels during summer. As of 2004, Zone 7 peaking capacity is 68mgd (5,480 AF+770 AF).
- Physical expansion of the SBA
- New Zone 7 facilities parallel to the SBA and/or SWP facilities
- Use of the Chain-of-Lakes and an Untreated In-Valley Conveyance System

The recommended conveyance alternative included acquisition of the Future Contractor share of SBA capacity, improvements to the South Bay Pumping plant, improvements to the Brushy Creek Pipeline, possible construction of a parallel (B4-A) pipeline from BBID diversion point to the proposed Altamont Water Treatment Plant, and construction of a new In-Valley Conveyance System consisting of pipelines L1, L2 and L3A to serve the majority of the existing and future South Livermore untreated maximum day demands. The proposed untreated water facilities are shown on Figure 2.7.

The future Chain-of-Lakes (COL) is projected to be completed by year 2030. Lake H and Lake I of the future Chain-of-Lakes are projected to be available as early as year 2003. Once available, Zone 7 would be able to divert water from Arroyo Mocho (50 cfs) and Arroyo Valle (500 cfs) into the COL for recharge into the groundwater basin and/or for subsequent pumping to meet peak agricultural demands through the proposed In-Valley Conveyance system. In the salt management studies developed in Chapter 9, it was assumed that Zone 7 would be able to release 50 cfs from SBA turnouts into Arroyo Mocho in 2010 (current projected date year 2004). It was assumed that about 20 cfs would recharge along Arroyo Mocho and the remaining 30 cfs would be diverted into Lakes H and I.

2.6 Water System Operations Model

As part of the Salt Management Plan (SMP) investigations, Zone 7 staff, Zone 7 consultants, the GMAC and TAG identified the need to evaluate the impacts of various strategies on delivered water quality more thoroughly. All groups agreed that ideal salt management strategies would need to both maintain or improve delivered water quality and to better equalize delivered water quality in the east and west sides of the valley (see Chapter 7). Zone 7 staff determined that the best way to make these evaluations at future demand and operating conditions was to develop a water (amount and quality) routing model for the entire Zone 7 water system. This type of numerical model would be capable of evaluating the impacts on delivered water quality of multiple water operations options such as varying the use of specified groundwater wells and proposed groundwater demineralization facilities. Future system improvements and new sources of storage and supply could be integrated in such a model.

The water system operating model selected was similar to one developed for ACWD by Water Resources Management, Inc. (WRMI). Zone 7 contracted with WRMI to develop a model of the Zone 7 system based on the OASIS (Operation and Simulation of Integrated Systems) model with Operation Control Language (OCL). OASIS is a generalized linear

MODIFICATIONS TO DWR FACILITIES

- Upgrade SBA Pumps to Deliver Design Capacity of 345 cfs
- Increase Surge Tanks on Brushy Creek Pipelines to handle 345 cfs

NEW CONVEYANCE FACILITIES

- B4–A (24–inch diameter) Pipeline, 36,000 ft Including Modified Intake Structure & Expanded Pump Station

UNTREATED IN–VALLEY FACILITIES

•	L1	42–inch diameter	20,500 ft
•	L2	30–inch diameter	13,200 ft
•	L3A	36–inch diameter	32,500 ft

TOTAL ESTIMATED PROJECT COSTS (MILLION $)

Purchase of Future Contractor Share	=	46
Modifications to DWR Facilities	=	5
New Conveyance Facilities	=	12
In–Valley Facilities	=	32
		$95M

ADVANTAGES

- No Enlargement of the SBA pipelines or canals required
- Minimizes size and cost of the New Conveyance Facilities (B4–A), required to bring new water supplies into the Valley
- Altamont WTP location takes advantage of hydraulics and proximity to the Brushy Creek Pipelines
- In–Valley facilities provide Zone 7 the ability to:
  - phase projects in response to demands
  - maximize use of groundwater and available water resources
  - increase operational flexibility
  - integrate well with the proposed Salt Management plan
- Low Cost Alternative

DISADVANTAGES

- Does not allow for expansion at Patterson Pass WTP
- Allows Del Valle WTP to expand to only 40 mgd if treated and untreated demands buildout as projected
- Does not take advantage of excess capacity in Reach 4, downstream of Patterson Pass WTP

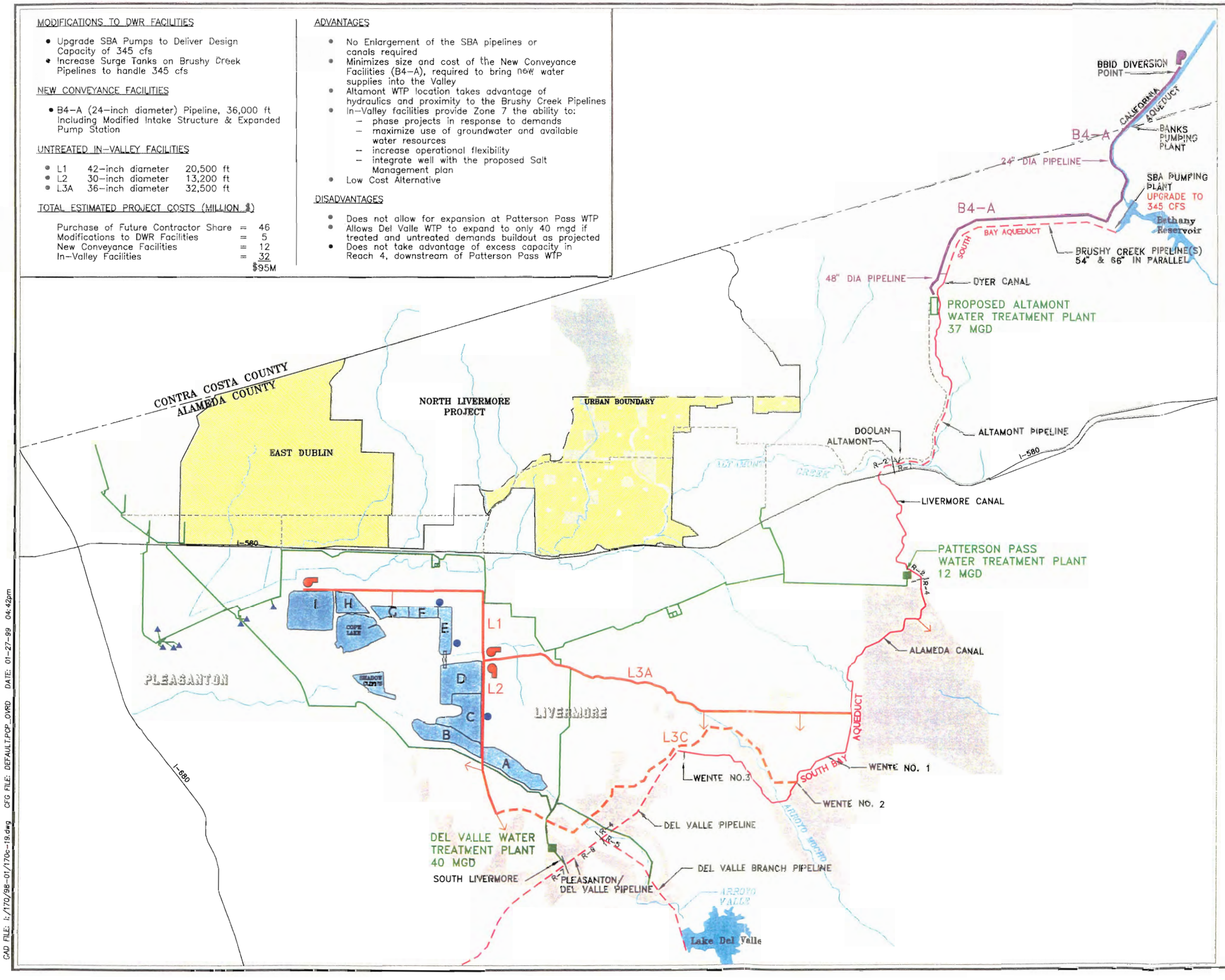

Figure 2.7

Zone 7 Water Supply Planning Study February 1999

SCHEMATIC SUMMARY OF RECOMMENDED CONVEYANCE ALTERNATIVE 5

MINIMAL UPGRADES TO SBA FACILITIES AND IN–VALLEY FACILITIES SIZED TO MINIMIZE ENLARGEMENT OF THE SBA

N

NO SCALE

NOTES:

1. MAPPING BASED ON USGS DIGITAL LINE GRAPHS, 1:100,000 SCALE AND MAPS PROVIDED BY ZONE 7. PIPING SCHEMATICS ARE APPROXIMATE.

LEGEND:

- EXISTING SBA AQUEDUCT, CANAL
- EXISTING SBA AQUEDUCT, PIPELINE
- EXISTING ZONE 7 TRANSMISSION SYSTEM
- R–1 | R–2 SBA REACH
- PROPOSED WATER TREATMENT PLANT
- ZONE 7 WATER TREATMENT PLANT
- ZONE 7 PRODUCTION WELL
- PROPOSED ZONE 7 INJECTION/EXTRACTION WELL
- H CHAIN–OF–LAKES
- POTENTIAL NEW UNTREATED WATER DEMAND AREAS
- EXISTING UNTREATED DEMAND AREAS
- PROPOSED IN–VALLEY PIPELINE
- PROPOSED PUMP STATION
- PROPOSED DELIVERY POINT

Water Transfer Associates

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programming systems optimization-modeling program created by WRMI to analyze operations of water systems. The model is run to simulate water system performance over long periods of time. The time length of simulation is limited by the availability of time-series data.

System Schematics—The first step in building the model was to develop a schematic of the Zone 7 water system. Figures 2.8, 2.9, 2.10 and 2.11 represent the Zone 7 water system under projected year 2010 conditions with existing and planned facilities. The schematic shows the combination of interconnected nodes and arcs that define the system. A node is a junction point of two or more arcs. A node can represent a demand point, a reservoir, or a treatment plant. In the schematic, circles represent junction nodes, rectangles represent demand nodes, triangles are reservoir or storage nodes and diamonds represent treatment plants. Arrows that connect two nodes represent arcs. An arc represents a conveyance feature in the system. Any arc depicted with a small circle on it is reversible.

The major system features modeled include the South Bay Aqueduct, the complete distribution network including treatment plants, Zone 7 and retailer municipal wells, potential wellhead demineralization facilities, the DSRSD and Livermore RO recycled water facilities, groundwater subbasins, natural and artificial recharge in the Arroyos, mining operations, the future Chain of Lakes, and Del Valle Reservoir.

The representation of the Zone 7 system shown in Figure 2.8 includes all turnouts, which are represented by demand nodes numbered in the 100s. The general areas served by each demand node is shown in Figure 2.9. The demand node areas were estimated by Zone 7 based upon the geographical location of the turnouts. Exact areas served will vary depending on operational conditions. The demand at the treated water turnouts has been divided into internal use and external use. For example, Table 2.7 shows the demand inputs for demand node 120.

Table 2.7

Node 120 Demand Projected for Year 2010, AF

NODE	JUNCTION	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (AF)	% Total
120	Total Interior demand	71	71	71	71	71	71	71	71	71	71	71	71	854	41%
	Exterior TW	0	34	67	66	61	50	65	71	90	98	41	36	679	
	Recycled Water	0	1	17	36	76	96	106	100	69	43	14	6	565	
	Recycled RO Water	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Exterior demand	0	35	84	102	137	146	171	171	160	140	55	42	1243	59%
	Total	71	106	155	173	209	218	243	243	231	212	126	113	2098	100%

External use demand is represented by nodes numbered 701 to 797 (for simplification these are not shown on Figure 2.8). Each of the numbers in the 700 series corresponds to the nodes in the 100 series with the same last two digits. For example node 720 represents the external demand at node 120. Figure 2.10 shows how the external use node connects

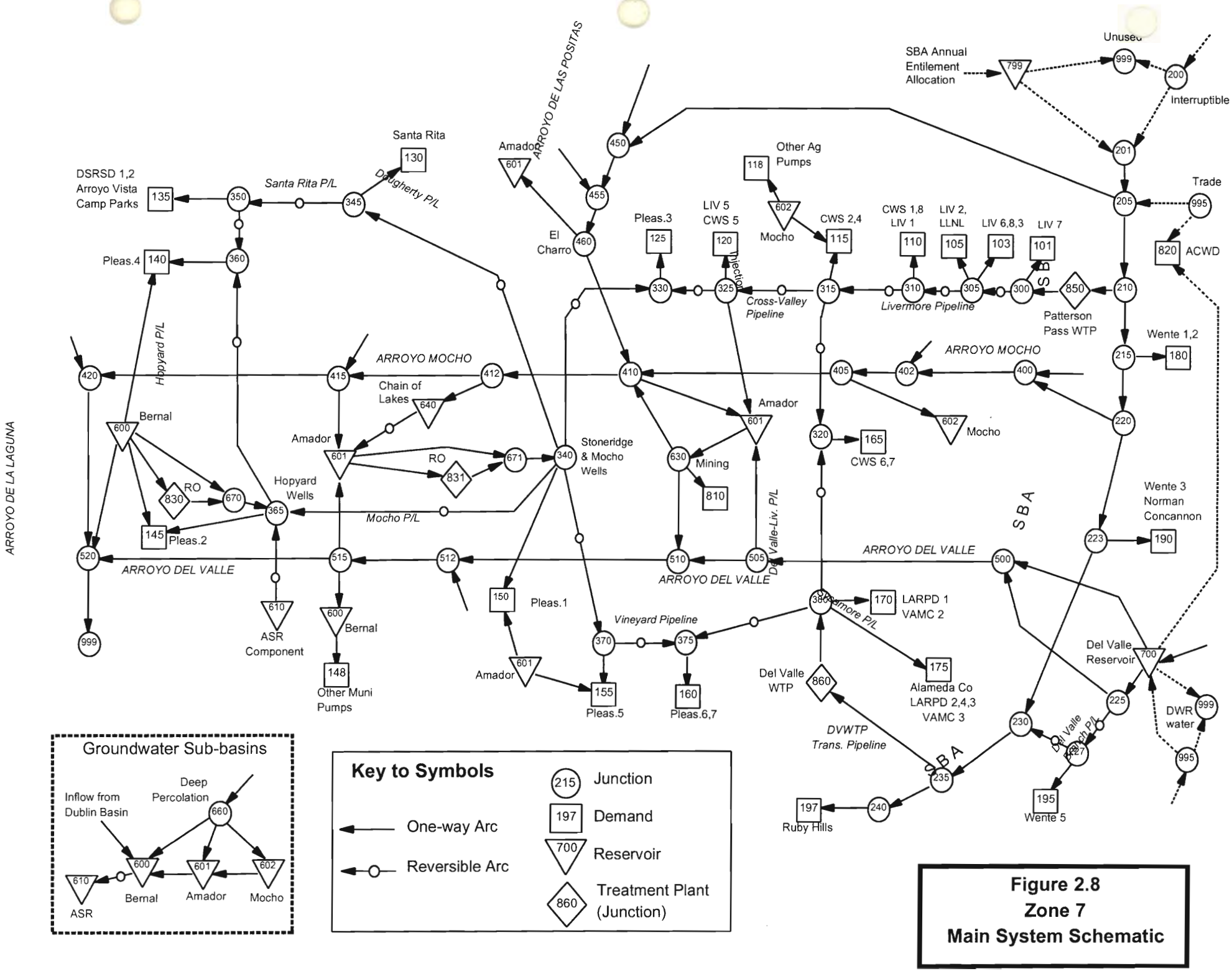

Figure 2.8
Zone 7
Main System Schematic

Figure 2.9

Bishop Sub-basin
Vasco Sub-basin
May Sub-basin
Cayetano Sub-basin
Altamont Sub-basin
Dougherty Sub-basin
Camp Sub-basin
Spring Sub-basin
Mocho II Sub-basin
Mocho I Sub-basin
Arroyo Del Valle Sub-basin
Bernal Sub-basin
Castlewood Sub-basin
MINING AREA
DOUGHERTY RESERVOIR
NODE 135
NODE 130
NODE 140
NODE 125
NODE 120
NODE 103
NODE 101
NODE 110
NODE 105
NODE 150
NODE 145
NODE 155
NODE 115
NODE 165
NODE 190 (AGRICULTURAL)
NODE 180 (AGRICULTURAL)
NODE 197 (AGRICULTURAL)
NODE 160
NODE 195 (AGRICULTURAL)
DSRSD 2
DSRSD 1
ARROYO VISTA
CAMP PARKS
SANTA RITA
PLS 1
PLS 2
PLS 3
PLS 4
PLS 5
PLS 6
PLS 7
LIV 1
LIV 2
LIV 3
LIV 5
LIV 6
LIV 7
LLNL
CWS 1
CWS 2
CWS 4
CWS 5
CWS 6
CWS 7
CWS 8
PPWTP
VAMC 2
DVWTP
VAMC 3, ARROYO VALLE I
LARPD 4, ALA. CO.
WENTE SPARKLING CELLARS
N
0' 3000' 6000'
SCALE

ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN TODD WENDLER
DESIGNED
CHECKED JARNAIL CHAHAL
APPROVED

WATER RESOURCES ENGINEERING
SERVICE AREAS BY WRMI DEMAND NODES
1997 WATER YEAR

SCALE 1" = 6000'
DATE 19 November 1997
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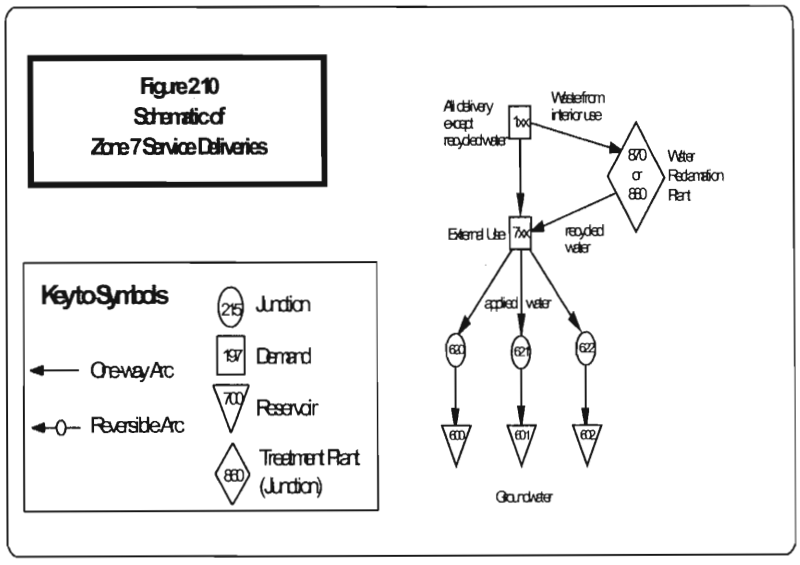
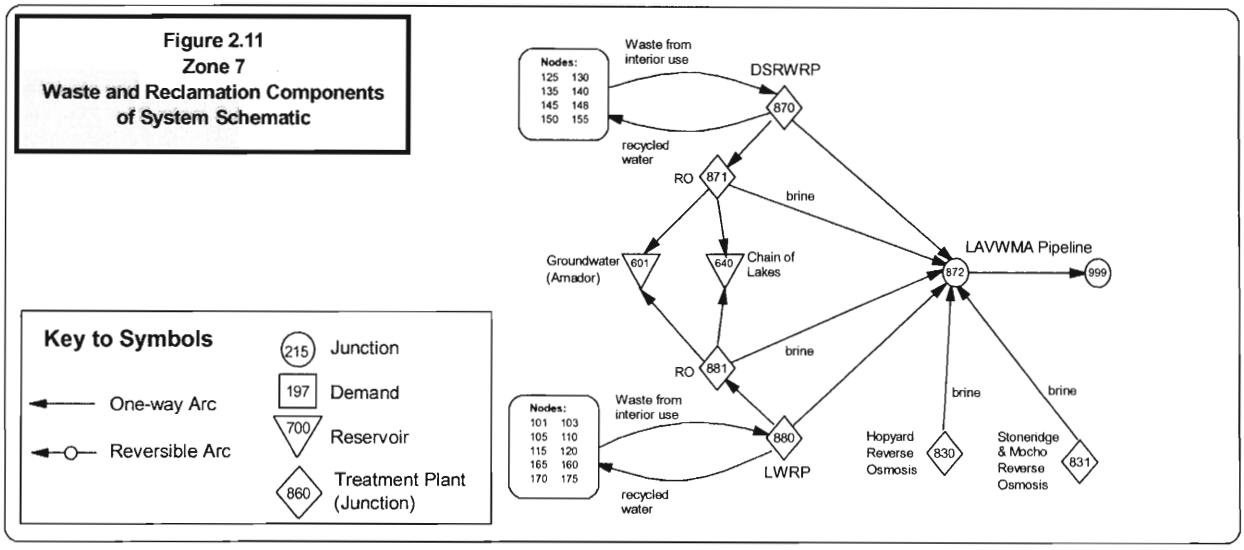
to the main demand node. The "*xx*" in Figure 2.10 is to indicate that this same set of nodes and arcs is repeated for every one of the demand nodes. Node 1xx represents all delivery, internal and external, except for recycled water delivery for irrigation. Through arc 1xx.870 or 1xx.880, 100% of the internal use is sent back to the two wastewater treatment plants. Node 7xx represents the entire external use delivery. An arc from the wastewater treatment plant also delivers recycled water to this node for some demand nodes. A certain percentage of the external use percolates into the groundwater basin through intermediate nodes 620,621 and 622.

The Figure 2.11 schematic shows how demineralization (RO) plants are included in the model. Each RO plant has one or more output arcs and one brine waste arc. The TDS is reduced in the output arcs, while the balance of mass of TDS is preserved by concentrating it in the brine waste arc. Nodes 871 and 881 represent RO plants that demineralize recycled water from the LWRP and DSRSD wastewater plants. These plants are assumed to have 90% removal efficiency so that the volume of brine waste is 10% of the volume of inflow. This rule is enforced as a constraint command. Maximum flows on the input arcs represent the capacity of the plants. The model then automatically balances the mass of TDS in the brine waste arc. The permeate (product water) from these two RO plants can be either used for injection to the Amador subbasin or sent to the chain of lakes. The actual use of the permeate from these plants is under further steady. Similarly nodes 830 and 831 represent RO plants that treat groundwater pumpage and connect to the Zone 7 distribution system near the Hopyard and Mocho well fields.





Model Use and Operation—The model is completely data driven and controlled by the operation Control Language (OCL). The time length of simulation of this system is limited by the availability of time-series data. Since the purpose of the model is to predict the reaction of the system to variable conditions, the historical hydrologic data for the 1922-94 period was used for simulation. This period was chosen since it is the same as that used by the DWR DWRSIM model that produces the State Water Project (SWP) yield and delivery predictions. The DWRSIM study 2020c9b-SWRCB-411 computes the SWP yield at year 2020 demand levels. The SWP yield data from this DWRSIM run is used in the Zone 7 WRMI model as one of the inputs for available surface water supply.

The OASIS model uses a mixed integer linear programming approach and Operations Control language to run the simulations. Water routing decisions are solved by the linear programming using a priority-objective function. The linear programming portion basically contains the operating constraints and goals of the system. The OCL is generally used to handle the special rules of each simulation. The model uses all the constraints and rules to route the flow from various sources to various turnouts. Every flow component (i.e. water source) is associated with water quality (TDS). Further documentation on OASIS and the Zone 7/WRMI water system routing model can be found in the report "*Documentation for OASIS with OCL - Application for Zone 7 Water Agency, January 1999*" (Reference D).

This water system operations model can produce various output parameters on a monthly average basis including groundwater recharge, groundwater storage, treatment plant production, Lake Del Valle Storage, delivered water quality, flow at any point in the system, etc. Zone 7 used the model to evaluate various groundwater basin Salt Management Strategies. The most valuable output parameter for evaluating salt management strategies was the delivered water quality (TDS). The model provides the monthly water quality (TDS) of Zone 7 deliveries by turnout and by retailer average deliveries to their customers under varying hydrologic conditions equivalent to the historic 1922-94 period. The analysis of this output provides the range of delivered water TDS in

the overall distribution system. Section 10.4 describes in detail the use of this water system operations model for evaluating Salt Management Strategy delivered water quality impacts.

Chapter 3

Groundwater Basin Characteristics

Chapter 3

Groundwater Basin Characteristics

3.1 Introduction

This chapter provides an overview of the hydrogeological characteristics of the Livermore-Amador Valley groundwater basin. Multiple studies of this important groundwater resource have been conducted over the last 100 years, as cited below (Section 3.2). A good overview and summary of fundamental basin characteristics was published in the 1974 DWR Bulletin 118-2 and summarized in the May 1992 Livermore-Amador Valley Water Recycling Study, appendices A and B. This chapter only briefly recounts that information (Section 3.3) and instead focuses on those aspects directly influencing salt loading impacts such as basin connectivity (Section 3.4) and Main Basin mixing and movement (Section 3.5). The approach taken to address vadose attenuation is presented in Section 3.6. Historic and on-going hydrogeological information collection is summarized in Section 3.7.

The groundwater flow and solute transport numerical model used in this SMP to evaluate the impacts of alternative salt management strategies (see Chapter 10) is described in Section 3.8. Section 3.8 also provides a detailed discussion of model calibration work conducted and a comparison of model results to actual measured groundwater elevations and TDS trends. The groundwater model provides the best current documentation of general basin characteristics.

3.2 Previous Groundwater Basin Studies

The earliest studies relating to the groundwater supply of the Livermore Valley were conducted in the early 1900s and mainly focused on the use of Livermore Valley groundwater for a drinking water supply to the City of San Francisco, California (Tibbetts, 1907; Lawson, 1912; Williams, Jr., 1912; Vickery, 1925; Smith, 1934). These early studies developed the conceptual model of a large artesian basin. The basin was recharged in the east where gravels were exposed at the surface. In the west the gravel aquifers were semi-confined under an extensive clay cap. The California Department of Water Resources (CDWR) began studying the basin in the late 1940's and published an initial study of water resources in all of Alameda County starting in July 1955. This report was revised and updated with the cooperation of Zone 7 and finally published in 1963 as Bulletin 13. Information in this report included surface water and groundwater supplies,

alternate plans for surface water development, and projected water demands. DWR continued their work in conjunction with Zone 7 and focused on groundwater recharge from streams, surface and groundwater quality, groundwater inventory and groundwater movement as it related to geological features (CDWR, 1960, 1964a, 1964b, 1966, and 1974).

In January 1964, CDWR published a report on the Alameda Creek watershed that discussed the effects of wastewater discharges on surface water and groundwater in Livermore and Sunol valleys (CDWR, 1964a). In June of that same year, a report was published discussing the need for standard well construction to prevent the commingling of waters of various qualities (CDWR, 1964b). An initial report on the geology as it relates to groundwater movement in Livermore and Sunol valleys was published in August of 1966 by CDWR as Appendix A to Bulletin 118-2. Bulletin 118-2 was published in 1974 again with the cooperation of Zone 7 and included comprehensive discussions of groundwater quality, movement, local geology, and inventory of each groundwater sub-basin (CDWR, 1966, 1974). The hydrology conceptual model was modified from Appendix A following the development and calibration of a computer flow model. Two very significant developments resulted from this modeling study. One was the realization that a detailed hydrologic inventory of all supply and demand components was absolutely essential to the quantitative analysis of the groundwater basin. Zone 7's hydrologic inventory was developed out of this early modeling effort and continues to be used as an essential element of all subsequent studies and modeling analysis. The second lesson learned was the importance of good hydrologic data records and the need to actively measure and collect hydrologic data. Bulletin 118-2 specifically recommended the construction of special monitoring wells to monitor shallow aquifer areas near recharge areas and near wastewater disposal areas.

In 1972, Brown and Caldwell Consulting Engineers completed a water quality management plan for the watershed of Alameda Creek above Niles Canyon for Zone 7 Alameda County Flood Control and Water Conservation District, City of Livermore, City of Pleasanton, and Valley Community Services District (now Dublin San Ramon Services District). The report discussed various plans for the management of surface water, groundwater, and wastewater treatment and disposal. Numerous other wastewater management studies were subsequently conducted in the 1970's leading to construction of the LAVWMA export pipeline in 1980. These studies and later ones were summarized in the report "Wastewater Disposal and Reuse Alternatives for the Livermore-Amador Valley 1960-1995" (EOA, July 1995).

In 1982, a wastewater management plan was prepared for Zone 7 that included wastewater and recycled water management policies for the unsewered, unincorporated area of the Alameda Creek watershed above Niles. It also addressed salt and nitrate loading impacts from septic tanks in these rural areas (Camp Dresser & McKee, 1982). The U.S. Geological Survey, working

cooperatively with Zone 7, conducted three investigations of surface and groundwater quality and the impacts thereon of wastewater discharges in the late 1970's and early 1980's (USGS Water Resources Investigations Reports 81-46, 82-4100, 84-4352). During this decade, following 118-2, the USGS supervised the construction of new monitoring wells and the establishment of a groundwater and surface water monitoring network. Zone 7 staff working with the USGS staff developed techniques for the collection of good monitoring data on the quality and quantity of surface and groundwater within the watershed and groundwater basin.

As noted above, the May 1992 Livermore-Amador Valley Water Recycling Study contains a comprehensive summary of the local hydrogeology based on many of the above reports, particularly USGS Bulletin 118-2.

The concept of a central basin or a Main Basin was developed in the 1980's by Zone 7 and others to signify the area of the groundwater basin that contained the majority of usable groundwater storage.

Groundwater flow from the fringe basins was calculated as subsurface inflow to the Main Basin utilizing aquifer properties and groundwater gradients developed from the cooperative studies by DWR and the USGS. The Zone 7 Water Resources section calculates the annual quantity of subsurface inflow to the main groundwater basin for each water year. In 1995, Zone 7 produced an internal memorandum detailing this calculation process for the water years 1974 through 1994. Because it was determined that the majority of the subsurface inflow comes from the Dublin and western Camp sub-basins, the memo focuses on these areas. It was found that the average subsurface inflow in this region of the basin is approximately 1,000 acre/feet per year.

Zone 7 has been monitoring the salt balance of the basin since the mid-1970s and the impacts of recycled water irrigation since the early 1980s. In the early 1980's Zone 7 expanded the hydrologic inventory to include a water quality inventory of the Main Basin. This quantitative inventory of water quality is called the salt balance. The latest annual Zone 7 salt balance report (August 1999) includes salt balance calculations for the basin from 1974-1998 (see Chapter 5).

In 1998, Zone 7 and CH2MHill developed a calibrated groundwater flow and solute transport model for the Livermore Valley Groundwater Basin. A summary report documented the calibration parameters and demonstrated the model's usefulness in evaluating basin-wide trends in TDS through time (CH2MHill, 1998). This model utilized the entire historic hydrologic inventory and salt balance inventory records 1974-98 for calibration. In January 1999, CH2MHill and Zone 7 produced an additional memorandum documenting results from using the model to examine 14 salt management strategies for the groundwater basin (see Section 3.8 and Chapter 10).

In 2004, Norfleet Consultants prepared the "Preliminary Stratigraphic Evaluation, West Side of the Main Basin." This study developed updated cross sections in a portion of the Main Basin using sequence stratigraphy, a method of relating the depositional environment of sediments to the stratigraphic framework in which they were deposited. The evaluation included:

- A data quality review of selected Zone 7 existing data,
- A standard presentation format for graphic logs representing lithologic and geophysical data,
- Two cross sections through the study area,
- Sequence stratigraphic analyses to correlate the cross sections, and
- A detailed stratigraphic description to assess the geologic controls on groundwater movement in the Chain of Lakes basin recharge area.

On the cross sections, four stratigraphic sequences were identified: cyan, gray, purple and red (youngest to oldest). Each sequence was marked by a sequence boundary at the base and series of fining upward braided fluvial channels containing sand and gravel with interstratified flood plain and lacustrine clays and silts. The results of the study showed that in the study area, the base of the youngest stratigraphic sequence appears to provide a pathway for groundwater to flow between the recharge basins and the underlying shallow aquifers (<250 feet below ground surface). However, no direct pathway was observed between the recharge basins and the deeper aquifer units in the study area.

3.3 Groundwater Basin Overview

The Livermore-Amador Valley Groundwater Basin is contained in the Livermore/Amador/Dublin Valley area (herein called the Livermore Valley, but also sometimes known as the Tri-Valley).

3.3.1 Physiographic Description

The Livermore Valley, an inland structural basin, is located in northeastern Alameda County (Figure 3.1). It is surrounded primarily by north-south trending faults and hills of the Diablo Range. The valley extends approximately 14 miles in an east-west direction and varies from three to six miles in width. It is separated from San Francisco Bay by several northwesterly trending ridges of the California Coast Ranges including the Pleasanton Ridge. The valley floor slopes gently west and southwest from an elevation of approximately 700 feet above sea level in the east to approximately 320 feet above sea level in the southwest.

Six principal streams flow into and/or through the valley, and join in the southeast where the Arroyo de la Laguna flows out of the valley. The other five arroyos are essentially tributaries to the Arroyo de la Laguna:

- Arroyo Valle,
- Arroyo Mocho,
- Arroyo Las Positas,
- South San Ramon Creek?
- Tassajara Creek, and
- Alamo Creek.

Average precipitation rates range from 16 inches per year at the valley floor to over 20 inches per year in the southeast and northwest portions of the valley.

3.3.2 Geologic Description

Structural uplift of the entire Coast Ranges occurred during the late middle Pliocene & Pleistocene causing extensive folding and faulting of the region. The Livermore Valley, a structural valley formed by a faulted, asymmetric syncline, was created as a result of downwarping of the Miocene-Pliocene sandstones and conglomerates between the western bordering Calaveras Fault and the eastern bordering Greenville Fault. Continued deposition, uplift, and faulting have led to the current Livermore Valley stratigraphy (DWR, 1964b, 1974; Crane, 1988; Hall, 1958). The majority of the valley consists of the following three types of geologic units (presented from youngest to oldest).

Valley Fill/Quaternary Alluvium - The valley is partially filled with Pleistocene-Holocene age (recent alluvium) alluvial fan, stream and lake deposits, which range in thickness from a few feet along the margins to nearly 400 (and possibly 800) feet in the west-central portion. The alluvium consists of unconsolidated gravel, sand, silt, and clay. This alluvium, most likely consisting of reworked Livermore Formation, was deposited and heavily influenced by the alluvial deposition of ancestral and recent streams, including Alamo Creek, Arroyo del Valle, Arroyo Las Positas, Arroyo Mocho, South San Ramon Creek, and Tassajara Creek.

The southern region of the Livermore Valley is the most important groundwater recharge area and consists of mainly sand and gravel that was deposited by the ancestral and present Arroyo del Valle and Arroyo Mocho. The eastern and northern regions of the valley contain thinner deposits and consist of alternating layers of gravel, sand, silt, and clay that are laterally discontinuous and resulted from the deposition of smaller streams. The western region of the valley has extensive gravel layers alternating with thick clay beds totaling approximately 400 feet in thickness. The alternation of sand/gravel layers and silt/clay layers form the basic aquifers for the area (CDWR, 1966, 1974).

Livermore Formation - The Livermore Formation consists of beds of clayey gravels and sands, silt, and clay that are unconsolidated to semi-consolidated and estimated to be 4,000 feet thick in the southern and western portion of the basin (DWR, 1964b). These sediments are exposed along the south flanks of the valley in the uplands, and exhibit bed dips 5 to 25 degrees toward the northeast in the Livermore Uplands. In between, the geologic contact between the recent alluvium and the underlying Livermore Formation is not discernable from drill cuttings in the central part of the valley because the formation materials are similar. Groundwater from this formation is sodium bicarbonate in nature and of moderately good quality.

Tassajara and Green Valley Formations - The Tassajara and Green Valley Formations, located uplands north of the valley, are roughly Pliocene in age and were deposited under both brackish and freshwater conditions. They basically consist of sandstone, tuffaceous sandstone/siltstone, conglomerate, shale, and limestone. Beds typically dip 60 to 80 degrees toward the south or north in the Tassajara Uplands. These formations are bordered on the northeast by Marine sediments and are overlain to the south by the Livermore Formation. Because of low groundwater yields, the use of these formations is limited to residential or basic agricultural uses.

3.3.3 *Hydrologic Inventory*

It is a common misconception that the Livermore Valley Groundwater Basin is a "closed" basin. In the late 1800s, the pre-development groundwater levels in the basin created a gradient causing groundwater to flow from east to west and naturally exit the basin as surface flow in the Arroyo de la Laguna. In the early to mid-1900s, groundwater began to be extracted in appreciable amounts causing groundwater levels to drop throughout the basin. At that time, groundwater levels dropped below the point where groundwater would naturally rise into the Arroyo de la Laguna and exit the basin through stream flow. This was the closest the Main Basin came to being, by definition, totally enclosed. Surface application of extracted groundwater through irrigation and septic systems reintroduced the groundwater to the system with minimal outflow at the Arroyo de la Laguna.

Since that time, additional development has required increased import of surface water and use of groundwater. The groundwater basin cannot be considered "totally enclosed" since water is exported from and recharged into the basin through various means. These include:

- Dewatering and export of mining water from the gravel pits,
- Export of irrigation runoff by streams to the Arroyo de la Laguna, and
- Municipal pumpage plus export of resultant treated wastewater to the bay through the LAVMA pipeline.

The total outflow of water from the basin is on average 20,000 acre-feet per year (this is about 8% of the total groundwater storage: 240,000 acre-feet). Approximately 20,000 acre-feet per year recharges (i.e., inflow) the groundwater basin through percolation of irrigation and stream flow.

The ratio of inflow to outflow will vary depending on precipitation. During drought years outflow increases due to increased pumping. During wet years more imported water is available and used to artificially recharge the basin. Land use also plays an important role total inflow and outflow from the groundwater basin.

As evidenced by the increase in "gaining stream" reaches during seasonal highs, observed groundwater levels have appeared to rise in various parts of the basin. Primarily, these gaining reaches are in the northeastern and western portions of the groundwater basin (Figure 3.3). Reasons for these increases may in part be attributed to urban development, which uses more imported water than groundwater from localized wells. Urban development also increases applied water recharge due to landscape irrigation.

3.4 Occurrence and Movement of Groundwater

3.4.1 Definitions

For the purposes of this report, geologic formations will be grouped into one of three categories:

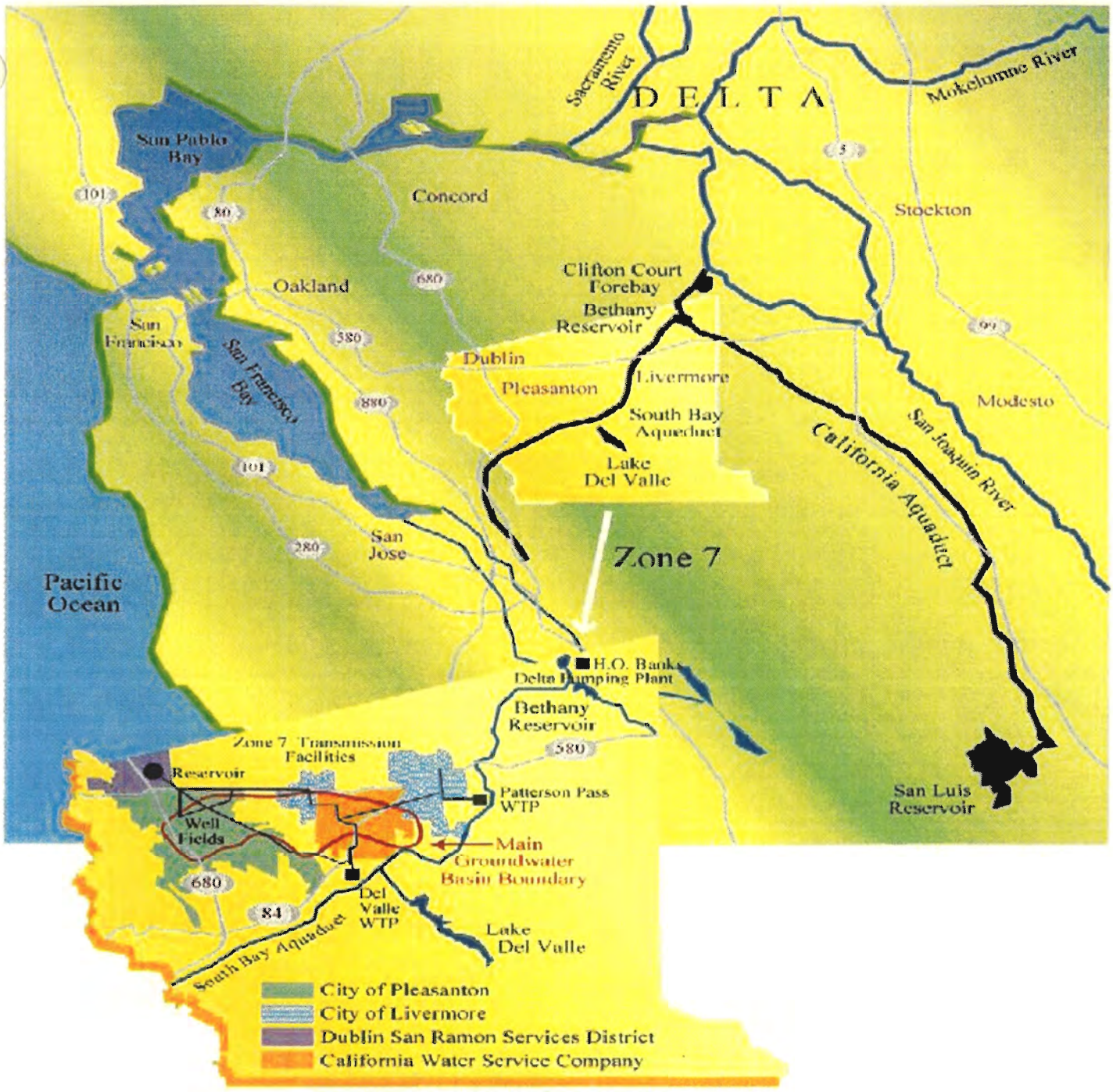
Water Bearing Formations - Water bearing strata represent geologic deposition of quaternary alluvium and portions of the Livermore Formation that are believed to extend beneath the alluvium.

Low Yielding Formations - The Tassajara Formation, Green Valley Formation, and upland areas of the Livermore Formation display lower yields. Groundwater from these formations is sodium bicarbonate in nature and of moderately good quality.

Non-water Bearing Formations - Totally non-water bearing strata consist of Cretaceous to mid-Tertiary marine sediments that do not readily absorb, transmit, or yield water to wells in appreciable amounts. Often, the groundwater that is extracted is of a poor quality sodium bicarbonate-chloride or sodium chloride nature with dissolved solids ranging from 700 to 2150 parts per million (CDWR, 1964b).

Several types of groundwater boundaries are present either along the edges of the basin or within the basin. These boundaries can be categorized into four types:

Barrier - A boundary where there is no hydraulic connectivity between the adjacent aquifer unit. Examples of this boundary may represent movement along a



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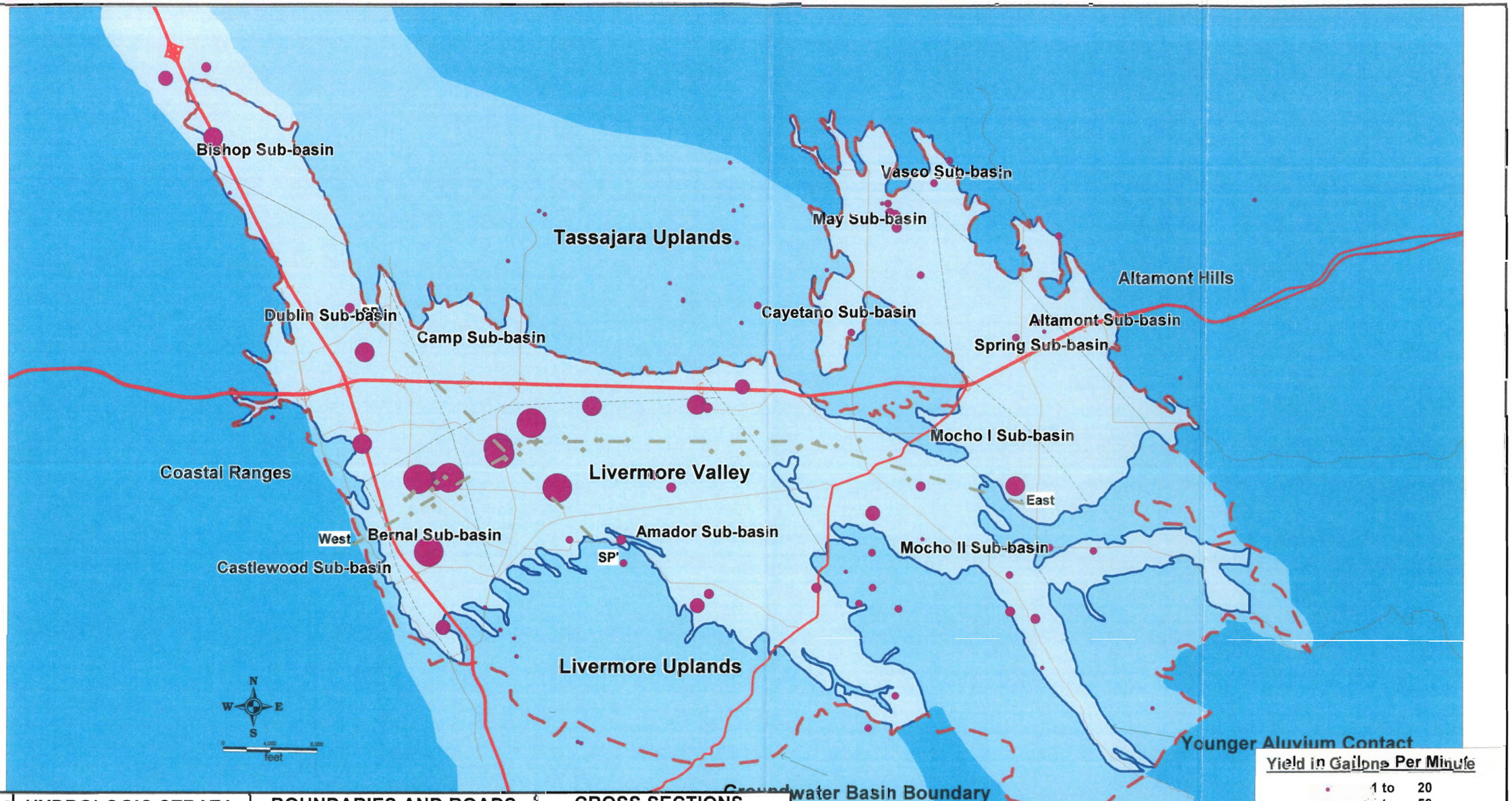
Water Resources Engineering
Salt Management Plan
Figure 3.1: Vicinity Map



Legend

HYDROLOGIC STRATA

- Water Bearing
- Lower Yielding
- Non-Water Bearing

BOUNDARIES AND ROADS

- Groundwater Basin
- Subbasin
- Recent Alluvium Contact
- Roads and Highways

CROSS SECTIONS

- East to West and SP to SP'

ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE
PLEASANTON, CA. 94588

DRAWN BY: C Mahoney	SCALE: 1" = 8,000'
DESIGNED BY: C MAHONEY	DATE: 3 JULY 2000
CHECKED BY: D LUNN	REVISED BY:
APPROVED:	FILE: \zone7-file\mapinfo\SMP\Fig3-2.WOR

WATER RESOURCES ENGINEERING
SALT MANAGEMENT PLAN
FIGURE 3.2:
BASIN OVERVIEW

Figure 3.3

DRAINAGE BASIN

BASIN

DOUGHERTY DRAINAGE BASIN

TASSAJARA DRAINAGE BASIN

POSITAS DRAINAGE BASIN

ALAMO CANAL AND SOUTH SAN RAMON DRAINAGE BASIN

UPLAND POSITAS DRAINAGE BASIN

P1 - 2 CFS

P3 - 0 CFS

P2 - 2 CFS

ARROYO MOCHO NEAR PLEASANTON

M5 - 0 CFS

M4 - 5 CFS

PLEASANTON

M6 - 0 CFS

M3 - 7 CFS

LIVERMORE

M2 - 4 CFS

LAGUNA DRAINAGE BASIN

V5 - 0 CFS

V4 - 7 CFS

MOCHO DRAINAGE BASIN

VALLE DRAINAGE BASIN

V3 - 2 CFS

V2 - 1 CFS

M1-0 TO 1 CFS

V1 - 2 TO 3 CFS

ARROYO VALLE ABOVE LANG CANYON NR LIVERMORE

DRAINAGE BASIN BOUNDARY

GROUNDWATER BASIN BOUNDARY

TDS SCALE	RECHARGE RATES
0 TO 399	0 TO -1 CFS
400 TO 499	0 TO 1 CFS
500 TO 699	1 TO 3 CFS
700 TO 999	3 TO 5 CFS
OVER 1000	5 TO 7 CFS
SW STATIONS	

N W E S

0 1 2 miles

ZONE 7 WATER AGENCY

5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN BY: GERALD GATES	SCALE: 1" = 1 MILE
DESIGNED BY: GERALD GATES	DATE: 3 JULY 2000
CHECKED BY: DAVID LUNN	REVISED BY: C MAHONEY
APPROVED:	FILE: h:\SMP\Fig3-3.WOR

WATER RESOURCES ENGINEERING
SALT MANAGEMENT PLAN

FIGURE 3.3:
STREAM RECHARGE RATES AND TDS

fault where a permeable unit has been displaced against a non-permeable unit or where the unit "pinches out" and abuts an impermeable unit.

Cascade - A boundary where movement along a fault has partially displaced an aquifer unit causing stepped flow across the boundary. This may exist along the upper aquifer of the Livermore fault boundary.

Leaky - A boundary where horizontal fault movement produces fault gouge that slows the movement of water across the boundary.

Unrestricted - A boundary where aquifer characteristics may change slightly, but do not impede the flow of water across the boundary. Examples of this can be observed by a slight change in head, but not in specific capacity between two wells on opposing sides of the boundary.

In a layered aquifer system, combinations of boundary types may exist along boundaries. The level of information varies as to which specific boundary conditions apply to many of the sub-basin boundaries. However, definite evidence for the existence of these boundaries is found in the differences in water level and/or water quality characteristics of the wells on either side of the given feature.

3.4.2 Basin Boundaries

The Livermore Valley Groundwater Basin is located in the heart of the Livermore Valley watershed and extends south into the hills south of Pleasanton and Livermore. It includes the areas occupied by both the flat portions of the Livermore Valley and the Livermore uplands (Figure 3.2). The basin is bounded on the:

- West by northwesterly trending ridges of the California Coast Ranges (including Pleasanton Ridge) and the Calaveras fault,
- North by the Tassajara Uplands and the steeply dipping east west trending Tassajara Formation.
- East by the Greenville fault and by the marine formations exposed in the Altamont Hills.
- South by the Verona faults and Livermore Uplands and the steeper Livermore Highlands.

While the Arroyo de la Laguna has little recharge, the other streams in the basin have "losing stream" stretches where at least a portion of their flow percolates through the stream bed and recharges the groundwater basin aquifers. In addition, three tributaries to the Arroyo Las Positas (i.e., Cayetano Creek, Altamont Creek,

and Arroyo Seco) and one tributary to the Arroyo Mocho (i.e., Dry Creek) can also impact the basin. The stream locations and the known "losing stream" stretches are shown on Figure 3.3 along with their approximate recharge rates.

Several subsurface barriers form impediments to lateral movement of groundwater in the Livermore Valley basin (DWR, 1964b, 1974). Based on these apparent linear groundwater barriers, the basin has been divided into sub-basins. Some of these sub-basins have a much larger capacity to store and transmit groundwater and are very significant for the local groundwater supply. These had been called the central basin, but since 1985, they have been called the **Main Basin**. These consist of the following sub-basins (shown on Figure 3.2):

- Bernal (usually includes the smaller Castle Sub-Basin)
- Amador
- Mocho I

The other basins are called **Fringe Basins**. These consist of the following sub-basins:

- Altamont
- Bishop
- Camp
- Cayetano
- Dublin
- May
- Spring
- Vasco
- Mocho II

Vertically, the majority of the groundwater basin can be split into two hydraulic zones:

Upper Aquifer Zone - The upper aquifer zone consists of alluvial materials including primarily sandy gravel and sandy clayey gravels. These gravels are usually encountered underneath the surficial clays (typically 20 to 40 feet bgs) to about 80-150 feet bgs. This aquifer extends throughout the majority of the groundwater basin. Groundwater in this zone is unconfined. The 2004 Stratigraphic Evaluation called this zone the 'Clay Sequence'. In the Main Basin, the upper aquifer is underlain by a relatively-continuous, silty clay aquiclude up to 50 feet thick.

Lower Aquifer Zone – Due to a lack of accurate geologic information, the water bearing units below the upper aquifer zone have been collectively known as the Lower Aquifer Zone. The aquifer materials consist of semi-confined to confined, leaky, coarse-grained, water-bearing units interbedded with relatively impermeable, fine-grained units. As additional geologic information becomes

available it is possible that this zone can be further subdivided into distinct aquifers. For example, Norfleet (2004) split the lower aquifer zone in the Amador Sub-basin into the "Gray," "Purple," and "Red" sequences. In future geologic and modeling studies, Zone 7 will likely extend the Norfleet sequence boundaries beyond the Norfleet study area.

In general, multiple aquifers are recognized in the alluvium of the Livermore Valley. As shown in Figure 3.4, a cross section of the basin from west to east, the water bearing alluvium increases in thickness from east to west across the basin and thins both north and south at its boundaries. Cross section SP to SP' (Figure 3.5) also shows a thickening of sediments from north to south to the central portion of the groundwater basin and then a thinning from the center towards the south. Although the upper aquifer zone appears to be very thick and continuous through the Central Amador Sub-basin, the water bearing units within the lower aquifer zone are often discontinuous and inter connected. The more recent geologic logging and monitoring of multilevel monitoring wells are allowing better understanding of the hydrostratigraphic units within the recent alluvium.

3.4.3 Subsurface Inflow into the Main Basin

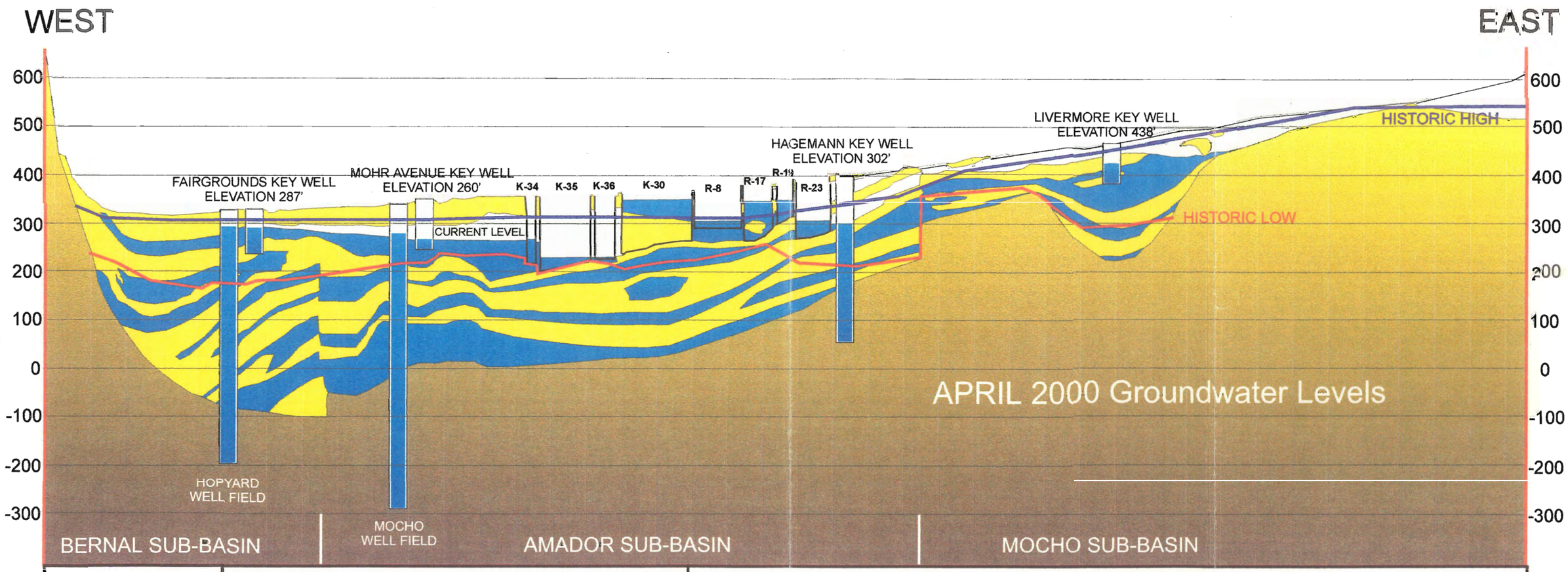
The existence of groundwater barriers along the edges and within the basin continues to be confirmed by the groundwater level measurements, investigations by Zone 7, and other investigations. In 1974 these groundwater barriers were generally interpreted as fault related. However, some may be the result of hydrostratigraphic boundaries and not fault related.

South of the basin, groundwater from the Livermore Formation is believed to move along the strike of the beds to the northwest and enter the Main Basin at the southern portions of the Bernal and Amador sub-basins. North of the basin, the near-vertical structural dip of the Tassajara and Green Valley formations is believed to prevent the commingling of waters among these formations and the alluvium, essentially cutting this water off from the groundwater basin (DWR, 1966, 1974, Zone 7 files).

The outer boundaries of the Main Basin have been divided into 10 regions of interest with respect to groundwater connectivity (Figure 3.6). Region 1, followed by regions 2 and 7, contribute the greatest amounts of subsurface inflow to the Main Basin through the shallow aquifers (Upper Zone). Subsurface inflow from the deeper aquifers (Lower Zone) is considered negligible as shown in Table 3.1.

Estimates of future inflow are based on currently planned development and assume that the potentiometric surface of the Main Basin will be drawn down to accommodate the added demand. Future TDS was taken from the technical memorandum, *Phase 4 Groundwater Modeling: Salt Management Plan Simulations* (CH2MHill, 1999). Scenario 1A, which examined the base case

LIVERMORE-AMADOR VALLEY GROUNDWATER BASIN
EAST-WEST CROSS-SECTION



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Water Resources Engineering
Salt Management Plan
Figure 3.4: East-West Cross Section

CDM 7/3/2000
Fig3-4EWxsec.cdr

Vasco Sub-basin
May Sub-basin
Dublin Sub-basin
Inflow=~100
Inflow=~50
Cayetano Sub-basin
Altamont Sub-basin
Inflow=~0
Camp Sub-basin
Inflow=~900
3
2
4
1
Spring Sub-basin
Inflow=~28
Mocho II Sub-basin
Mocho I Sub-basin
Amador Sub-basin
5
7
10
Bernal Sub-basin
9
Inflow=~0
Inflow=~0
8
Inflow=~360
6
Inflow=~0
Castlewood Sub-basin
Inflow=~0

Legend

MONITORING SYSTEM	BOUNDARIES AND ROADS	INFLOW REGIONS
Proposed Well	Sub-basins	1, 5, 9
Proposed Transect	Roads & Highways	2, 6, 10
Monitoring Well	Main Basin	3, 7
Proposed Stream Gage	Inflow Region	4, 8

Inflow in Acre / Feet per Year

N W E S

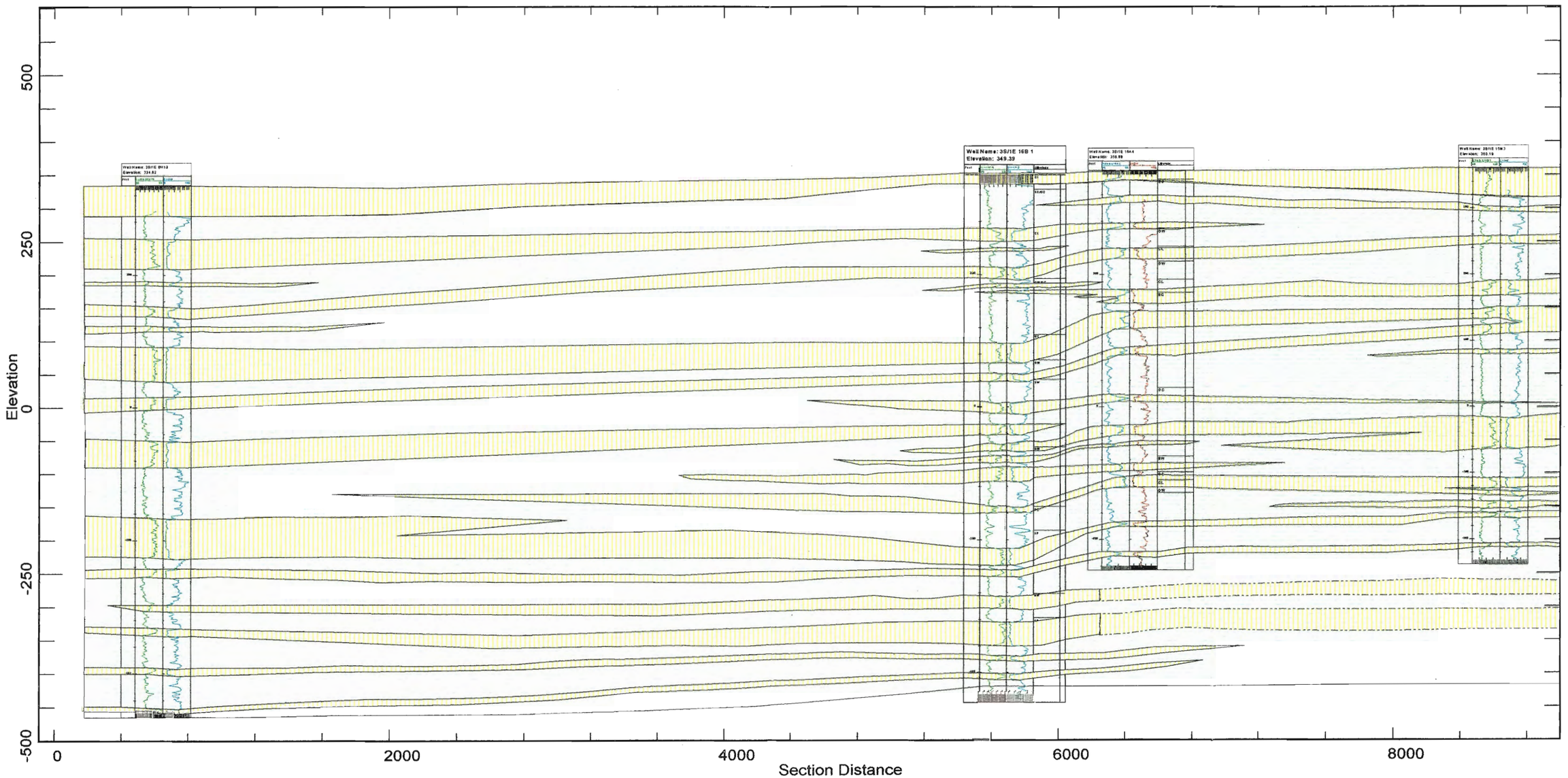
0 0.5 miles

ZONE 7 WATER RESOURCES MANAGEMENT

ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE
PLEASANTON, CA. 94588

DRAWN BY: C MAHONEY	SCALE: 1" = 1 mile
DESIGNED BY: C MAHONEY	DATE: 3 JULY 2000
CHECKED BY: D LUNN	REVISED BY:
APPROVED:	FILE: h:\SMP\Fig3-6.WOR

WATER RESOURCES ENGINEERING
SALT MANAGEMENT PLAN
Figure 3.6:
Hydrologic Regions of Inflow



Sand/Gravel Unit Clay Unit	Zone 7 Water Agency 5997 Parkside Drive Pleasanton, CA 94588	Salt Management Plan Figure 3.5: SP - SP' Cross Section	Vertical Exaggeration: 5 H:\Viewlog\SPX_Section.map Nov. 1, 2000

scenario with no recycled water injection, was used to represent future impact conditions. This scenario examined TDS at 50 years from the initial condition of October 1995.

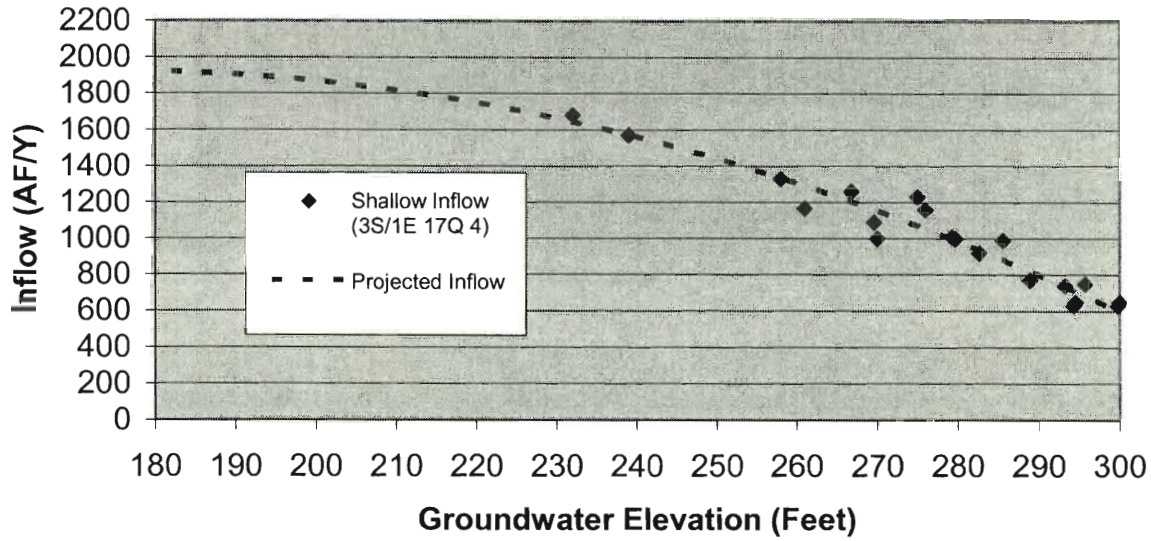
Table 3-1
Subsurface Inflow and TDS with Respect to Urban Development
Inflow (Acre Feet per Year) and TDS (mg/L)

Inflow Region	Upper Zone afy		Lower Zone afy		Upper Zone Mg/L		Lower Zone mg/L	
	Current Inflow	Future Inflow	Current Inflow	Future Inflow	Current TDS	Future TDS	Current TDS	Future TDS
1	900	950	<50	<50	900	1000	400	850
2	100	200	<10	<20	1000	1000	400	950
3	50	100	<5	<10	850	1000	450	850
4	N	N	N	N	750	800	450	800
5	28	U	N	U	650	700	500	700
6	N	N	N	N	700	750	450	700
7	360	360	N	N	450	450	450	450
8	N	N	N	N	450	400	450	350
9	N	N	N	N	500	700	450	650
10	N	N	N	N	600	900	500	800
Total Inflow	1438	1610	<65	<65				

Notes:
TDS = Total dissolved solids
N = Negligible inflow
U = Unknown at this time
AFY = acre-feet per year

In Figure 3.7, inflow from the "Fairgrounds Key" Well, currently designated as 3S/1E 17Q 4, is shown at observed groundwater elevations. These data represent calculated inflows from 1974 through 1994 into the northwestern boundary of the Main Basin as associated with the observed groundwater elevation. The projected linear curve represents the average inflow that may be expected at any given groundwater elevation. As the basin approaches the historic low elevation of 180 feet below ground surface (e.g., following a seven-year drought), the relative rate of subsurface inflow decreases. At some elevation below 180 feet, inflow is projected to stabilize at about 1,900 AF/year.

Figure 3-7:
Trends in Shallow Aquifer Inflow



Region 1 is the boundary between the Dublin Sub-basin and the Main Basin. The boundary is the Parks Fault, which creates a vertical zone of very low permeability at about a 100-foot depth. Subsurface groundwater inflow is precluded below this depth, therefore, subsurface inflow occurs mainly in the shallower portion over this boundary. Subsurface flow across this Region 1 boundary accounts for the majority of groundwater flow into the Main Basin. Subsurface flow from the Dublin Sub-basin into the Main Basin is calculated from groundwater gradients every year. The average calculated flow is approximately 900 acre-feet per year with a TDS of about 900 mg/L and it moves from northwest to southeast.

Region 2 is the western boundary between the Camp Sub-basin and the Main Basin. This boundary is made up of the eastern extension of the Parks Fault and a low permeability boundary of alluvial deposits interfingering with the less permeable alluvial deposits eroded from the Tassajara Formation. North of the boundary, all subsurface flow is in the upper aquifer. The Tassajara Formation precludes deep formation subsurface inflow from entering into the Main Basin. This inflow is computed each year from groundwater gradients and averages about 100 acre-feet. The100 AF/year of subsurface inflow moves in the upper aquifer alluvial materials that overlie the Livermore and Tassajara formations and crosses the Amador Sub-basin boundary flowing south. Again, inflow from the deeper aquifers in considered to be minor.

Region 3 represents the eastern boundary between the Camp Sub-basin and the Main Basin and the western portion of the Cayetano Sub-basin and the Main

Basin. Again the lower aquifer groundwater from the northern portion of this sub-basin is precluded from flow into the Main Basin. Shallow subsurface inflow in this region is moving south to southwest and is estimated to be approximately 50 AF/year or less.

Region 4 is the boundary between the eastern portion of the Cayetano Sub-basin and the Main Basin. The Cayetano Sub-basin is underlain by the Tassajara Formation, which has little to no hydraulic connectivity with the overlying alluvial deposits and the Main Basin, and contains water of a sodium bicarbonate character. The volume of subsurface flow is assumed to be insignificant and travels southwest. Minor flows rise into the creek and are counted in the Arroyo Las Positas stream recharge calculations.

Region 5 is the northern boundary between the Mocho I Sub-basin and the Main Basin, or more specifically the Mocho II Sub-basin. Subsurface flow is limited to the upper aquifer. Gradients in this area are very flat and often flow to the East. Zone 7 estimates no flow across this gap and others have estimated 28 AF/Y.

Region 6 represents the contribution of Dry Creek to the Main Basin. Only small quantities of surface water flow through this creek due to agricultural applications. It is unknown how much of the surface flow recharges the groundwater and moves as subsurface flow. Subsurface flow moves in a western direction across this boundary and is assumed to be insignificant.

Region 7 is the boundary between the Main Basin and the less permeable Livermore Formation uplands located between the upper reaches of Arroyo Mocho and Arroyo del Valle. Groundwater quality in this area ranges from a sodium chloride to a sodium bicarbonate water type. Subsurface flow exits in this region through a storm drain on the northeastern side of the boundary and moves in a north to northwest direction to the Arroyo Mocho. Discharge from this drain is estimated to be approximately 360 AF/year but with a fairly low TDS of 450 mg/L. It recharges the groundwater via the Arroyo Mocho and is included in Arroyo Mocho recharge calculations.

Region 8 is the boundary between the Main Basin and the less permeable Livermore Formation uplands located west of the Arroyo del Valle. Water here is considered to be of a sodium bicarbonate character. Subsurface flow in this region is moving northwest and is assumed to be insignificant. This is based on well yields and observations of dry summer creek beds.

Region 9 is the boundary between the Main Basin and southwestern most area of less permeable Livermore Formation uplands. Water in this region is of sodium bicarbonate character. The Livermore Formation in this area is striking northwest/southeast and is dipping northeast toward the Main Basin. Subsurface flow in this region is moving northwest along strike and is assumed to be

insignificant. This is based on field observations at dry creeks and from limited well observation within the uplands.

Region 10 is the boundary between the Castle Sub-basin and the Main Basin. The boundary is the west branch of Calaveras Fault. Formations west of the fault are water bearing.

Table 3.1 shows that future development is not anticipated to result in any significant changes to the quantity or quality of subsurface inflow to the Main Basin. Region 1, the largest contributing area, is only expected to increase in flow from 900 to 950 AF/year and the TDS is only projected to increase from 900 to 1000 mg/L. Total inflow would increase from 1438 to 1610 AF/year (+215 AF/year). Areas in the lower zone showing moderate TDS increases are also areas with negligible inflow.

3.4.4 Main Basin Groundwater Mixing and Movement

Groundwater always moves from areas of high groundwater level potential (high groundwater level elevation) towards area of low potential. Recharge in an area raises the groundwater level elevation and discharge from an area lowers the groundwater level elevation. The difference in groundwater level potential per unit distance between two points is called groundwater level gradient. Therefore, groundwater always moves from areas of artificial and natural recharge towards areas of artificial and natural discharge or withdrawal. In general, recharge and discharge areas in the same aquifer create intra-aquifer (horizontal) movement and in different aquifers create inter-aquifer (vertical) movement.

The main groundwater basin is a multi-layered system having an upper unconfined aquifer overlaying a sequence of semi-confined aquifers. In general groundwater in both the upper and lower aquifer zones generally follows a westerly flow pattern, along the structural central axis of the valley, towards municipal or gravel mining company groundwater pumping wells in the western portion of the basin.

The groundwater movement and mixing in the Main Basin is very dependent on the location and magnitude of recharges into and discharge from the basin. Stream recharge, ASR injection, rainfall recharge, applied water recharge and subsurface inflow are the main sources of recharge. The main demand components (pumpage or discharge components) are municipal pumpage, agricultural pumpage, gravel mining water use and groundwater basin outflow. The average annual Main Basin recharge and pumpage is about 20,000 AF.

Groundwater monitoring data, and results from the Zone 7 numerical groundwater model for the Main Basin, indicate that the extent of mixing in the Main Basin varies considerably from location to location. The groundwater model animations help visualize the groundwater movement in the basin. Bernal, Amador and

Mocho II are the three main sub-basins of the Main Basin. The groundwater exchange between these sub-basins also varies with the extent of groundwater elevation gradient changes.

The Main Basin is made up of the Castle, Amador, Bernal, and the Mocho II sub-basins overlain by recent alluvium. The Mocho Sub-basin has been divided into two distinct areas, Mocho I and Mocho II distinguished by a change in aquifer characteristics from a sodium bicarbonate (Mocho I) to a magnesium bicarbonate water type (Mocho II) and by the presence of the less permeable Livermore Formation extending from both north and south into the middle of the sub-basin. The Main Basin is bounded:

- On the north primarily by the Parks Boundary and by a lack of hydraulic continuity with the Livermore and Tassajara formations,
- On the west by the Calaveras Fault,
- On the south primarily by thinning of the recent alluvium and contact with the Livermore Formation, and
- On the east by the divide between the Mocho I and II sub-basins.

Amador Sub-basin - The Amador Sub-basin is located in the west central portion of the groundwater basin and is bounded to the:

- West by the Pleasanton Fault,
- East by the Livermore Fault,
- North by a permeability barrier of inter-fingering of alluvial deposits. Historically this boundary was thought to also include a fault called the Parks Fault, however there has not been any direct evidence of this fault. It is possible that this barrier is caused by permeability change between younger and older alluvium. Herein this boundary is called the Parks Boundary, and
- South by the drainage divide and partly by contact with non-water bearing formations.

This sub-basin is host to the majority of high production wells and has both unconfined and confined aquifers. Well production in this sub-basin ranges from 42 to 2,820 gallons per minute (gpm) and specific capacities of 1.1 to 217 gpm per foot of drawdown (CDWR, 1974). Waters from this sub-basin are of good to excellent quality, characterized by sodium bicarbonate, magnesium bicarbonate, and calcium bicarbonate with few instances of elevated levels of boron and nitrate.

In this sub-basin the maximum thickness of the Quaternary alluvium was previously thought to be approximately 500 feet. However, Norfleet (2004) did not find any evidence for the bottom of the alluvium at over 800 feet below ground surface. The alluvium is believed to lie unconformably over the Livermore Formation.

Bernal Sub-basin - The Bernal Sub-basin is located in the southwestern portion of the groundwater basin and is bounded to the west by branches of the Calaveras Fault, to the east by the Pleasanton Fault, to the north by the Parks Fault, and to the south by contact with non-water bearing formations and partly by contact with the Verona Fault. Both unconfined and confined aquifers exist in the water bearing sediments. Waters from this sub-basin are of fair to excellent quality. However, much of the upper aquifer water has high TDS exceeding 600 mg/l. The water from the northern and southern portions of the sub-basin are of a sodium bicarbonate nature, while the central portion is of the magnesium bicarbonate type and the western and south-central portion is of a calcium bicarbonate character.

The Bernal Sub-basin is the point of convergence for all of the major streams that drain the Livermore Valley. The Arroyo de la Laguna subsequently drains the sub-basin. Like the surface water, the groundwater also historically converges in this sub-basin, which allows for the mixing of the dominant cations of sodium, magnesium, and calcium. The Quaternary alluvium is estimated to have a thickness of at least 400 feet in this sub-basin and conformably overlies the Livermore Formation. Well production in this sub-basin ranges up to 3,500 gpm and specific capacities range from 3 to 260 gpm per foot of drawdown.

Mocho I/II Sub-basin - The Mocho Sub-basin is located in the east central portion of the groundwater basin and is bounded to the west by the Livermore Fault, to the east by the Tesla Fault, to the north by the Tassajara Formation that is not hydraulically connected to the sub-basin, and to the south by the Livermore Uplands and contact with non-water bearing marine formations. Both unconfined and confined aquifers exist in the water bearing sediments. Waters from this sub-basin are of fair to excellent quality sodium bicarbonate (Mocho I) and magnesium bicarbonate character (Mocho II) with some instances of elevated boron and sodium ions.

The recent alluvium ranges in thickness from approximately 10-50 feet thick in Mocho I and up to 150 feet thick in Mocho II. This alluvium overlies, both conformably and unconformably, the Livermore Formation. Mocho I and Mocho II appear to be hydraulically connected only in the shallow alluvial deposits. Well production in this sub-basin ranges up to 950 gpm with specific capacities of 2 to 50 gpm per foot of drawdown.

3.4.5 *Horizontal Mixing and Movement (Intra-Aquifer Movement)*

Groundwater level gradient and hydraulic conductivity are two essential parameters for characterizing groundwater movement in an aquifer. Hydraulic conductivity is an aquifer property and groundwater gradient is dependent on recharge/discharge locations.

Upper Aquifer - The upper aquifer in the Main Basin has generally good hydraulic conductivity. The presence of geologic faults in the Main Basin does not impede flow at shallow depths as compared to the higher impedance at deeper depths.

The main components of recharge for the upper aquifer are the areal recharge (rainfall and irrigation), stream recharge, fringe basin subsurface inflow and groundwater inflow from deep aquifers at some locations. The discharge components are dewatering by gravel mining, rising groundwater in Arroyo de la Laguna, and leakage to the deeper aquifer. Figure 3.8 presents the groundwater level contours for the upper and deep aquifers.

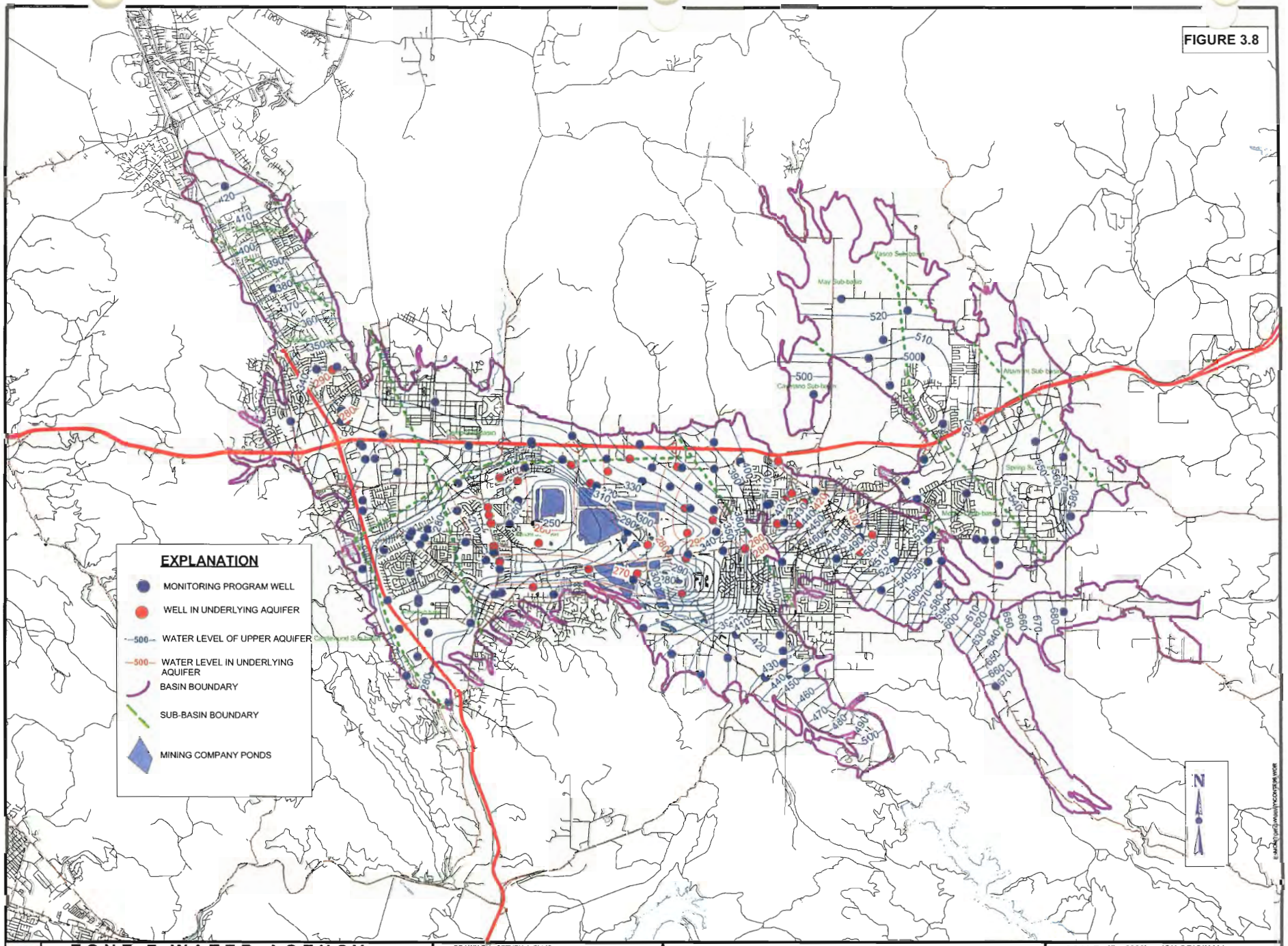
Areal recharge occurs over most of the Main Basin and in and of itself does not create any significant groundwater gradients in the upper aquifer. This is primarily why Main Basin areas in the upper aquifer that do not have any other major source of recharge or discharge other than areal recharge have very poor groundwater mixing and movement. For the Bernal Sub-basin upper aquifer, the recharge sources are areal recharge and subsurface inflow from the Dublin Sub-basin. The discharge components are the small amount of rising groundwater to Arroyo de la Laguna and leakage to the deeper aquifer.

Groundwater exchange between the Amador and Bernal sub-basins also occurs. There is a significant groundwater gradient from north to south in the northern portion of the Main Basin due to subsurface inflow from the Dublin Sub-basin recharging this area. The gradient can also be affected due to groundwater leakage to the deep aquifer occurring in the central portion of this sub-basin during drought years. There is also a mild groundwater gradient from the western and southern portions towards the center.

The stream recharge that occurs along the arroyos creates a higher groundwater potential along the arroyos. For the most part the groundwater flows away from the stream recharge areas. Groundwater de-watering by gravel mining companies in the Amador sub-basin creates groundwater gradients towards the central portion of the Main Basin. The groundwater level contours in Figure 3.8 indicate flow from the eastern part of the Main Basin towards the central part of the Main Basin. A part of the areal recharge and stream recharge that occurs in the Amador and Mocho II sub-basins moves towards the gravel mining areas and the remaining portion moves down to the deep aquifer.

Groundwater TDS in the upper aquifer at most locations is dependent upon the TDS of the locally recharged water. The groundwater TDS along the northern boundary of the Main Basin is high because of the high TDS subsurface inflow from the Dublin Sub-basin and high TDS recharge from Arroyo Las Positas. The groundwater TDS along Arroyo Mocho and Arroyo Valle is lower because of the lower TDS water recharged in those areas. The groundwater TDS in the shallow aquifer at locations where the recharge source is only areal recharge, and at

FIGURE 3.8



ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN BY: STEVEN J. ELLIS
DESIGNED BY: STEVEN J. ELLIS
CHECKED BY:
APPROVED BY:

WATER RESOURCES ENGINEERING
GROUNDWATER LEVEL CONTOURS
FALL 1996

SCALE: 1" = 6000' (ON ORIGINAL)
DATE: 10 JANUARY 1997
FILE NO.: B-342

locations not receiving any low TDS stream recharge, is high because of the high TDS of the areal recharge.

Although the TDS of rainfall recharge is insignificant, the TDS of recharge from irrigation is generally quite high. For example, if the irrigation water TDS is 300 mg/l, the irrigation water recharge (percolate) TDS could range from 1,200 mg/l to 3,000 mg/l depending upon the soil type. Typically 75-90% of the applied irrigation water evaporates and 10-25% recharges into the aquifer, along with 100% of the applied salts. This concentration process increases the TDS of recharge from irrigation by 4-10 times the TDS of irrigation water.

Deep Aquifer - The deep aquifer in the Main Basin is a sequence of semi-confined aquifers with good hydraulic conductivity. The presence of some geologic faults in the Main Basin impedes flow across the sub-basin boundaries at deeper depths.

The recharge components for the deep aquifer include groundwater leakage from the upper aquifer and treated surface water injection from the Hopyard well #6 (ASR well). As discussed in Section 3.3, subsurface inflow from the fringe basins through the deep aquifer is insignificant. Since the groundwater leakage from the upper aquifer is spread over the Main Basin, it does not create any significant potential gradient between two geographically separated points. The Hopyard #6 injection raises the groundwater potential in the Hopyard well field depending upon the injection amounts.

The discharge components from the deep aquifer include groundwater pumpage and leakage into the upper aquifer in the Amador Sub-basin due to upper aquifer dewatering near the gravel mining operations. The groundwater pumpage is the major reason for gradients between two geographically separated points in the deep aquifer in the Bernal and Mocho II sub-basins. Groundwater pumpage and leakage to the upper aquifer are the main reasons for gradients in the Amador Sub-basin.

The mixing in the deep aquifer appears to be primarily dependent upon the distribution and amount of groundwater pumpage from the aquifer. The groundwater model animations show how some of the stream recharge on Arroyo Valle leaks to the deeper aquifer and moves towards Pleasanton's municipal wells (Pleasanton #5, 6 & 8).

3.4.6 *Vertical Mixing and Movement (Inter-Aquifer Movement)*

The relatively low hydraulic conductivity of the aquitard layers impedes the vertical movement of groundwater between the upper and lower aquifers. The low conductivity of the aquitard is the major reason for the slower movement and reduced mixing that occurs between the upper and deep aquifers.

The location of the water sources and water sinks also controls the movement and mixing of groundwater in the Main Basin aquifers. Most of the vertical movement and mixing occurs by leakage through the aquitard separating the upper and lower aquifers. Some exchange also occurs by leakage due to geologic faults and wells screened in different aquifers.

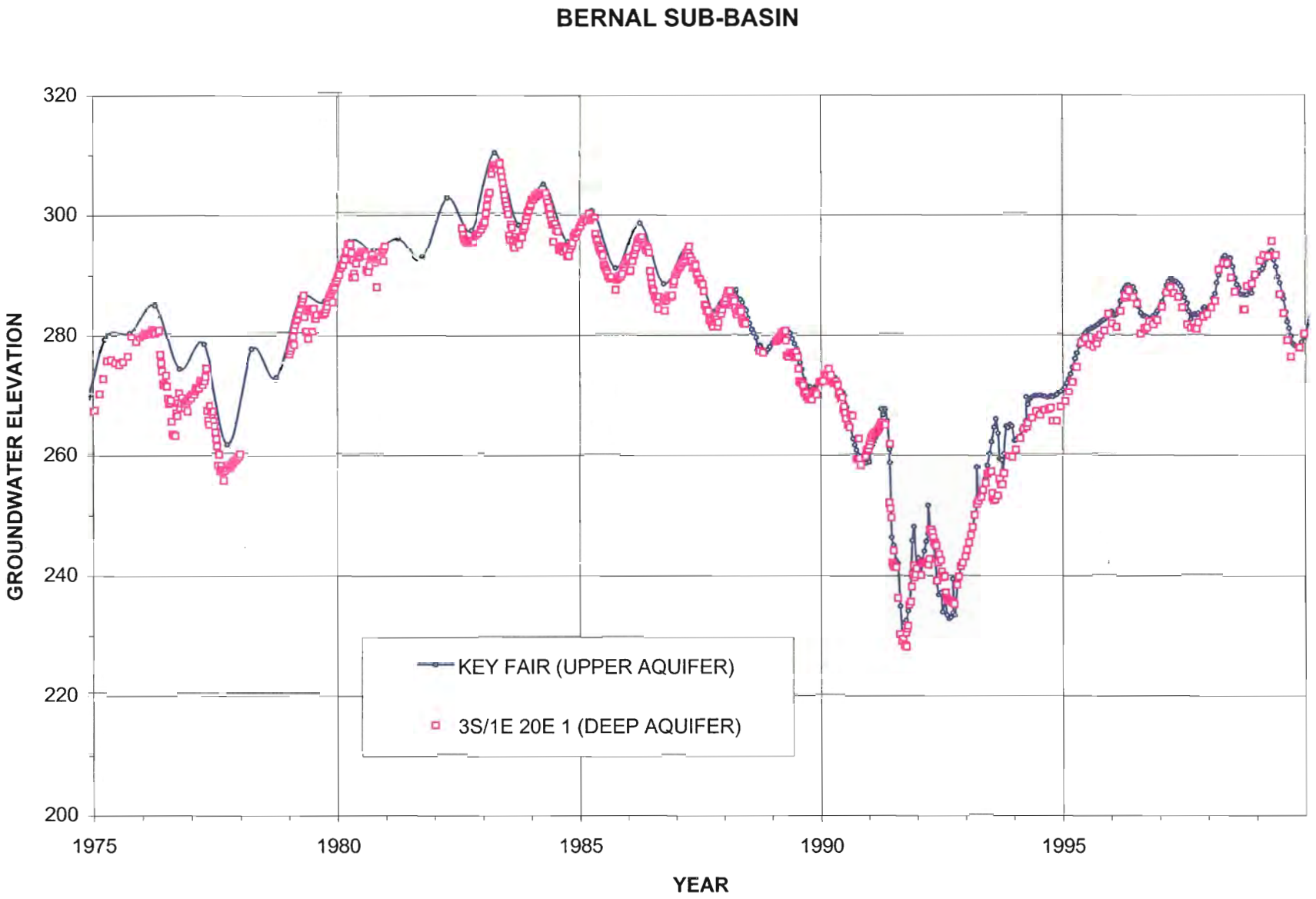
The exchange between the two aquifers, as indicated by the groundwater monitoring data, varies depending upon the thickness and permeability of the separating aquitard and the potential gradient. Even though the movement of water and salts from the upper aquifer to the lower aquifer is slow, it is still the major source of recharge to the lower aquifer. In the past, prior to injection (ASR) to the lower aquifer, the leakage from the upper aquifer was the only source of water and salts.

Water quality monitoring data and the groundwater model simulations indicate that the movement of salts from the upper aquifer to the lower aquifer is even slower due to the other transport mechanisms. This section describes the mixing processes occurring between the upper and deep aquifers within the Bernal, Amador and Mocho II sub-basins.

Bernal Sub-basin upper and deep aquifer mixing - Figure 3.9 presents the actual groundwater level data for two wells in the Bernal Sub-basin for the period 1975-99. The Fairgrounds Key well levels are representative of the upper aquifer and well 3S/1E 20E1 levels are representative of the deep aquifer. During drought conditions in 1976-77 and 1987-92, the deep aquifer groundwater levels declined due to increased municipal pumpage. The groundwater levels in the upper aquifer also declined with the decline in the upper aquifer tracking the decline in the deep aquifer. Since there was no significant increase in pumpage from the upper aquifer, this indicates that significant amounts of groundwater moved from the upper to the deep aquifer. Similarly, when the upper aquifer groundwater level recovered during wet years, the deep aquifer groundwater levels followed. From this figure and other groundwater level data, it can be concluded that there is significant linkage between the two aquifers. The increase in potential gradient due to wet or dry conditions increases the amount of groundwater mixing between the upper and deep aquifers in the Bernal Sub-basin.

Amador Sub-basin upper and deep aquifer mixing - Figure 3.10 presents groundwater level data for two wells in the Amador Sub-basin. The Mohr Avenue key well represents groundwater levels in the upper aquifer and the Mocho-II represents groundwater levels in the deep aquifer. During drought conditions in 1976-77, the groundwater level in both aquifers declined due to increased groundwater pumpage from the deep aquifer. The groundwater levels in the upper aquifer recovered during 1978-83 due to wet years, and the groundwater levels in the deep aquifer returned to even higher elevations than before the drought. Then, the gravel mining companies increased their pumpage from the upper aquifer,

Figure 3.9



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municipal pumpage increased from the deep due to drought conditions, and both aquifers declined from 1984 through 1992.

The upper aquifer levels declined to lower elevations than in the deep aquifer. This happened because of deeper mining (but still within the upper aquifer) and hence increased pumpage from the upper aquifer at this location. The groundwater flow around these wells seemed to be from the deep to the upper aquifer during that period. It can be concluded that there is linkage between the two aquifers and that whenever there is sufficient gradient, groundwater flows and there is mixing between the upper and deep aquifer.

Mocho-II Sub-basin upper and deep aquifer mixing - Figure 3.11 presents groundwater level data for two wells in the Mocho II Sub-basin for the period 1975-99. The figure shows the groundwater levels in the Livermore Key well as representative of the upper aquifer and well 3S/2E 8p1 as representative of the deep aquifer. The major groundwater pumpage from this sub-basin is the municipal pumpage by CWS. It does not change significantly for the most part with either dry or wet conditions. During 1991-92, CWS pumped more than their GPQ. This increased pumpage lowered the deep groundwater levels during that period. As the upper aquifer levels recovered during the subsequent wet years, the deep aquifer levels followed higher. This indicates groundwater movement from the upper to the deep aquifer.

In summary, it can be concluded from the water level monitoring data and groundwater model simulations that there is inter and intra aquifer mixing, the extent of which varies with location and time. During prolonged droughts when the deep aquifer is pumped heavily, the upper aquifer water and salts move to the deep aquifer. The increased pumpage during these dry years increases the vertical hydraulic gradient and the horizontal gradient towards the pumping centers. The increased groundwater level potential gradient during drought years thereby increases the mixing in the main groundwater basin.

3.5 Vadose Zone Attenuation

Attenuation is a natural process whereby a material is reduced in amount, force, or severity. Attenuation may occur by various methods including dilution, dispersion, absorption, biodegradation, volatilization, and/or chemical reactions with soil particles. The vadose zone of soil is that area where the soil is mainly void of water. This region is also called the unsaturated zone or zone of aeration and generally represents the soil layers which lie above a water table or saturated zone, where present.

Evaluation of vadose zone attenuation within a groundwater basin poses various problems with respect to modeling. Example sites must be chosen carefully to insure that they represent the overall groundwater basin vadose zone. The general thickness of the vadose zone at these sites must be established for both wet and dry

Figure 3.10

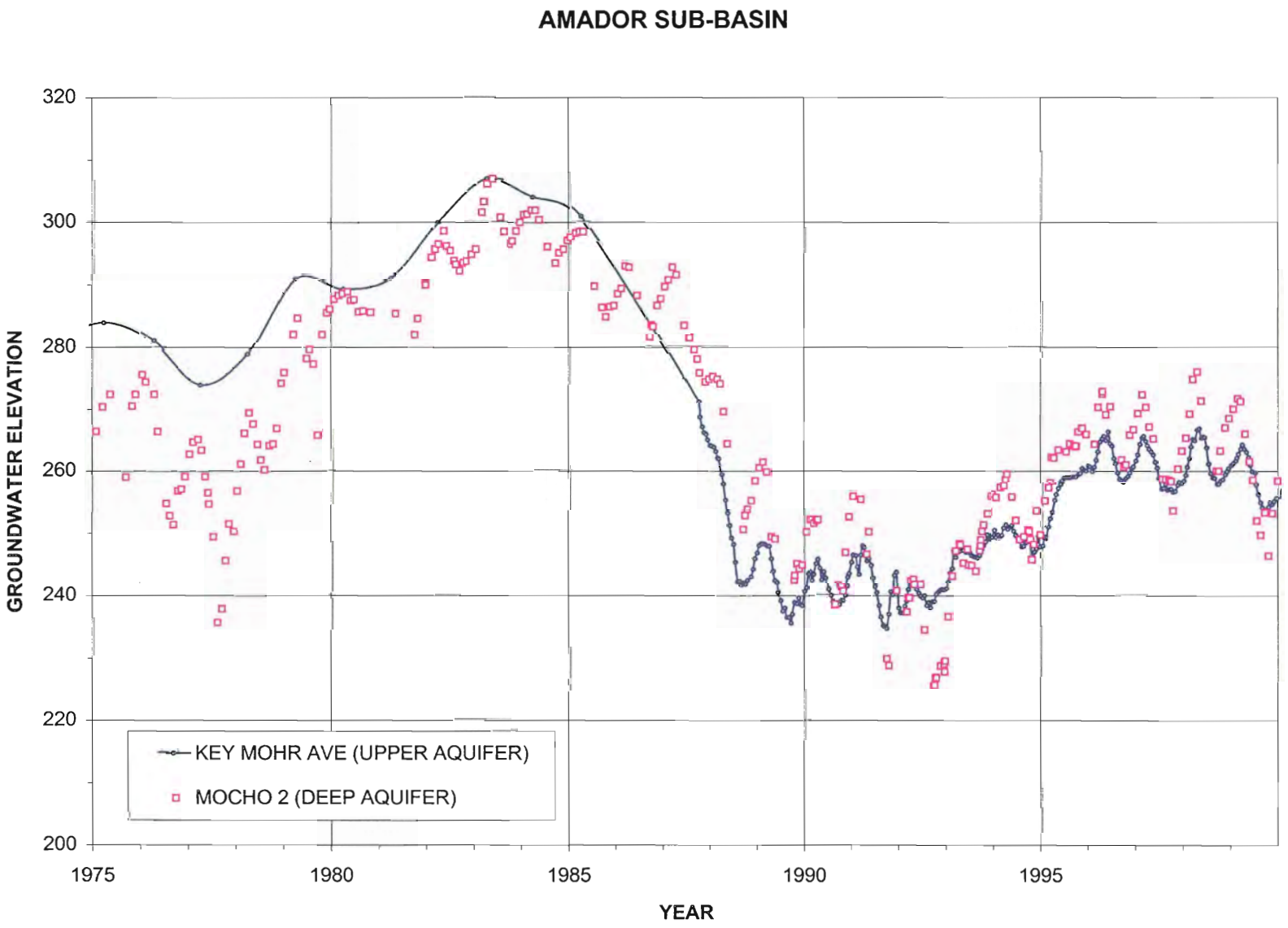

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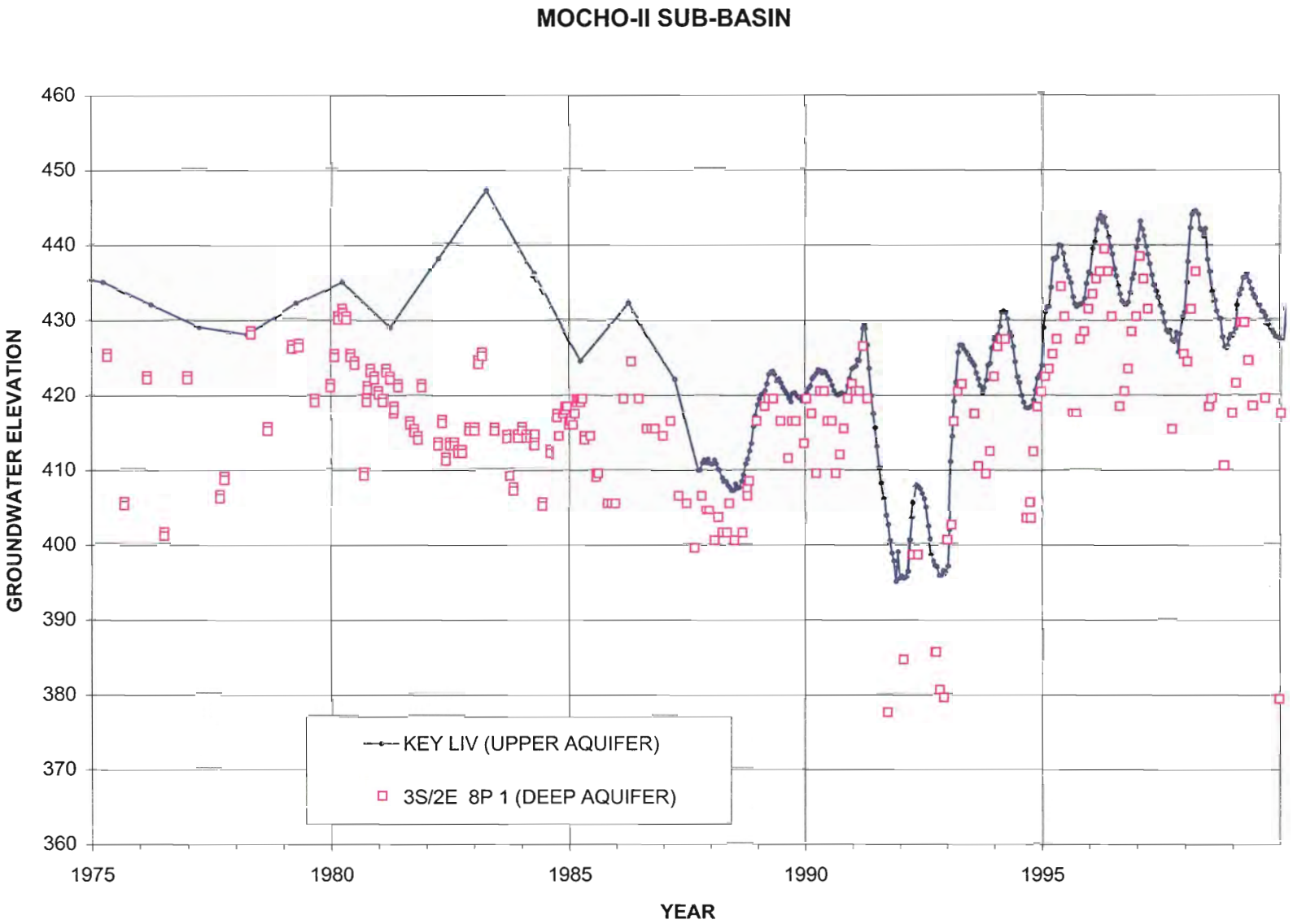
Figure 3.11



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water years. The material makeup of the vadose zone soil must be established for these sites and can be ascertained from geologic logs of wells. Intermittent layers of sands, gravels, silts, and clays must be taken into account in the calibration of the model along with variation in potentiometric surfaces through time and differences in hydraulic conductivities. Input data for a model also needs to take into account land use, surface cover, annual rainfall, and applied water quality. Values must be estimated where field data is lacking, which increases the margin of error.

In 1996, Zone 7 contracted with Todd Engineers to undertake a vadose zone attenuation modeling demonstration for selected sites to define the accumulation of salts, represented by TDS, under predetermined conditions (Todd, 1996). The preliminary model results from this demonstration project were inconclusive, reaffirming the complexity and level of effort and data required to construct a representative vadose model for the Livermore-Amador Valley groundwater basin. The results did provide evidence that regardless of where water is applied in the Main Basin and regardless of the total dissolved solids (TDS) concentrations in the applied water, the results would be very similar across the basin. This showed that vadose zone attenuation in the Livermore Valley did not appear to be a function of TDS or soil type.

A literature search was also undertaken to determine if there were similar groundwater basins that had successfully created an attenuation model and ranges of attenuation found. Most notably among these were papers by Aulenbach, et.al. (1974); Bouwer, H. (1974); Rice, et.al. (1989); Runnells, D.D. (1976); Saffigna and Keeney (1977); and Tedaldi and Loehr (1992).

Aulenbach, et.al. (1974) found that the release of treated effluent into a filtration system of natural delta sands did not appreciably reduce the amount of phosphates, nitrates, and chlorides, even at a 10-foot depth. Bouwer (1974) noted that, in arid regions, salt concentrations increase as the percolate from irrigation water passes through the root zone and deeper. Rice, et.al. (1989) states that about 25% of the irrigation water applied to arid soils results in the deep percolation that recharges groundwater. They further noted that, if artificial recharge processes were undertaken in these areas, salt loading could be "very significant."

Runnells (1976) discussed the potential to use the vadose zone to attenuate certain chemicals by evaluating the soil type and adding certain amendments such as pH buffering or oxidation agents. Saffigna and Keeney (1977) found that the application of irrigation water was increasing the nitrate and chloride concentrations in the groundwater of the sand plains of central Wisconsin. Tedaldi and Loehr (1992) theorized that the dissolution of naturally occurring minerals could be a significant contributor to the amount of salts in groundwater.

A literature search and vadose zone modeling conducted for the Chino Basin indicated that 70 to 80% of the applied salt mass would reach the groundwater. The remaining mass was believed to be locked in the vadose zone as immobile

mass. The fate of the immobile mass was unclear particularly under conditions such as if groundwater levels were to rise and saturate the vadose zone.

Zone 7's limited vadose attenuation literature review and preliminary modeling investigation confirmed the complexity of the issue and the likely high costs of attempting to more rigorously quantify site specific attenuation percentages. Zone 7 water quality and salt mass balance results also generally supported an assumption of minimal attenuation

Given these results and recommendations from the GMAC and TAG, a policy decision was made that instead of spending significant amounts of money on vadose zone modeling, the money should be spent on fixing the salt loading problem. It was further decided to use zero salt attenuation as a conservative management policy decision. However, several salt management strategies were evaluated (Chapter IX) that did include assumptions of 15 and 30% attenuation to determine how sensitive the results and conclusions were to the zero attenuation assumption.

3.6 Hydrogeologic Information Collection

There have been over 5,000 wells, and countless soil borings drilled in the Livermore Groundwater Basin. The record goes back approximately 110 years to the late 1800s. Basin geology, water levels, water quality, aquifer properties, and boundary conditions have been compiled, studied, and reported by the USGS, California Department of Water Resources, and Zone 7 Water Agency since the 1950's (Williams, 1912, CDWR, 1955, 1960, 1963, 1974; Zone 7 annual monitoring reports, Sorenson et al, 1985; Dibblee, 1980; Sylvester, 1983).

Zone 7 has been collecting precipitation, surface water and groundwater level, and water quality data since 1978. Currently, a network of 23 surface water gauging sites, 11 climatological stations and approximately 200 wells are monitored by Zone 7 for the purpose of groundwater management; i.e., water inventory and quality. Included in the monitoring well network are several multi-level piezometers or well clusters. Water level measurements are periodically made and water quality samples are collected annually from these wells/piezometers to evaluate vertical gradients and flow components.

Municipal water supply well data, such as production histories, water quality, and production logs are shared between local agencies and local water purveyors. Additionally through its Groundwater Protection Ordinance program (GPO), Zone 7 receives well location, well log, and pump test (when performed) information for all new wells drilled in the Zone 7 Service area from the permittees. These data are all cataloged and archived in Zone 7's historic databases.

Recently, Zone 7 conducted a well siting study to evaluate several locations in the Main Basin as potential new production well sites. During the investigation, Zone 7 drilled and tested six sites, Sites 7, 8, 9, 11, 15, and Murrieta. Lithology and borehole geophysical logging and depth-specific water quality sampling were conducted at each site. At Sites 7, 9, 11 and 15, a second well was drilled for production testing purposes. Aquifer testing, production logging, and additional water quality sampling were conducted in these wells. The data and analyses are reported in individual site-specific reports written by Fugro West, Inc. (Fugro 1999a-e) and have been added to the appropriate Zone 7 databases. Similar testing was done by DSRSD and the City of Livermore at several locations for their proposed RO recycled water injection projects. Table 3.2 summarizes the aquifer property results from recent well siting investigations, as well as those from the recycled water project aquifer tests.

Table 3.2:
Summary of Recent Aquifer Test Results

Site No.	State Well No.	Ave. Transmissivity (gpd/ft)	Ave. Storage Coefficient
Site 7	3S/1E 8H 14	98,400	0.0022
Site 9			
Site 11	3S/1E 15M 4	54,300	0.0062
Site 15 (Hop 4)	3S/1E 17D 2	90,400	0.0007
Stoneridge	3S/1E 9B 1	280,500	0.00178
Mocho 1	3S/1E 9M 2	485,600	0.00031
Site 15 (Hop 9)			

Other recent data acquisitions include the collection of various geophysical log data for several private and public production or test wells that have been recently drilled in the valley. Zone 7 has encouraged, and in some instances provided for, the logging of several new key wells.

Zone 7 will continue to collect hydrogeologic data through its various monitoring and GPO programs. Zone 7 has scheduled the construction of several new production wells in the near future. As these wells are drilled and tested, Zone 7 will collect additional data from these locations. As other potential well sites are explored by Zone 7 as part of the Well Master Plan effort, staff will continue to collect lithologic, hydrologic, and geophysical data from these locations. An attempt will be made to fill in the areas where modern geophysical logs are sparse or lacking by continuing to encourage, and sometimes provide for the running of

geophysical surveys in key new private wells and exploration borings as they are identified during the permitting process.

Several new monitoring wells are planned for the explicit purpose of salt impact monitoring (see Chapter 6, Salt Management Monitoring Plan). Besides providing additional water level, flow gradient and water quality data, they provide an opportunity to collect additional geological information such as: lithology, geologic heterogeneity, and aquifer thickness near the basin margins.

Lawrence Livermore National Laboratories (LLNL) has recently obtained a grant from the State Water Resources Agency to investigate the vulnerability of groundwater supplies throughout the state by age dating the water from several hundred production wells. Zone 7 and several other local groundwater producers may cooperate in this investigation. The results may be used to refine the current understanding of flow velocities and directions and aquifer mixing.

3.7 Groundwater Model

A groundwater model is a device that represents an approximation of a groundwater basin. Physical models such as laboratory sand tanks simulate groundwater flow directly. A mathematical groundwater model simulates groundwater flow indirectly by means of equations to represent the physical process that occur in the groundwater basin. A mathematical model can be solved analytically or numerically. Since analytical solutions are not suitable due to complexities in the groundwater flow modeling, numerical groundwater modeling is more often used for groundwater basin modeling.

Groundwater models are useful for predicting the consequences of a proposed groundwater basin management action. Groundwater models can also be used to learn about the controlling parameters in a site-specific setting such as establishing locations and characteristics of aquifer boundaries.

The original Main Basin groundwater model was developed by Zone 7 and the California Department of Water Resources (DWR) in the 1970's and is documented in DWR Bulletin 118-2. Davies (a Stanford graduate student) developed a groundwater model of the Amador Sub-basin in 1981. Danskin (another Stanford graduate student) extended this model into the Bernal Sub-basin in December 1985 and calibrated the model for average fluxes for the period 1977-1981. Although these models and the associated documentation provided some useful technical information, Zone 7 did not use them for basin management studies.

In 1996, Zone 7 staff retained consultant CH2M Hill to assist with the development of a groundwater flow and solute (salt) transport model for the main groundwater basin. The model was designed to be useable by Zone 7 staff for evaluating alternative Salt Management Plan (SMP) strategies (see Chapter X) and

future Main Basin management options. The resultant model, as currently used by Zone 7 staff, includes the Visual MODFLOW for Windows version 2.61 by Waterloo Hydrologic, Inc. package. Visual MODFLOW uses the three-dimensional MODFLOW code to simulate groundwater flow and the three-dimensional MT3D code to simulate solute transport.

3.7.1 Model Grid and Properties

The model grid has four layers and a uniform 500 x 500 foot grid in X and Y directions covering the entire Livermore-Amador Valley Groundwater Basin. Figure 3.12 shows the modeled area. It is a three dimensional model and the thickness of the grid cells varies throughout the model area. The top three layers represent the upper unconfined aquifer, the deep confined aquifer and an intervening aquitard layer, respectively. Figures 3.13 and 3.14 present cross-sectional profiles in the North-South and East-West directions. These cross-sections illustrate typical layer geometry. The model layer elevations for the major portion of the model are based upon a number of geologic well logs.

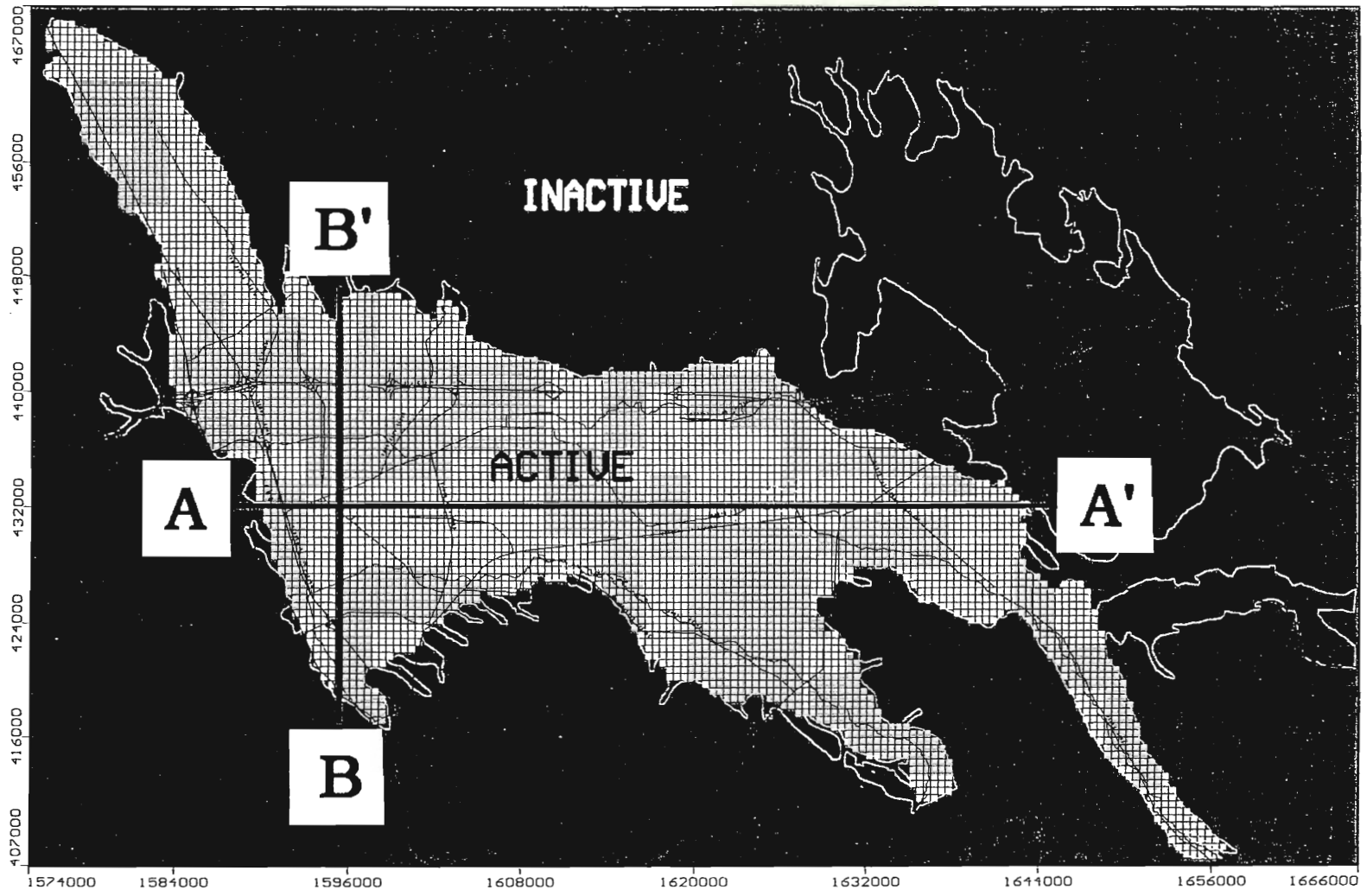
Most of the municipal wells are screened in the deep aquifer. The fourth layer of the model represents the Livermore and Tassajara formations. This layer at this time is inactive since the Livermore and Tassajara formations are low yielding it is believed that there is not any significant interaction with the deep aquifer. To further focus Zone 7 resources it was decided to activate only the Main Basin and some key fringe basins. The current active model area therefore covers the Main Basin (Amador, Bernal, Castle and Mocho II sub-basins) plus the Dublin, Camp, and Bishop fringe sub-basins. The active and inactive areas of the model are shown in Figure 3.12. The boundary between the active and inactive areas represents a no flow boundary.

Figures 3.15 through 3.17 show the hydraulic conductivity distribution for the three active model layers. The hydraulic conductivity ranges from 0.7 to 134 ft/day for model layer 1 (upper aquifer), 0.001 to 0.2 ft/day for model layer 2 (aquitard layer) and 1 to 350 ft/day for model layer 3 (deep aquifer). Figures 3.18 and 3.19 show the distribution of specific yield (Sy) in the model layer 1 and specific storage (Ss) in model layer 3.

The Livermore, Mocho, Parks and Pleasanton faults are represented in the model using the MODFLOW horizontal flow boundary package. Figure 3.20 shows the location of the faults in the deep aquifer. Groundwater monitoring data and earlier investigations indicate that these faults impede flow across them only in the deep aquifer.

3.7.2 Model Fluxes

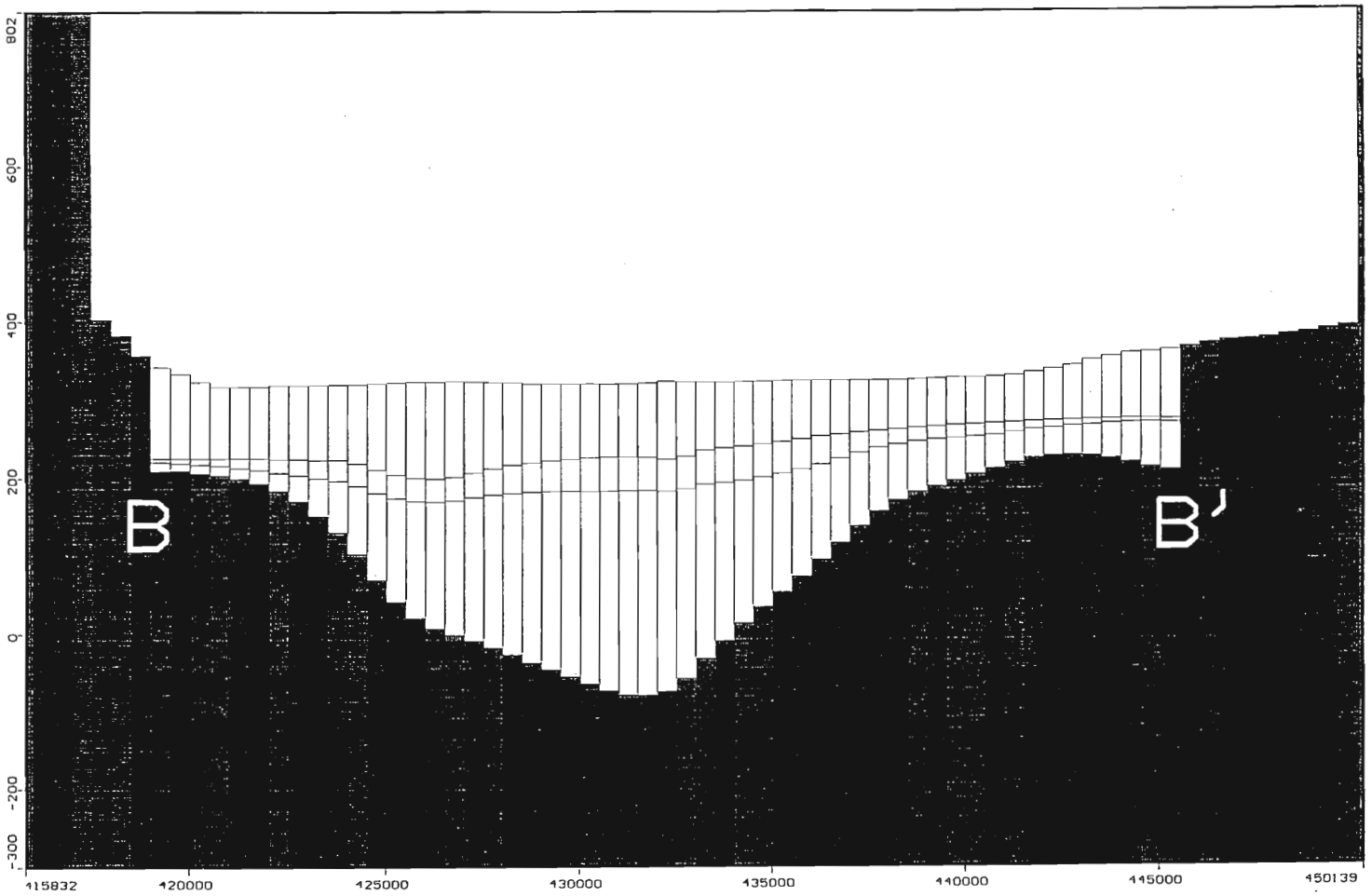
The model flux sources (i.e., inputs) include rainfall recharge, applied irrigation water recharge, stream recharge, and injection well recharge. Flux sinks (outputs)



CH2M Hill Inc – Oakland, CA
Project: LVGWB Model v. 2.0.55
Description: Model Grid
Modeller: CH2M Hill
9 Jan 98

Visual MODFLOW v.2.61, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 184 NR: 120 NL: 4
Current Layer: 1

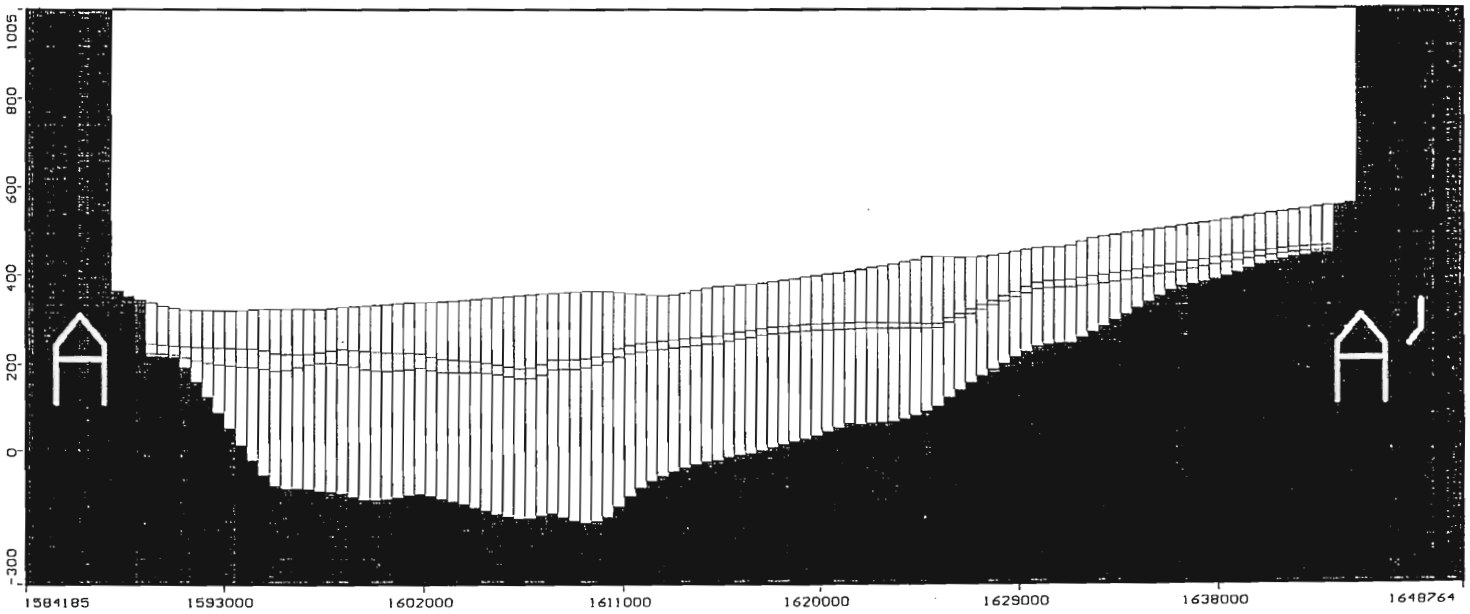
FIGURE 3.12



CH2M Hill Inc – Oakland, CA
Project: LVGWB Model v. 2.0.55
Description: Cross Section B–B' (C43)
Modeller: CH2M Hill
9 Jan 98

Visual MODFLOW v.2.61, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 184 NR: 120 NL: 4
Current Column: 43

FIGURE 3.13



CH2M Hill Inc – Oakland, CA
Project: LVGWB Model v. 2.0.55
Description: Cross Section A–A' (R70)
Modeller: CH2M Hill
9 Jan 98

Visual MODFLOW v.2.61, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 184 NR: 120 NL: 4
Current Row: 70

FIGURE 3.14

include groundwater well pumping, gravel mining pumping and groundwater outflow (gaining streams).

Each of these main flux components has sub-components. For example, stream recharge includes natural recharge, artificial recharge, and gravel mining recharge. Recharge on each stream is also divided into a number of reaches since recharge rates vary depending on stream location. Based upon monitoring program data, two databases were prepared that had monthly data for each component of recharge and pumpage for the period 1974-95. Tables 3.3, 3.4 and 3.5 list the components of recharge and pumpage. Each of the recharge components was also assigned a TDS value based upon the monitoring data. Table 3.6 lists the TDS in mg/L for each recharge component.

The rainfall recharge and applied water recharge in the model are combined as areal recharge. The areal recharge amounts and TDS vary with soil type and hydrologic conditions throughout the model area. To address this situation, the areal recharge was distributed using DWR model nodal zone designations. Fig 3.21 presents the node numbers and the average TDS of areal recharge for each node.

Natural stream recharge, artificial stream recharge and gravel mining stream recharge are modeled using the MODFLOW river package. The river package is used in the model in such a way that the recharging streams operate as specified flux boundaries. The gaining streams and mining gravel pits are modeled using the MODFLOW drain package. During the model application for salt management plan simulations, the mining ponds (Chain of Lakes) were modeled as evaporation boundaries with the west face (recharging face) of Lake I modeled as injection wells into the upper aquifer.

3.7.3 Initial Conditions

Initial conditions for the flow model were based upon Zone 7 fall 1975 groundwater level data for the upper and lower aquifers. The initial conditions for the aquitard were assumed to be the same as for the upper aquifer. The initial conditions for the solute transport model were also based upon actual Zone 7 data (generally 1990-1995 monitoring data) for the upper and lower aquifers. The aquitard TDS used was the average of upper and lower aquifer TDS.

3.7.4 Model Flow Calibration

Model calibration typically involves running the model, comparing the model output with the observed data, adjusting the model properties and/or model fluxes, and then redoing this repeatedly until there is a reasonable fit between the predicted and observed data. Comparisons between contour maps of measured and simulated heads provides a qualitative measure of the similarity between patterns, thereby giving an idea of the spatial distribution of error. Comparisons between

ZONE 7
WATER RESOURCES ENGINEERING

DESCRIPTION OF RECORDS IN "RECHRAGE.DBF" FILE

THE DBF FILE IS LOCATED AT E:\MODFLOW\CH2M\FLOWDATA\RECHARGE.DBF. THE FILE CONTAINS THE RECHARGE COMPONENTS FOR THE MAIN GW BASIN FOR 1974-95.

STATION	FIRST YEAR	Rech/Pump	Layer	Description
ADLL_OUT_M1	1974	Recharge	1	ADLLP outflow
ALP_RC_M1	1974	Recharge	1	ALP conservation rech. thru M1
ALP_RC_M2	1974	Recharge	1	ALP conservation rech. thru M2
ALP_RC_M3	1974	Recharge	1	ALP conservation rech. thru M3
ALP_RN_M1	1974	Recharge	1	ALP natural rech. thru M1
ALP_RN_M2	1974	Recharge	1	ALP natural rech. thru M2
ALP_RN_M3	1974	Recharge	1	ALP natural rech. thru M3
AM_RC_M1	1974	Recharge	1	AM conservation rech. thru M1
AM_RC_M2	1974	Recharge	1	AM conservation rech. thru M2
AM_RC_M3	1974	Recharge	1	AM conservation rech. thru M3
AM_RC_M4	1974	Recharge	1	AM conservation rech. thru M4
AM_RC_M5	1974	Recharge	1	AM conservation rech. thru M5
AM_RC_M6	1974	Recharge	1	AM conservation rech. thru M6
AM_RCM_M4	1974	Recharge	1	AM recharge from Calmat thru M4
AM_RKA_M5	1974	Recharge	1	AM recharge from Kaiser thru M5
AM_RN_M1	1974	Recharge	1	AM natural rech. thru M1
AM_RN_M2	1974	Recharge	1	AM natural rech. thru M2
AM_RN_M3	1974	Recharge	1	AM natural rech. thru M3
AM_RN_M4	1974	Recharge	1	AM natural rech. thru M4
AM_RN_M5	1974	Recharge	1	AM natural rech. thru M5
AM_RN_M6	1974	Recharge	1	AM natural rech. thru M6
AV_RC_M1	1974	Recharge	1	AV conservation rech. thru M1
AV_RC_M2	1974	Recharge	1	AV conservation rech. thru M2
AV_RC_M3	1974	Recharge	1	AV conservation rech. thru M3
AV_RC_M4	1974	Recharge	1	AV conservation rech. thru M4
AV_RC_M5	1974	Recharge	1	AV conservation rech. thru M5
AV_RKA_M4	1974	Recharge	1	AV recharge from Kaiser thru M4
AV_RLS_M4	1974	Recharge	1	AV recharge from Lonestar thru M4
AV_RN_M1	1974	Recharge	1	AV natural rech. thru M1
AV_RN_M2	1974	Recharge	1	AV natural rech. thru M2
AV_RN_M3	1974	Recharge	1	AV natural rech. thru M3
AV_RN_M4	1974	Recharge	1	AV natural rech. thru M4
AV_RN_M5	1974	Recharge	1	AV natural rech. thru M5
INFLOW_N15	1974	Recharge	1	Inflow into Node 15
INFLOW_N16	1974	Recharge	1	Inflow into Node 16
INFLOW_N23	1974	Recharge	1	Inflow into Node 23
RC_AW_U_N15	1974	Recharge	1	Urban Applied Water Recharge in Node 15
RC_AW_U_N16	1974	Recharge	1	Urban Applied Water Recharge in Node 16
RC_AW_U_N17	1974	Recharge	1	Urban Applied Water Recharge in Node 17
RC_AW_U_N18	1974	Recharge	1	Urban Applied Water Recharge in Node 18
RC_AW_U_N19	1974	Recharge	1	Urban Applied Water Recharge in Node 19
RC_AW_U_N20	1974	Recharge	1	Urban Applied Water Recharge in Node 20
RC_AW_U_N23	1974	Recharge	1	Urban Applied Water Recharge in Node 23
RC_AW_U_N24	1974	Recharge	1	Urban Applied Water Recharge in Node 24
RC_AW_U_N25	1974	Recharge	1	Urban Applied Water Recharge in Node 25
RC_AW_U_N26	1974	Recharge	1	Urban Applied Water Recharge in Node 26
RC_AW_U_N29	1974	Recharge	1	Urban Applied Water Recharge in Node 29
RC_AW_U_N30	1974	Recharge	1	Urban Applied Water Recharge in Node 30
RC_AW_U_N31	1974	Recharge	1	Urban Applied Water Recharge in Node 31
RC_AW_U_N33	1974	Recharge	1	Urban Applied Water Recharge in Node 33
RC_AW_U_N34	1974	Recharge	1	Urban Applied Water Recharge in Node 34
RC_AW_U_N35	1974	Recharge	1	Urban Applied Water Recharge in Node 35
RC_AW_U_N38	1974	Recharge	1	Urban Applied Water Recharge in Node 38
RC_AW_U_N39	1974	Recharge	1	Urban Applied Water Recharge in Node 39
RC_AW_U_N40	1974	Recharge	1	Urban Applied Water Recharge in Node 40
RC_AW_U_N41	1974	Recharge	1	Urban Applied Water Recharge in Node 41
RC_AW_U_N42	1974	Recharge	1	Urban Applied Water Recharge in Node 42
RC_LWRP_N29	1974	Recharge	1	LWRP Applied Water Recharge in Node 29
RC_LWRP_N30	1974	Recharge	1	LWRP Applied Water Recharge in Node 30
RC_LWRP_N33	1974	Recharge	1	LWRP Applied Water Recharge in Node 33

ZONE 7
WATER RESOURCES ENGINEERING

DESCRIPTION OF RECORDS IN "RECHRAGE.DBF" FILE

THE DBF FILE IS LOCATED AT E:\MODFLOW\CH2M\FLOWDATA\RECHARGE.DBF. THE FILE CONTAINS THE RECHARGE COMPONENTS FOR THE MAIN GW BASIN FOR 1974-95.

RC_RR_N15	1974	Recharge	1	Rainfall Recharge in Node 15
RC_RR_N16	1974	Recharge	1	Rainfall Recharge in Node 16
RC_RR_N17	1974	Recharge	1	Rainfall Recharge in Node 17
RC_RR_N18	1974	Recharge	1	Rainfall Recharge in Node 18
RC_RR_N19	1974	Recharge	1	Rainfall Recharge in Node 19
RC_RR_N20	1974	Recharge	1	Rainfall Recharge in Node 20
RC_RR_N23	1974	Recharge	1	Rainfall Recharge in Node 23
RC_RR_N24	1974	Recharge	1	Rainfall Recharge in Node 24
RC_RR_N25	1974	Recharge	1	Rainfall Recharge in Node 25
RC_RR_N26	1974	Recharge	1	Rainfall Recharge in Node 26
RC_RR_N29	1974	Recharge	1	Rainfall Recharge in Node 29
RC_RR_N30	1974	Recharge	1	Rainfall Recharge in Node 30
RC_RR_N31	1974	Recharge	1	Rainfall Recharge in Node 31
RC_RR_N33	1974	Recharge	1	Rainfall Recharge in Node 33
RC_RR_N34	1974	Recharge	1	Rainfall Recharge in Node 34
RC_RR_N35	1974	Recharge	1	Rainfall Recharge in Node 35
RC_RR_N38	1974	Recharge	1	Rainfall Recharge in Node 38
RC_RR_N39	1974	Recharge	1	Rainfall Recharge in Node 39
RC_RR_N40	1974	Recharge	1	Rainfall Recharge in Node 40
RC_RR_N41	1974	Recharge	1	Rainfall Recharge in Node 41
RC_RR_N42	1974	Recharge	1	Rainfall Recharge in Node 42
RC_SFWD_N19	1974	Recharge	1	SFWD Applied Water Recharge in Node 19
RC_SFWD_N20	1974	Recharge	1	SFWD Applied Water Recharge in Node 20
RC_UNAG_N15	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 15
RC_UNAG_N16	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 16
RC_UNAG_N17	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 17
RC_UNAG_N18	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 18
RC_UNAG_N19	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 19
RC_UNAG_N20	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 20
RC_UNAG_N23	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 23
RC_UNAG_N24	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 24
RC_UNAG_N25	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 25
RC_UNAG_N26	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 26
RC_UNAG_N29	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 29
RC_UNAG_N30	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 30
RC_UNAG_N31	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 31
RC_UNAG_N33	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 33
RC_UNAG_N34	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 34
RC_UNAG_N35	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 35
RC_UNAG_N38	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 38
RC_UNAG_N39	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 39
RC_UNAG_N40	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 40
RC_UNAG_N41	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 41
RC_UNAG_N42	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 42

ZONE 7
WATER RESOURCES ENGINEERING

DESCRIPTION OF RECORDS IN "WELLPRO2.DBF" FILE

THE DBF FILE IS LOCATED AT E:\MODFLOW\CH2M\FLOWDATA\WELLPRO2 .DBF. THE FILE CONTAINS THE PRODUCTION COMPONENTS FOR THE MAIN GW BASIN FOR 1974-95.

STATION	YEAR	Rech/Pump	Layer	Description
CASTLEWOOD_G	1974	Pumpage	3	Pumpage from Well 3S/1E 19A 3
CWS#20 (18B)	1974	Pumpage	3	Pumpage from Well 3S/2E 18B 1
CWS#24 (7P3)	1974	Pumpage	3	Pumpage from Well 3S/2E 7P 3
GWP_3S1E1P3	1974	Pumpage	3	Pumpage from Well 3S/1E 1P 3
GWP_3S1E20B2	1974	Pumpage	3	Pumpage from Well 3S/1E 20B 2
GWP_3S1E20C3	1991	Pumpage	3	Pumpage from Well 3S/1E 20C 3
GWP_AG_SFWD	1974	Pumpage	3	Pumpage from Well 3S/1E 20E 1
GWP_CASTLE	1974	Pumpage	3	Pumpage from Well 3S/1E 29E 4
GWP_CM_R16	1984	Pumpage	1	Calmat Pumpage From R16
GWP_CM_R17	1983	Pumpage	1	Calmat Pumpage From R17
GWP_CM_R19	1987	Pumpage	1	Calmat Pumpage From R19
GWP_CM_R21	1994	Pumpage	1	Calmat Pumpage From R21
GWP_CM_R3	1974	Pumpage	1	Calmat Pumpage From R3
GWP_CM_R5	1976	Pumpage	1	Calmat Pumpage From R5
GWP_CM_R8	1980	Pumpage	1	Calmat Pumpage From R8
GWP_KA_K24	1980	Pumpage	1	Kaiser Pumpage From K24
GWP_KA_K28	1983	Pumpage	1	Kaiser Pumpage From K28
GWP_KA_K30	1974	Pumpage	1	Kaiser Pumpage From K30
GWP_KA_K34	1987	Pumpage	1	Kaiser Pumpage From K34
GWP_KA_K35	1990	Pumpage	1	Kaiser Pumpage From K35
GWP_KA_K36	1985	Pumpage	1	Kaiser Pumpage From K36
GWP_LS_P20	1985	Pumpage	1	Lonestar Pumpage From P20
GWP_LS_P21	1987	Pumpage	1	Lonestar Pumpage From P21
GWP_LS_P22	1974	Pumpage	1	Lonestar Pumpage From P22
GWP_LS_P23	1980	Pumpage	1	Lonestar Pumpage From P23
GWP_LS_P30	1990	Pumpage	1	Lonestar Pumpage From P30
GWP_LS_P31	1983	Pumpage	1	Lonestar Pumpage From P31
GWP_LS_P7	1979	Pumpage	1	Lonestar Pumpage From P7
GWP_TVGLF	1992	Pumpage	3	Pumpage from Well 3S/1E 2P 7
GWP_UAG_N15	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 15
GWP_UAG_N16	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 16
GWP_UAG_N17	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 17
GWP_UAG_N18	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 18
GWP_UAG_N19	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 19
GWP_UAG_N20	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 20
GWP_UAG_N23	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 23
GWP_UAG_N24	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 24
GWP_UAG_N25	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 25
GWP_UAG_N26	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 26
GWP_UAG_N29	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 29
GWP_UAG_N30	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 30
GWP_UAG_N31	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 31
GWP_UAG_N33	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 33
GWP_UAG_N34	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 34
GWP_UAG_N35	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 35
GWP_UAG_N38	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 38
GWP_UAG_N39	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 39
GWP_UAG_N40	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 40
GWP_UAG_N41	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 41
GWP_UAG_N42	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 42
HOP 1	1974	Pumpage	3	Pumpage from Well 3S/1E 18A 1
HOP 4	1974	Pumpage	3	Pumpage from Well 3S/1E 17D 2
HOP 6	1974	Pumpage	3	Pumpage from Well 3S/1E 18A 6
MOCHO 1	1974	Pumpage	3	Pumpage from Well 3S/1E 9M 2
MOCHO 2	1974	Pumpage	3	Pumpage from Well 3S/1E 9M 3
PLEAS #5	1974	Pumpage	3	Pumpage from Well 3S/1E 16L 5
PLEAS #6	1974	Pumpage	3	Pumpage from Well 3S/1E 16L 7
PLEAS #7	1974	Pumpage	3	Pumpage from Well 3S/1E 18A 5
PLEAS #8	1993	Pumpage	3	Pumpage from Well 3S/1E 16A 2
STONERIDGE_1	1992	Pumpage	3	Pumpage from Well 3S/1E 9B 1

ZONE 7
WATER RESOURCES ENGINEERING

DESCRIPTION OF RECORDS IN " RECHG_E. DBF" FILE

THE DBF FILE IS LOCATED AT E:\MODFLOW\CH2M\FLOWDATA\RECHG_E.DBF. THIS FILE CONTAINS THE RECHARGE AND DISCHARGE COMPONENTS FOR DUBLIN, CAMP AND BISHOP SUBBASINS. IT ALSO CONTAINS THE ADDITIONAL AG APPLIED WATER RECHARGE IN NODE 40 OF MOCHO SUBBASIN DUE TO DELIVERIES FROM SBA REACH 4 OF SBA.. THIS DBF FILE FOR THE PERIOD 1974-1995.

STATION	FIRST YEAR	RECHARGE/ DISCHARGE	LAYER	DESCRIPTION
ALMO_OUT_M1	1974	DISCHARGE	1	GW OUTFLOW INTO REACH M1 OF ALAMO CANAL
ALMO_OUT_M2	1974	DISCHARGE	1	GW OUTFLOW INTO REACH M2 OF ALAMO CANAL
DUB_OUT_M2	1974	DISCHARGE	1	GW OUTFLOW INTO REACH M2 OF DUBLIN CREEK
RC_AW_U_N1	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N10	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N11	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N12	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N13	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N14	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N2	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N21	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N22	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N27	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N28	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N3	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N32	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N37	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N4	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N5	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N6	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N7	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N8	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N9	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_RR_N1	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N10	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N11	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N12	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N13	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N14	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N2	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N21	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N22	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N27	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N28	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N3	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N32	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N37	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N4	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N5	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N6	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N7	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N8	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N9	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_SBA4_N40	1974	RECHARGE	1	AG APPLIED WATER RECHARGE IN NODE 40 FROM SBA DELIVERIES IN RECCH 4 OF SBA
SMON_OUT_M2	1974	DISCHARGE	1	GW OUTFLOW INTO REACH M2 OF SAN RAMON CREEK
TJ_RN_M2	1974	RECHARGE	1	NATURAL STREAM RECHARGE IN REACH 2 OF TASAJARA CRE
DSRSD#1	1974	GW PUMPAGE		GW PUMPAGE FROM LAYER #3 BY WELL # 3S/1W 1B 1 CCE=1588899.8, CCN=442474.5
DSRSD#2	1974	GW PUMPAGE		GW PUMPAGE FROM LAYER #3 BY WELL # 3S/1W 1G 2 CCE=1589903.5, CCN=442109.7
DSRSD#3	1974	GW PUMPAGE		GW PUMPAGE FROM LAYER #3 BY WELL # 3S/1W 1H 2 CCE=1590968.1, CCN=441785.4

TABLE 3.6

RECHARGE WATER TDS IN mg/l

year	ARROYO VALLE					ARROYO MOCHO				ARROYO LAS POSITAS				TASAJARA CREEK	TDS OF BLENDED AREAL RECHARGE (INCLUDED AW_U, RR, AW_UNAG AND LWRP RECHARGE)					SUBSURFACE INFLOW	SUBSURFACE OUTFLOW	MINING COMPANY RECHARGES
	NATURAL		ARTIFICIAL	BLENDED TDS FOR		NATURAL	ARTIFICIAL	BLENDED TDS FOR		NATURAL	ARTIFICIAL	WASTEWATER	ALP BLENDED TDS	NATURAL RECHARGE TDS	ALL MAIN BASIN NODES EXCEPT NODES 29,30 & 33	NODES 29,30&33 (LWRP)	NODES 1 THROUGH 5	NODES 6 THROUGH 14	NODES 21,22,27 28, 32 & 37			
	upper reaches AV REACHES M1 TO M3	lower reaches AV REACHES M4 TO M5		REACHES M1 - M3	REACHES M4 - M5			REACHES M1 - M3	REACHES M4 - M6													
1974	597	233	150	**341**	**372**	400	150	**314**	**321**	700		650	**675**	**609**			**168**	**716**	**0**	**1,500**		450
1975	404	194	200	**268**	**280**	400	200	**335**	**355**	700		650	**670**	**609**			**171**	**659**	**0**	**1,500**		450
1976	800		200	**292**	**334**	400	200	**229**	**251**	700		650	**663**	**609**			**700**	**2384**	**0**	**1,500**		450
1977	800		500	**555**	**551**	400	500	**490**	**484**	700		650	**663**	**609**			**700**	**4807**	**0**	**1,500**		450
1978	478	209	350	**398**	**402**	400	350	**384**	**386**	700	350	650	**659**	**609**			**119**	**624**	**0**	**1,500**		450
1979	800	250	200	**295**	**295**	400	200	**234**	**265**	700		650	**670**	**609**			**370**	**1164**	**0**	**1,500**	**850**	450
1980	561	214	200	**282**	**282**	400	200	**264**	**302**	700	200	650	**590**	**609**			**125**	**332**	**0**	**1,500**	**850**	450
1981	800	250	200	**262**	**268**	400	200	**229**	**269**	700	200		**455**	**609**			**700**	**2111**	**0**	**1,500**	**850**	450
1982	441	209	200	**299**	**309**	400	200	**319**	**340**	1,000	200		**834**	**609**			**34**	**99**	**0**	**1,500**	**850**	460
1983	298	193	150	**257**	**283**	400	150	**376**	**394**	1,200			**1,200**	**609**			**25**	**58**	**0**	**1,500**	**850**	430
1984	739	247	150	**556**	**508**	400		**400**	**405**	1,200			**1,200**	**609**			**261**	**605**	**0**	**1,500**	**850**	420
1985	800	250	200	**430**	**425**	400		**400**	**404**	1,200			**1,200**	**609**			**700**	**2176**	**0**	**1,500**	**850**	420
1986	345	177	240	**320**	**394**	400		**400**	**402**	1,200			**1,200**	**609**			**69**	**257**	**0**	**1,500**	**850**	460
1987	800	250	240	**451**	**473**	400		**400**	**400**	1,200			**1,200**	**609**			**700**	**2424**	**0**	**1,500**	**850**	480
1988	800	250	330	**557**	**552**	400	330	**360**	**360**	1,200			**1,200**	**609**			**700**	**3492**	**0**	**1,500**	**850**	550
1989	800	250	270	**425**	**489**	400	270	**291**	**291**	1,200			**1,200**	**609**			**700**	**3128**	**0**	**1,500**	**900**	510
1990	850	250	320	**539**	**500**	400	295	**305**	**305**	1,070			**1,070**	**609**			**700**	**3280**	**0**	**1,500**	**920**	490
1991	535	203	320	**453**	**535**	400	360	**375**	**375**	980			**980**	**609**			**535**	**3044**	**0**	**1,500**	**900**	570
1992	710	250	330	**545**	**548**	350	330	**345**	**345**	1,180			**1,180**	**609**			**520**	**2772**	**0**	**1,500**		550
1993	377	247	240	**317**	**427**	410	260	**330**	**339**	1,150			**1,150**	**609**			**61**	**229**	**0**	**1,500**		550
1994	570	250	270	**362**	**482**	580	260	**308**	**323**	850			**850**	**609**			**700**	**2619**	**0**	**1,500**		540
1995	409	239	200	**341**	**435**	370	160	**246**	**314**	1,000			**1,000**	**609**			**47**	**146**	**0**	**1,500**	**830**	520

FOR ALL MAIN BASIN NODES, SEE TABLE 3.6A FOR AREAL RECHARGE TDS.

AREAL RECHARGE TDS FOR ALL MAIN BASIN NODES

Table 3.6A

	Model stress		BLENDED TDS FOR EACH NODE(FOR APPLIED URBAN, APPLIED UNAG, RAIN , LWRP and AG applied water reharge)																				
	period		NODE NMBERS																				AVERAGE
YEAR	in days		15	16	17	18	19	20	23	24	25	26	29	30	31	33	34	35	38	39	40	41	42	
1974			1420	295	565	432	1014	885	706	600	529	1774	2427	1873	253	1844	1476	301	710	491	620	515	512	916
1975			1319	261	519	332	303	300	627	342	504	1677	2626	1872	243	2072	1348	274	631	430	642	455	460	821
1976	0.0	365.0	4115	2384	3419	2563	2717	2545	3220	2603	3229	4331	5302	4781	4800	5046	4215	1201	2511	953	946	953	953	2990
1977	365.0	730.0	4802	4807	4804	4807	4804	4805	4805	4807	4804	4801	5393	4800	4800	5567	4802	1922	4807	1923	1923	1923	1923	4182
1978	730.0	1095.0	1068	307	481	427	619	574	548	392	520	1466	2550	1706	189	2369	1256	290	645	496	861	527	528	849
1979	1095.0	1460.0	1199	404	950	565	1140	977	650	515	881	2444	3379	2604	494	3046	2126	421	838	498	689	516	520	1184
1980	1460.0	1825.0	179	132	391	163	357	326	190	170	330	1428	2369	1445	172	2464	1130	183	368	230	471	244	247	618
1981	1825.0	2190.0	844	704	1432	924	1919	1837	889	864	714	2299	4086	2974	367	3747	1398	626	1458	629	788	641	644	1418
1982	2190.0	2555.0	58	47	128	63	120	126	61	63	43	315	803	300	14	667	289	54	189	92	279	100	101	186
1983	2555.0	2920.0	33	27	71	33	231	187	35	40	29	162	636	194	0	566	177	31	84	56	182	61	70	138
1984	2920.0	3285.0	274	228	650	256	398	441	287	271	327	1087	2497	1445	0	1959	803	183	440	304	483	318	359	619
1985	3285.0	3650.0	544	524	470	622	1688	1586	573	666	866	2049	3383	2471	499	2644	2984	376	960	558	686	575	574	1205
1986	3650.0	4015.0	125	91	92	116	547	412	132	147	166	407	1028	713	0	939	686	111	241	199	402	214	215	332
1987	4015.0	4380.0	1717	1526	2564	1662	3453	3069	1792	1678	1934	2508	4644	3840	0	3998	2254	742	2197	880	919	887	891	2055
1988	4380.0	4745.0	2235	1979	1996	2162	3310	3095	2235	2253	2641	3168	5017	3790	0	4610	2489	1194	2584	1234	1288	1247	1241	2370
1989	4745.0	5110.0	1912	1825	1760	1981	3087	2948	1912	2040	2522	2976	4801	3633	0	4546	1840	1119	2283	1116	1164	1123	1124	2177
1990	5110.0	5475.0	2577	2369	2460	2492	3574	3410	2577	2589	2829	3580	5068	4000	0	4650	3265	1347	2751	1233	1236	1239	1246	2595
1991	5475.0	5840.0	252	185	172	205	955	821	269	224	170	698	2396	1080	0	2353	570	145	348	329	944	353	361	611
1992	5840.0	6205.0	1028	834	731	951	916	958	1084	1057	821	1185	3051	1452	0	3024	1140	524	1296	918	1133	947	951	1143
1993	6205.0	6570.0	130	94	92	120	109	128	137	130	117	185	1020	238	0	933	109	73	198	197	388	212	214	230
1994	6570.0	6935.0	853	702	672	837	772	841	894	924	726	801	3226	1580	0	3091	757	476	1148	721	885	739	741	1018
1995	6935.0	7300.0	86	62	61	80	72	78	91	92	66	73	596	161	0	641	61	52	124	130	282	140	140	147
			1217	899	1113	991	1459	1380	1078	1021	1126	1792	3014	2134	538	2763	1599	529	1219	619	782	633	637	1264

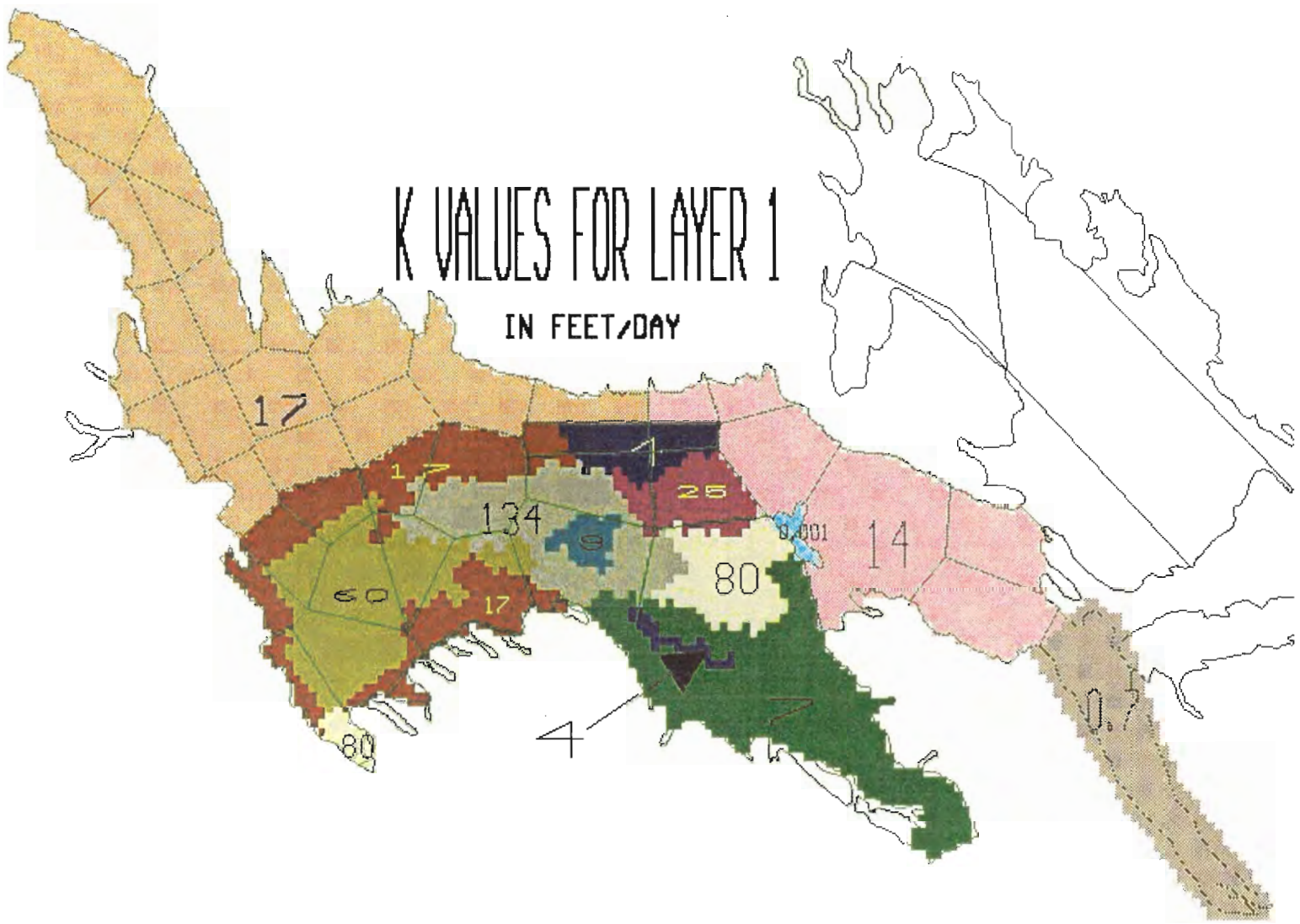

K VALUES FOR LAYER 1
IN FEET/DAY
17
1
25
134
9
80
14
0.001
60
17
80
4
0.7

FIGURE 3.15

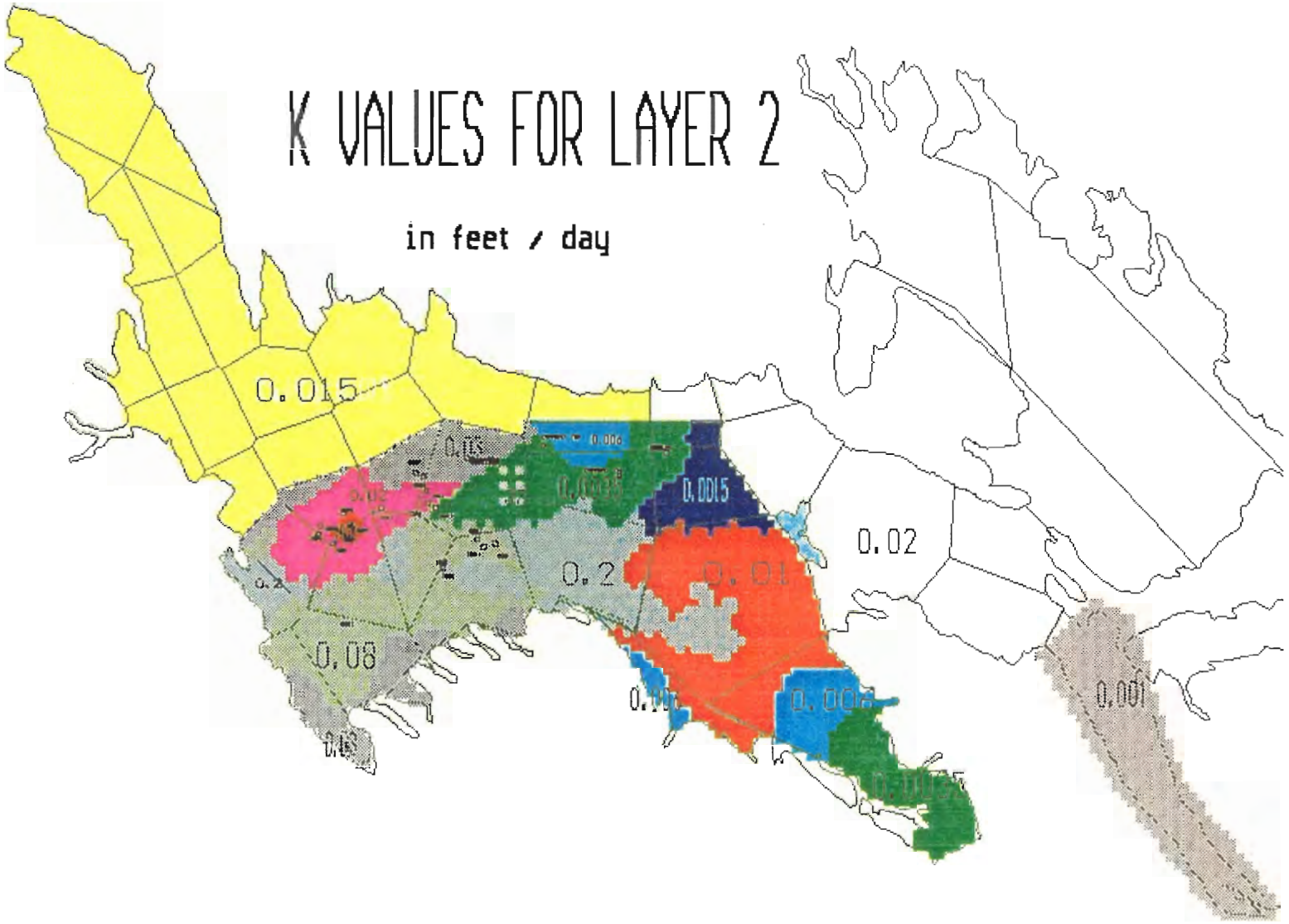


FIGURE 3.16

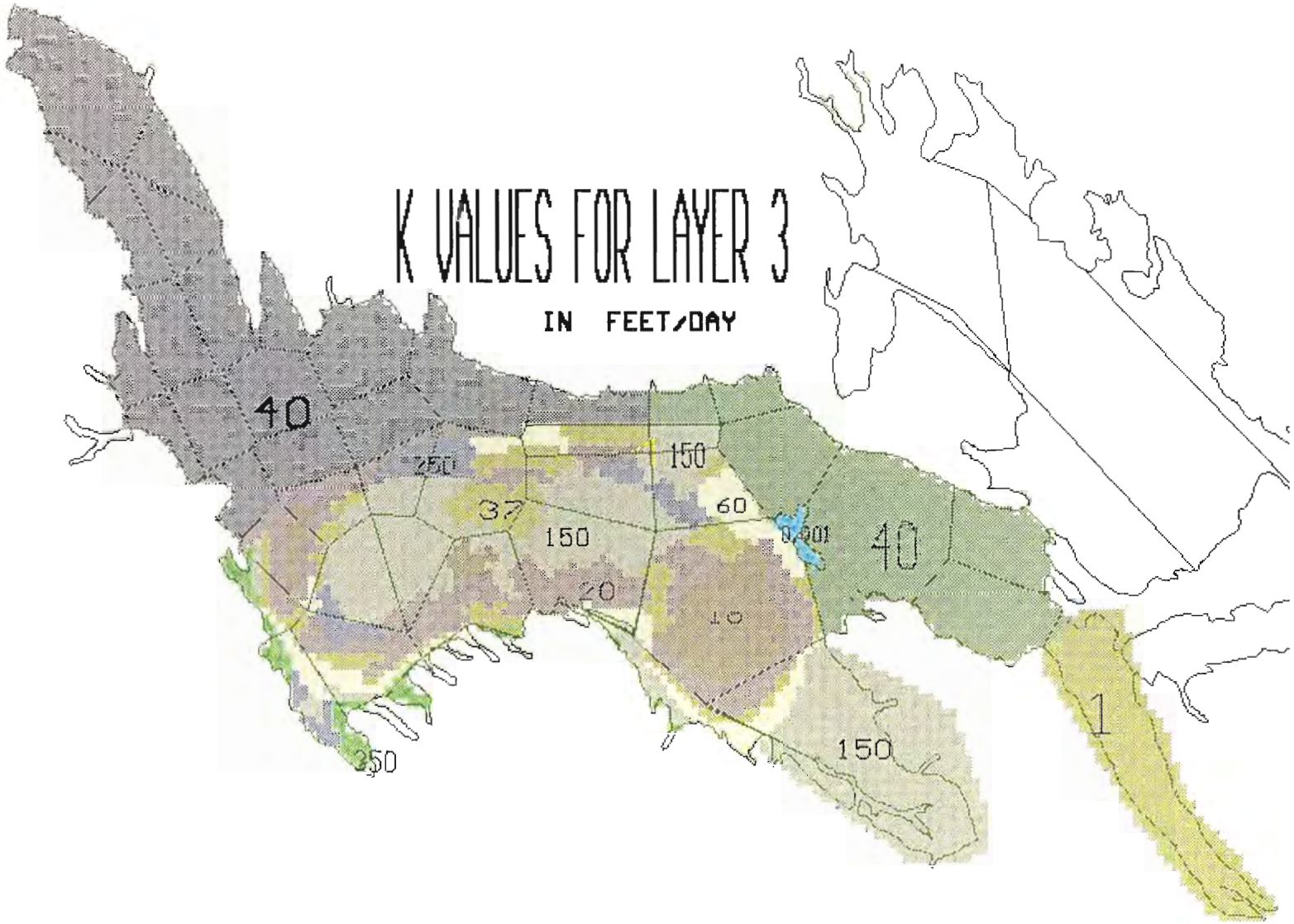

K VALUES FOR LAYER 3
IN FEET/DAY
40
250
37
150
150
60
0.001
40
20
10
250
150
1

FIGURE 3.17

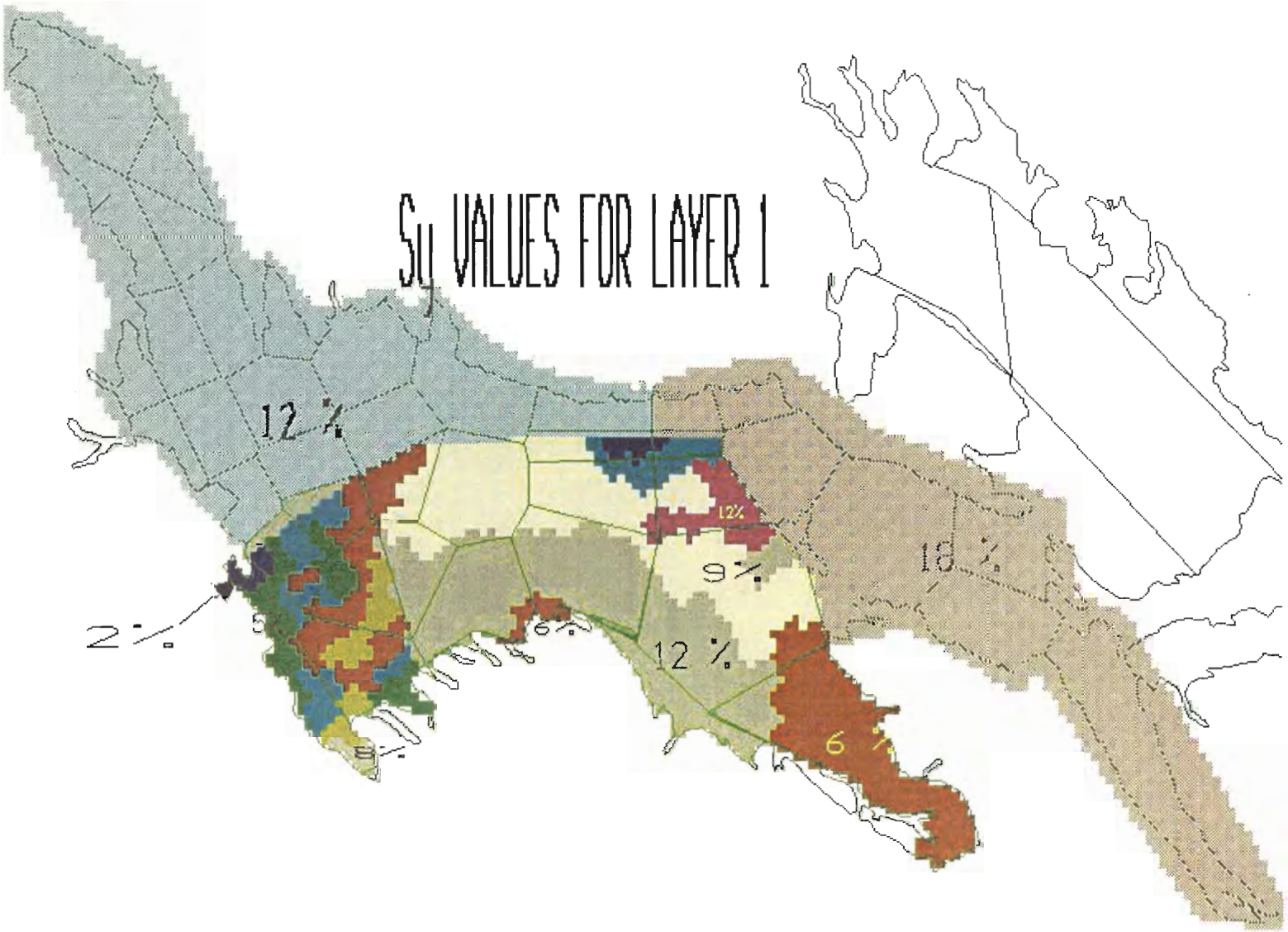


FIGURE 3.18

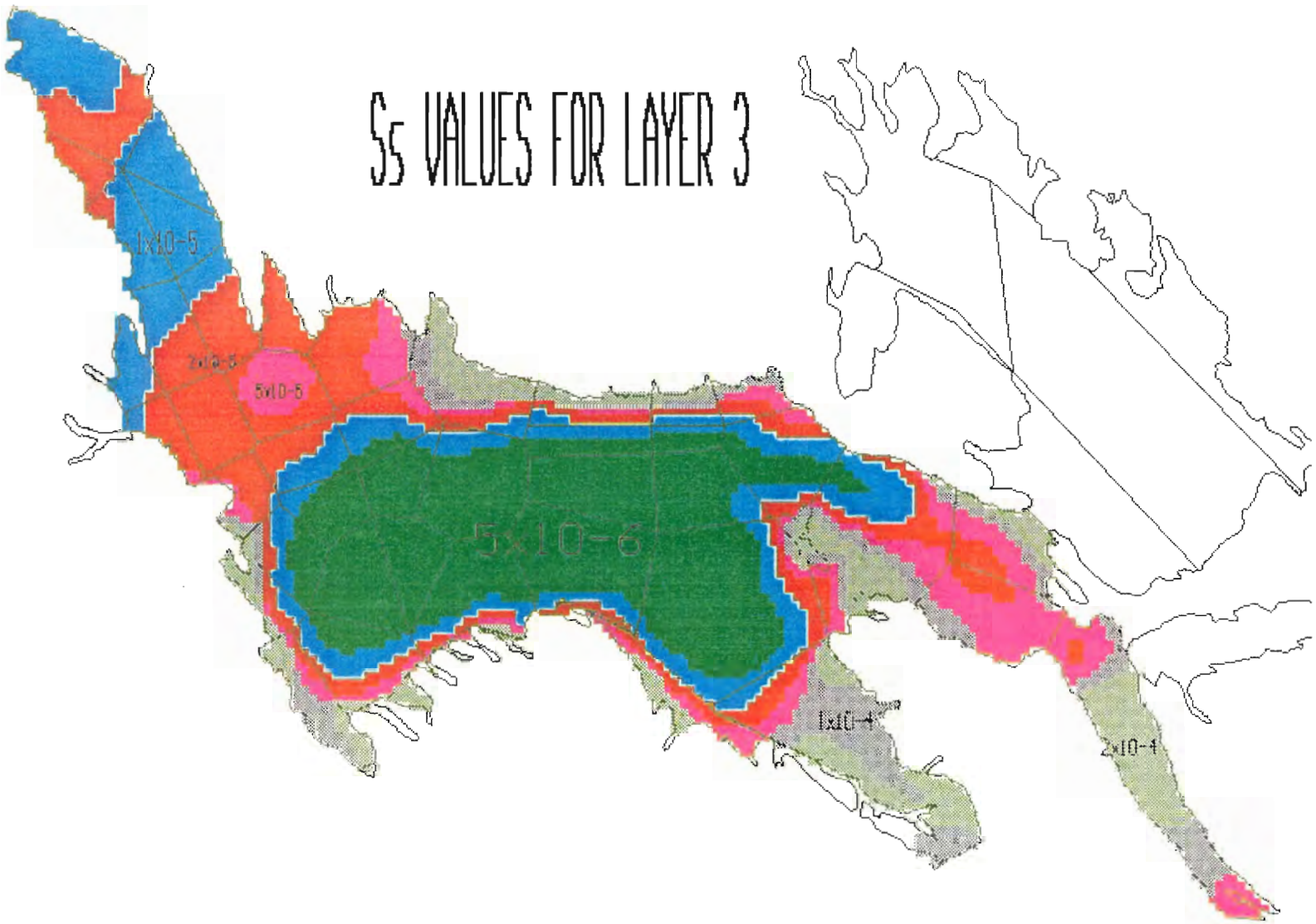
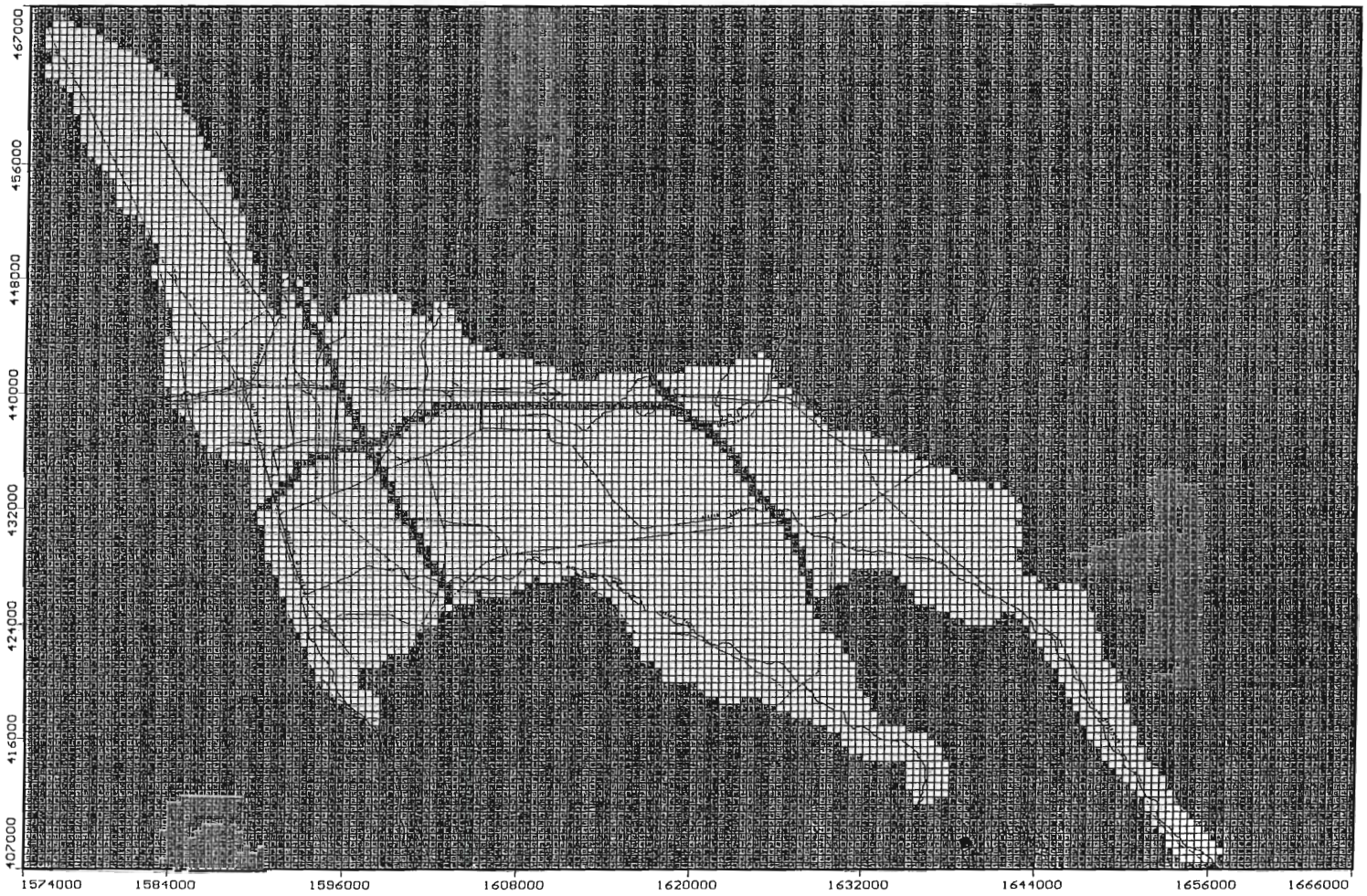


FIGURE 3.19

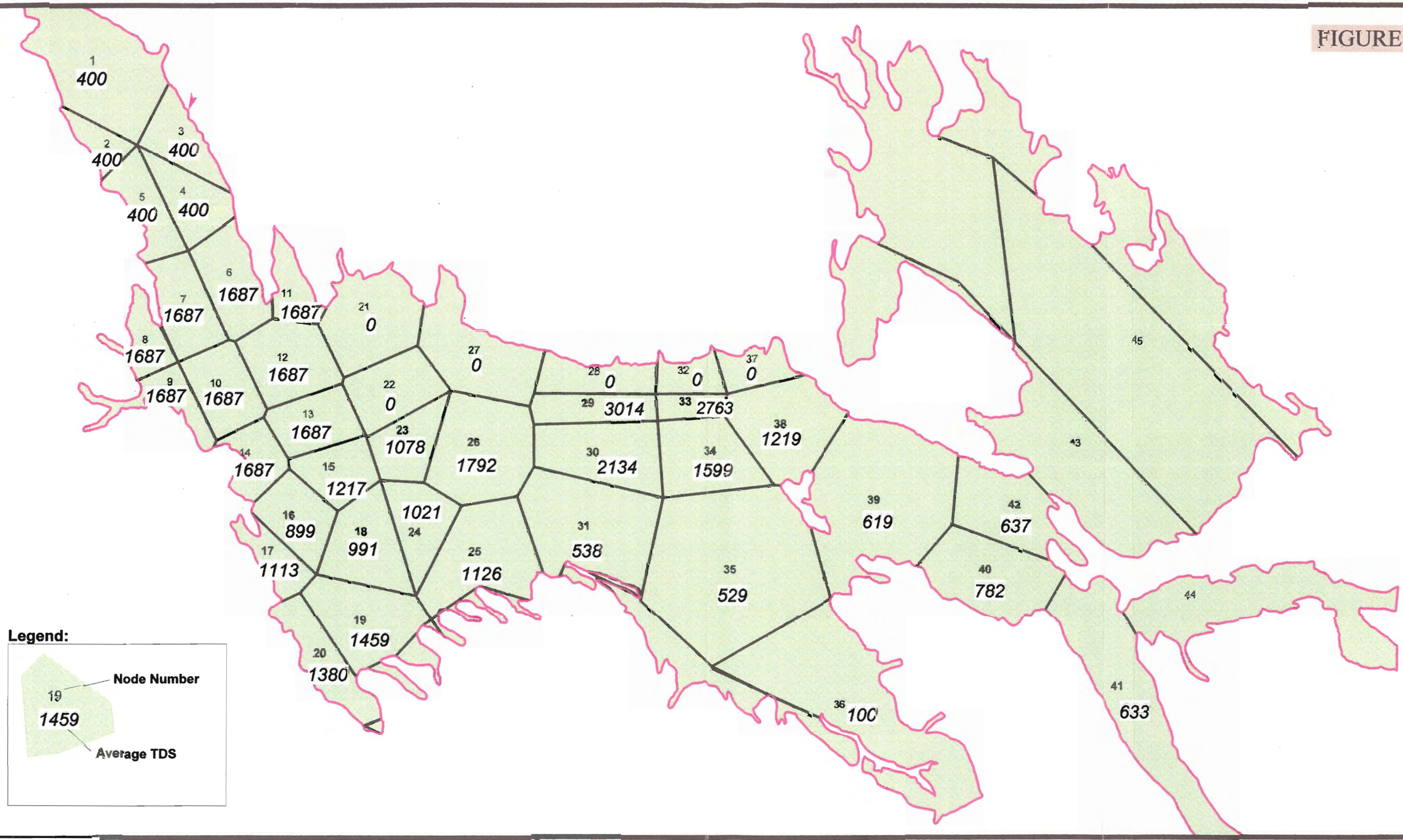


Zone 7 Water Agency – Pleasanton, CA
Project: LVGWB Model V 2.0.55
Description: Model Grid
Modeller: CH2M hILL & Zone 7
9 Jun 00

Visual MODFLOW v.2.61, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 184 NR: 120 NL: 4
Current Layer: 3

FIGURE 3.20

FIGURE 3.21



Legend:

ZONE 7 WATER AGENCY 5997 Parkside Dr, Pleasanton, Ca.	**Drawn By:** Todd Wendler **Designed By:** **Checked By:** **Approved by:**	WATER RESOURCES ENGINEERING **1974 - 95 AREAL RECHARGE** **(Rainfall and Applied Water)** **AVERAGE TDS**	**Scale:** 1"=6,000' **Date:** June 12, 2000 **File #:** H:\Geodata\avgtds2.wor

measured and simulated hydrographs at a given location help to evaluate the calibration in individual areas around the basin. Since most of the fluxes for the model were actual monitoring data, only model properties needed to be adjusted.

CH2M Hill performed 55 iterations by adjusting various model properties to calibrate the flow model. The availability of over 20 years of reliable hydrologic inventory and groundwater level data allowed for fairly precise calibration. The model properties were adjusted to match contour maps of measured and simulated heads, plus hydrographs of measured and simulated heads for nine selected wells.

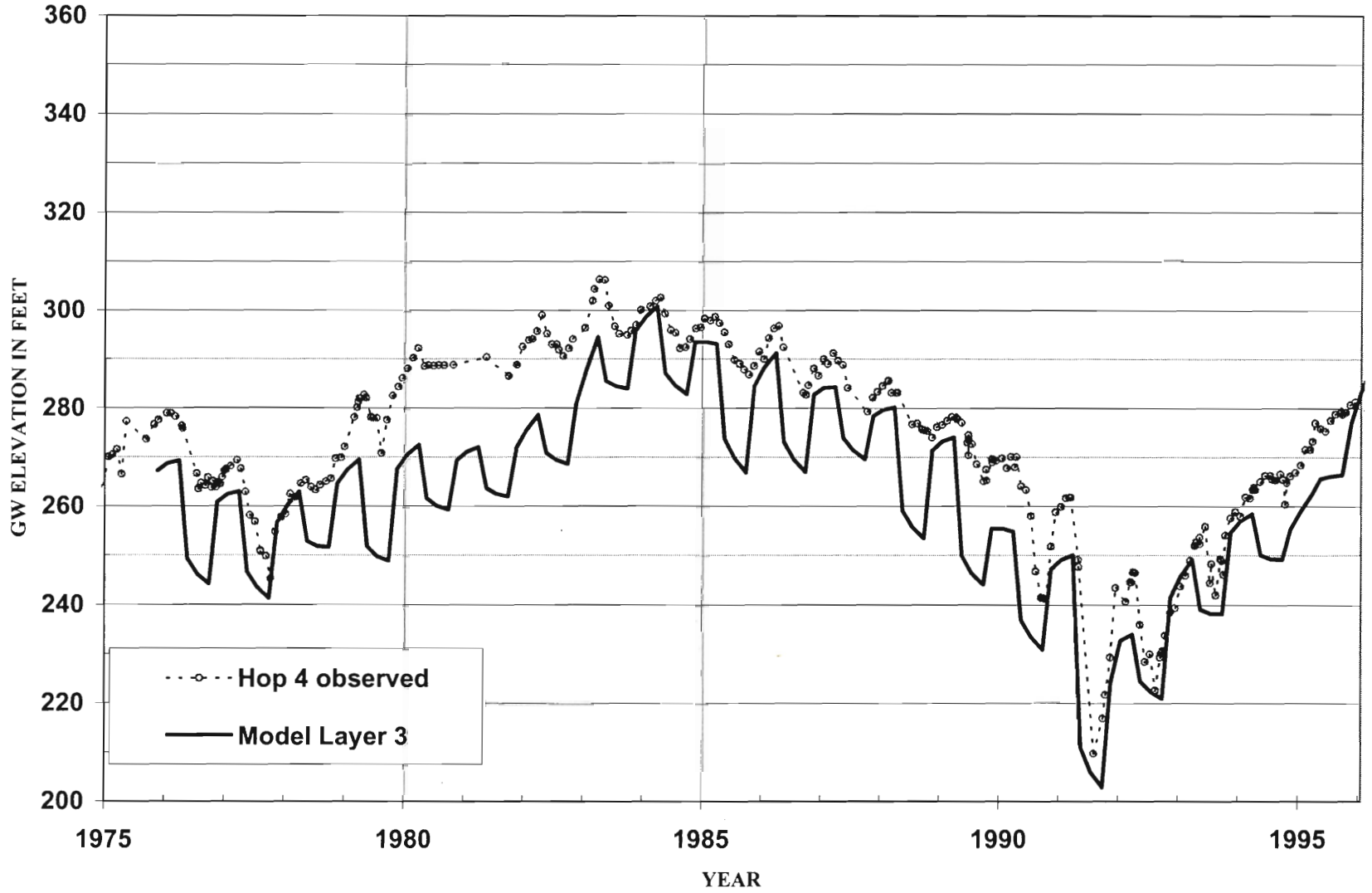
Calibration Hydrographs - As part of the calibrations, two wells from each sub-basin were selected for comparing observed and simulated outputs. Figure 3.22 presents the observed and simulated groundwater levels at the Hopyard well #4 in the Bernal sub-basin. The match between the observed and simulated groundwater levels was very good through most periods. The simulated and observed groundwater levels match very well from 1975 through 1979. During the 1980-83 period the simulated levels were about 20 feet lower than the observed groundwater levels. During 1984 the model groundwater levels recovered and by the end of 1984 and through the rest of the simulation period (1984-95) the simulated and observed groundwater levels matched well. Overall, the model acceptably matched both the long-term trends and semi-annual trends in observed groundwater levels.

Figure 3.23 presents the observed and simulated groundwater levels at the Mohr Avenue well (3s/1e 9p5) in the West Amador Sub-basin in model layer 1 (upper aquifer). The match between the observed and simulated groundwater levels is generally good. The simulated and observed groundwater levels match very well in 1978 (beginning of the observed data), show a similar trend between 1978-1995 and almost exactly match near the end of the simulation period in 1995. Overall, the model acceptably matched the long-term trend and end-of-period trend in observed groundwater levels.

Figure 3.24 presents the observed and simulated groundwater levels at the Mocho #2 well in the West Amador Sub-basin in model layer 3 (lower aquifer). The results at this location are very similar to the calibration simulation (above) for the Hop 4 location. The simulated and observed groundwater levels match very well from 1975 through the middle of 1980, while during the 1981-83 period the simulated levels were about 15 feet lower than the observed groundwater levels. During 1984 the model groundwater levels recovered and by the end of 1984 and through the rest of the simulation period (1984-95) the simulated and observed groundwater levels matched well. Overall, the model acceptably matched both the long-term trends and semi-annual trends in observed groundwater levels. The simulated groundwater levels almost exactly matched the observed levels near the end of the period.

Figure 3.25 presents the observed and simulated groundwater levels at the Hagemann key well in the East Amador Sub-basin in model layer 3 (lower

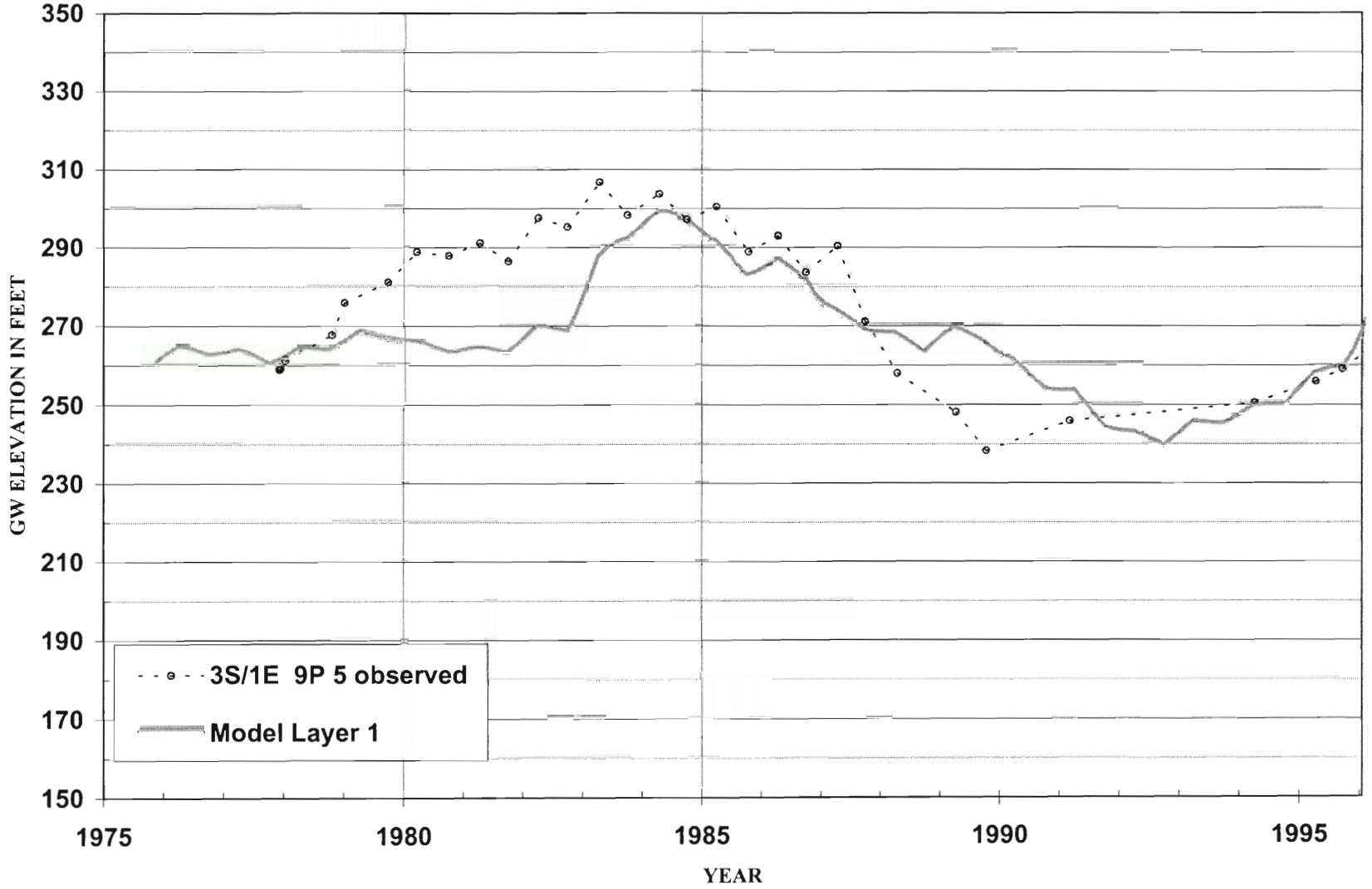
Hopyard-4 Well Hydrograph: Layer 3



6/16/00

FIGURE - 3.22

Well 3S/1E 9P 5 Hydrograph: Layer 1



6/16/00

FIGURE - 3.23

aquifer). The simulated and observed groundwater levels match very well from 1975 through the middle of 1987. During the 1987-90 and 1992-93 periods the simulated levels were about 30 feet higher than the observed groundwater levels, although at the end of 1991, the match is again very good. From the end of 1993 to the end of the simulation period the match remains very good. Although there are about six years out of 20 when the match is weaker than at the other wells shown, the overall calibration at this location appears acceptable.

These hydrographs indicate generally good agreement between simulated and observed groundwater levels. The hydrographs presented represent the Main Basin area of the model. For calibrations in the fringe basin area, see the CH2M Hill June 1998 technical memorandum that presents the complete calibration results (Reference A).

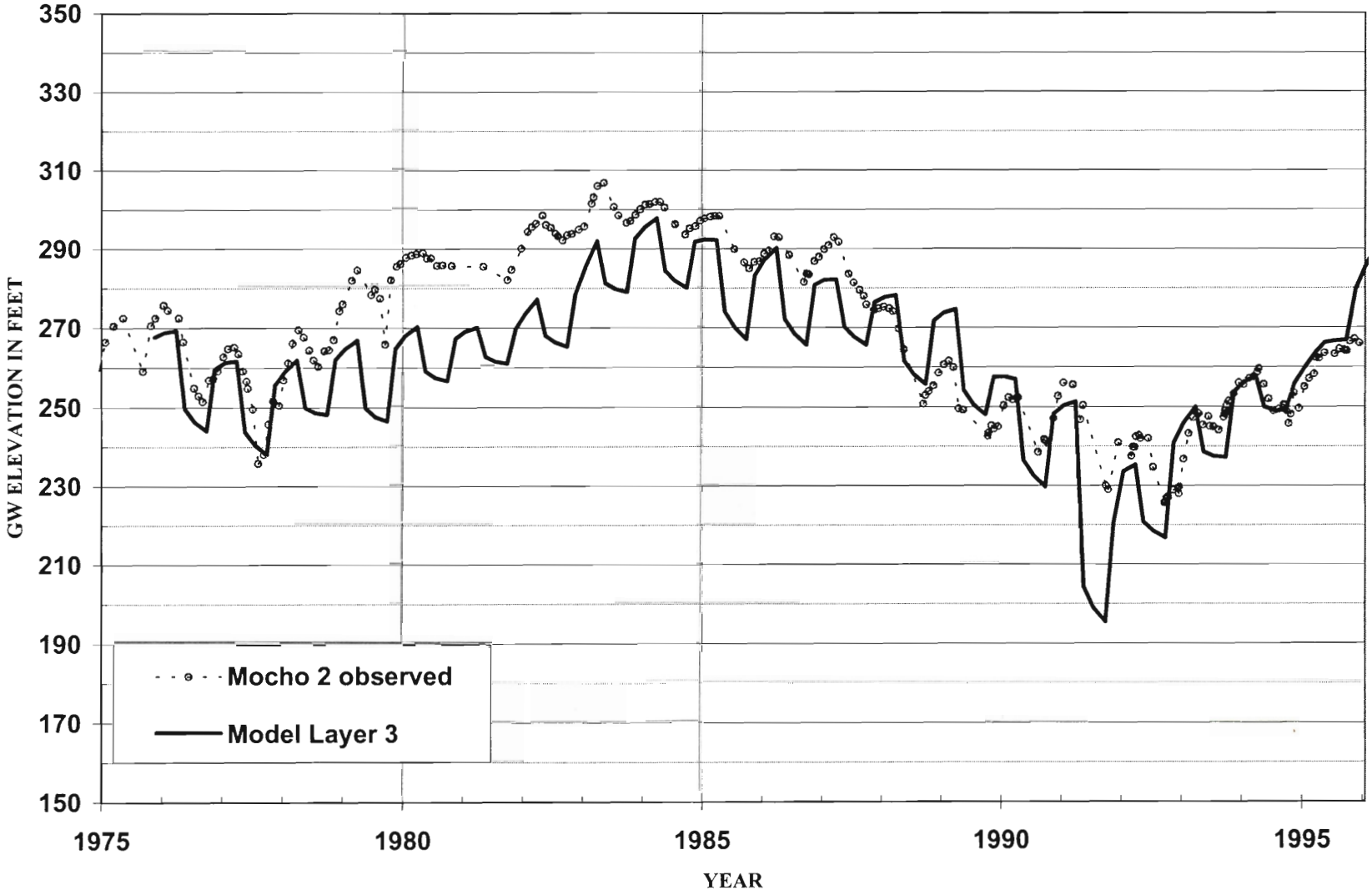
Groundwater Level Maps - Simulated groundwater level maps also show good agreement with observed groundwater level maps. Figure 3.26 is the groundwater level map prepared from the Zone 7 spring 1994 measured groundwater levels. The solid line contours represent groundwater levels in the upper aquifer and the dashed line contours (drawn only in applicable portions of the basin) represent the deep aquifer. Deep aquifer groundwater level data is limited to parts of the Main Basin.

Figure 3.27 presents the model simulated groundwater levels in the upper aquifer for spring 1994. The simulated and observed contour elevations and contour shapes match well. The elevation difference in the key high yielding basin areas is about +/- 20 feet and the contour pattern is very similar. Figure 3.28 presents the model simulated groundwater levels in the deep aquifer for spring 1994. Although there are only a few deep aquifer observed groundwater level contours drawn on Figure 3.26, the pattern and the elevations match very well with the simulated contours.

3.7.5 *Solute Transport Calibration (Non-Reactive)*

Solute transport calibration involves adjusting the solute transport model parameters and the recharge concentrations. Since most of the assigned recharge concentrations for the model were determined from actual monitored data, only model parameters were adjusted during calibration. In non-reactive (TDS) solute transport, advection is the primary mechanism responsible for TDS migration in aquifers. Advection involves transport by bulk movement where it is assumed that the dissolved solute travels in the same direction and with the same velocity as the groundwater itself. Since the model was already calibrated for flow, an acceptable level of non-reactive transport calibration was readily achievable. The calibration was checked by comparing the simulated and observed groundwater TDS hydrochemographs and groundwater TDS maps. Figures 3.29 through 3.32

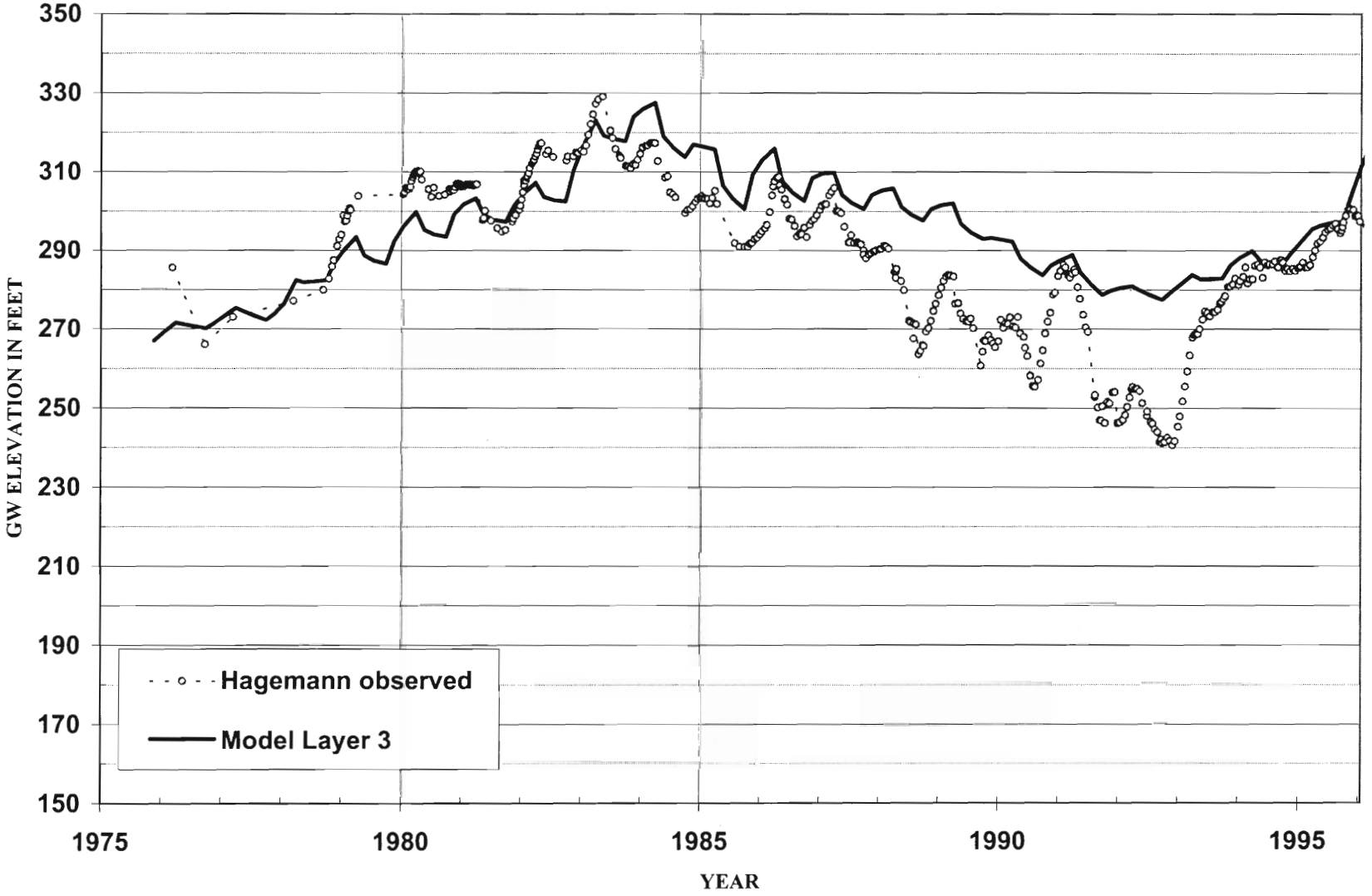
Mocho-2 Well Hydrograph: Layer 3



6/16/00

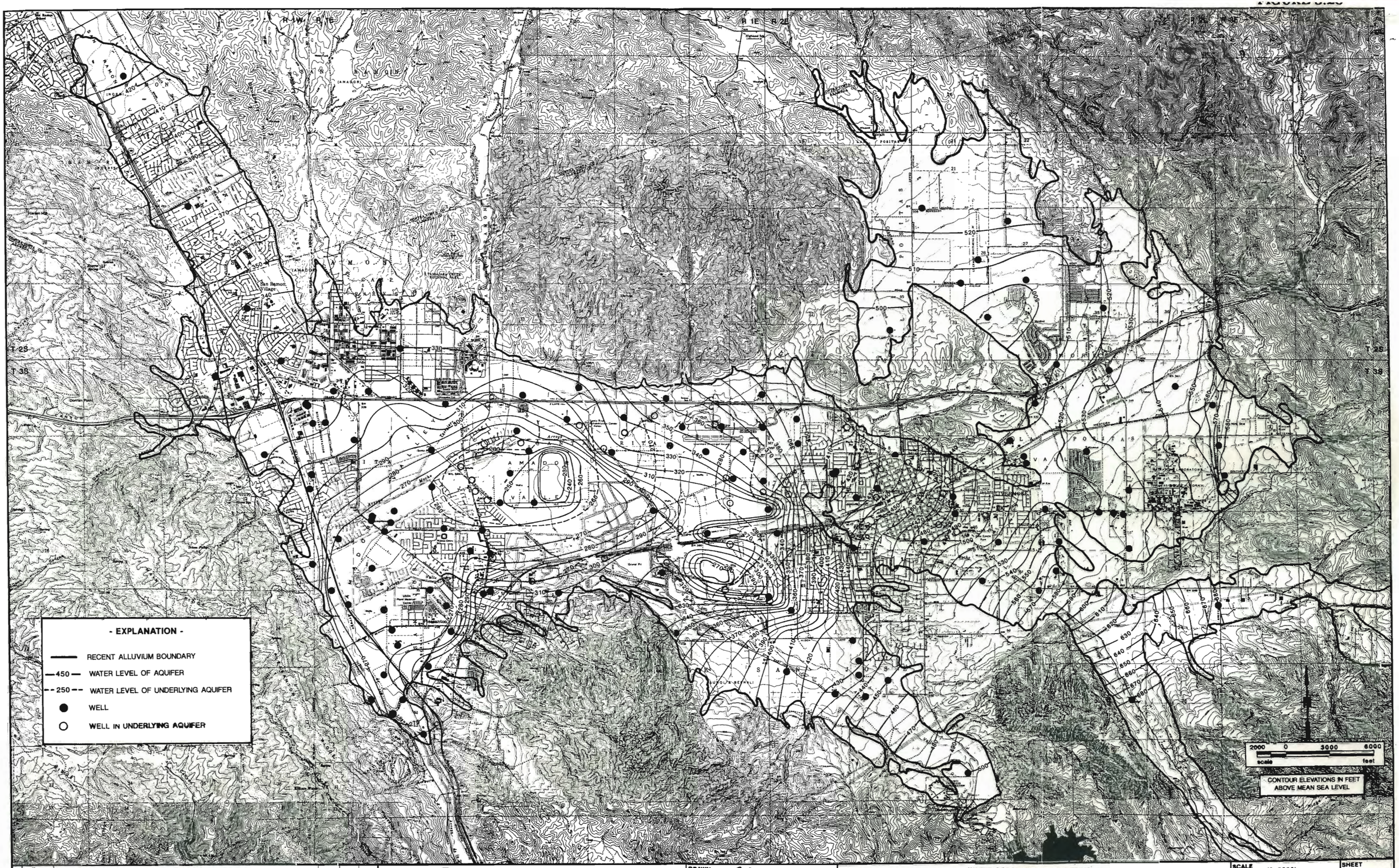
FIGURE - 3.24

Hagemann Well Hydrograph: Layer 3



6/16/00

FIGURE - 3.25



REVISIONS	NUMBER	DESCRIPTION	BY	DATE	APVD
	7				
	6				
	5				
	4				
	3				
	2				
	1				

ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588

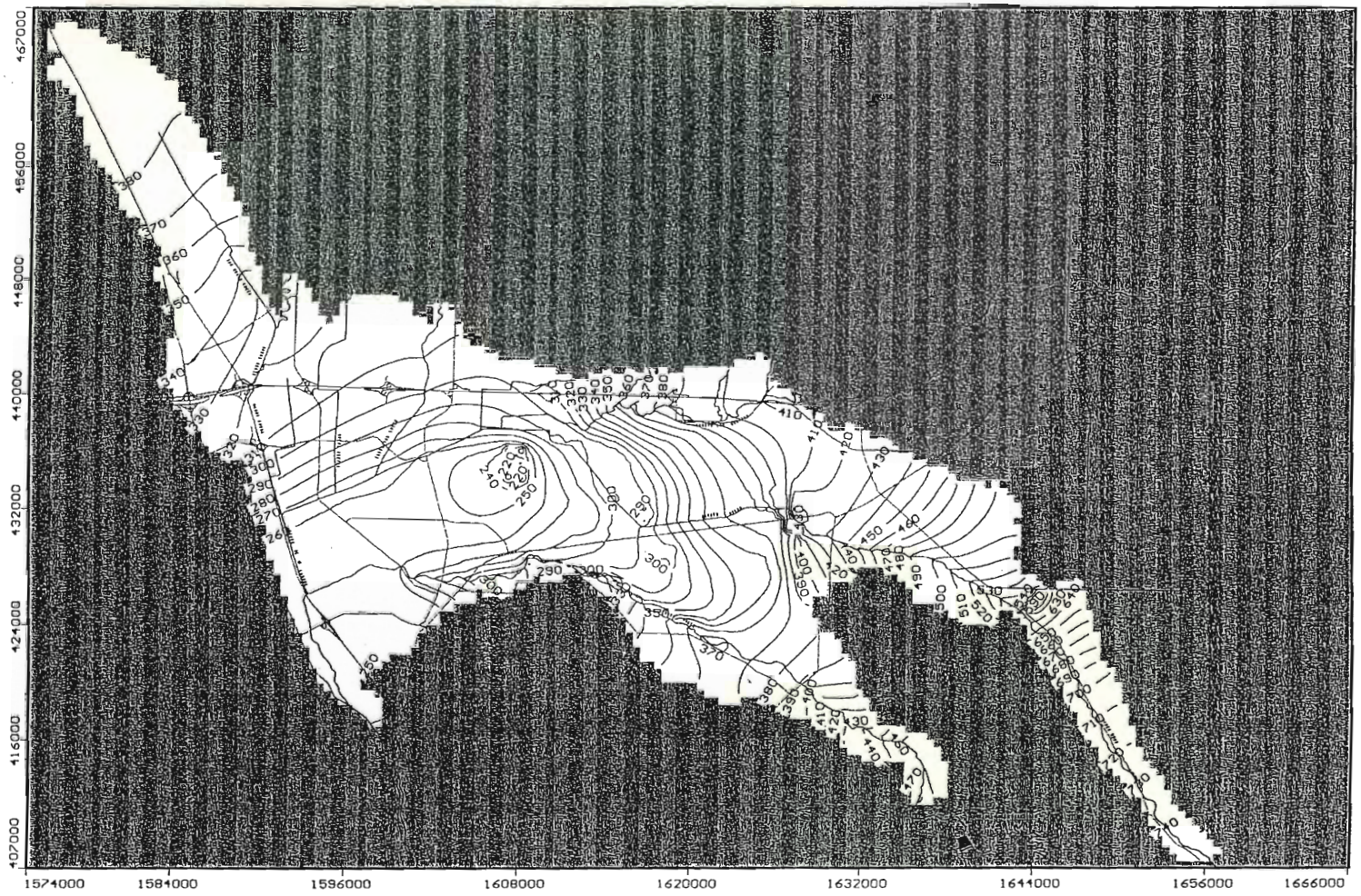
DRAWN	G GATES
DESIGNED	Steven J. Ellis
CHECKED	Steven J. Ellis
APPROVED	

WATER RESOURCES ENGINEERING

SPRING 1994

GROUNDWATER LEVEL CONTOURS

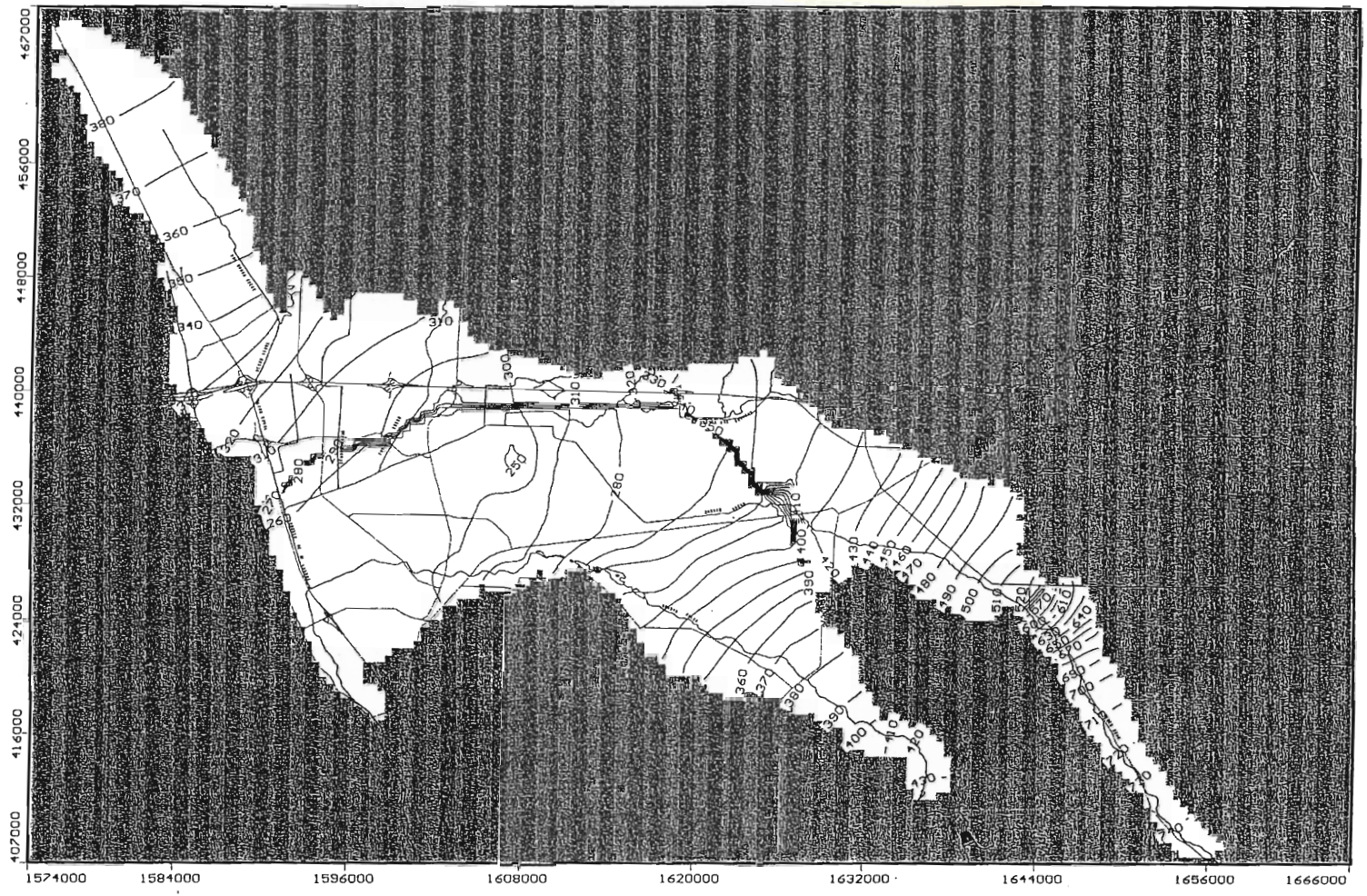
SCALE	1"=6000'
DATE	28 MAY 1994
FILE NO.	B-334
SHEET	OF SHEETS



Zone 7 Water Agency – Pleasanton, CA
Project: LVGWB Model V 2.0.55
Description: L1 GWL Spring 1994 (SP37)
Modeller: CH2M hILL & Zone 7
12 Jun 00

Visual MODFLOW v.2.61, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 184 NR: 120 NL: 4
Current Layer: 1

FIGURE 3.27



Zone 7 Water Agency – Pleasanton, CA
Project: LVGWB Model V 2.0.55
Description: L3 GWL Spring 1994 (SP37)
Modeller: CH2M HILL & Zone 7
12 Jun 00

Visual MODFLOW v.2.61, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 184 NR: 120 NL: 4
Current Layer: 3

FIGURE 3.28

present the observed and simulated TDS at some selected well locations. Figures 3.33 through 3.36 present the observed and simulated groundwater TDS maps.

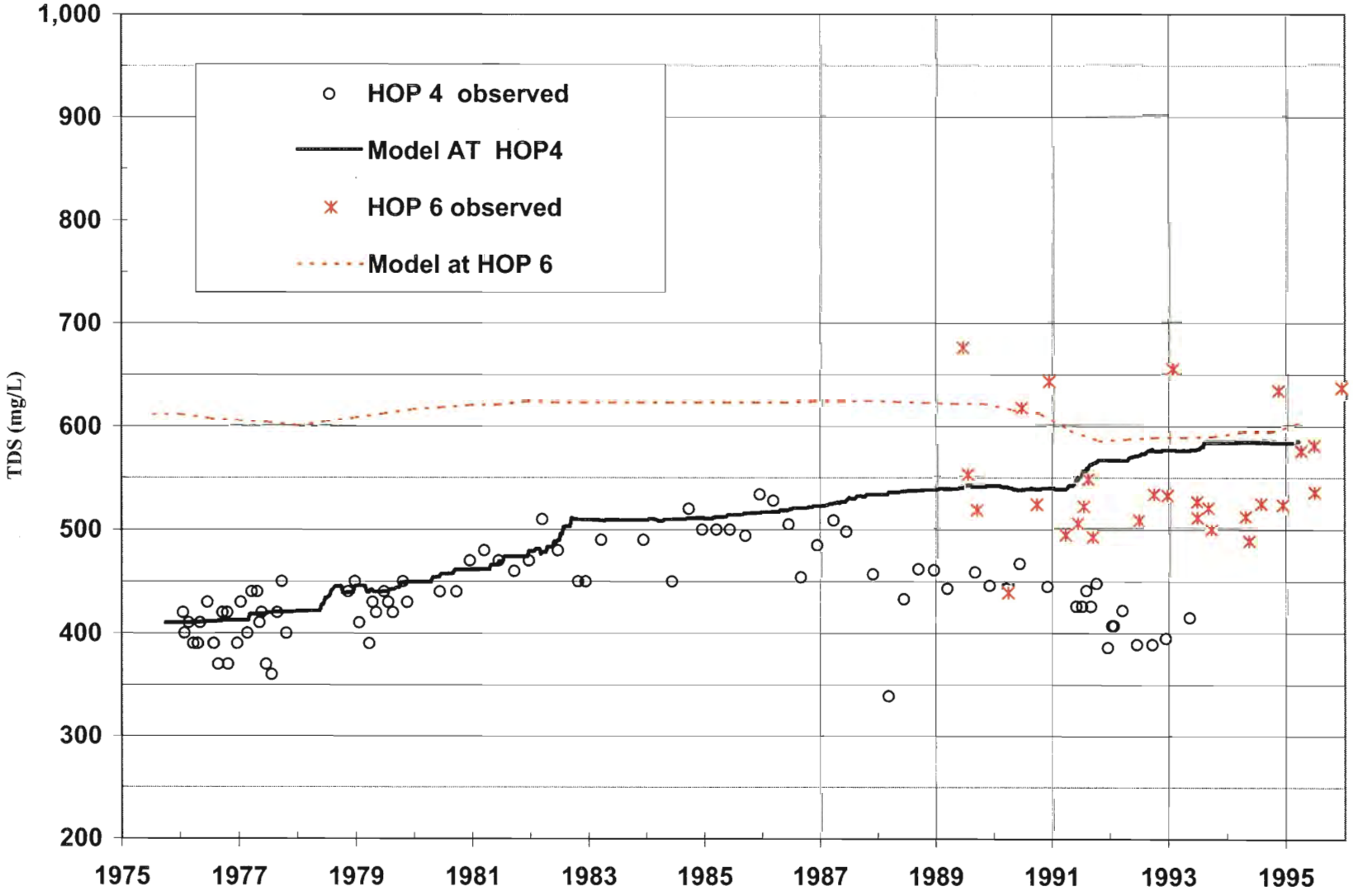
TDS Graphs (Chemographs) - The chemograph for the Hop 4 (Figure 3.29) location shows a good correlation between observed and simulated TDS for the 1975-1987 period. Both the data sets show a rising groundwater TDS trend during this period. Beginning in 1988, the observed and simulated TDS lines start diverging from each other. The simulated TDS data continue to show a rising groundwater TDS trend and the observed TDS data show a declining TDS trend for 1988-95. Based upon the data for the Hop 4 location, it can be concluded that the model tracks the observed data acceptably for the 1975-87 period but not for 1988-95.

To analyze this 1988-95 period further, the observed and simulated TDS results for the Hop 6 location were also plotted on the Hop 4 figure. The Hop 6 well is about 1,500 feet upgradient from the Hop 4 well. The simulated TDS for the Hop 6 well was a good match with the observed TDS at the Hop 6 well. This could be caused by different boundary conditions or model property assumptions along the 500-foot grids in the relatively close 1,500 feet between Hop 4 and 6. Although the model could not precisely match the observed and simulated TDS for the exact Hop 4 location for the 1988-95 period, the predicted TDS and calibration for the Hopyard well field as a whole appears adequate.

The simulated TDS line for the Mocho 2 well (Fig 3.30) appears potentially more representative of actual conditions than the observed data. The simulated data indicates a gradual increase in groundwater TDS at Mocho 2 while the observed groundwater TDS shows large fluctuations ranging from 350 mg/L to 950 mg/L over short periods of time. Groundwater quality generally does not change as rapidly as shown by the observed data. The observed data for Mocho 2 therefore seem suspect. It is possible there were problems with the sampling protocol (e.g., inadequate well purging before sampling). The primary conclusion that can be drawn at this time is that additional data need to be collected to verify the accuracy of the historic data before meaningful simulation comparisons can be made.

The chemograph for the Mohr Avenue key well (3s/1e 9p5, Fig 3.31) shows similar trends for the simulated and observed TDS lines. The simulated TDS is generally about 50 to 75 mg/L higher than the observed TDS. This difference increases to about 250 mg/L during 1983-86. However, the simulated and observed TDS lines converge again in 1987 (the end of the observed dataset). The simulated and observed TDS trend match is impressive during the most part except for 1983-86. One reason why the simulated TDS line is always above the observed line could be that due to the limited observed dataset, the initial TDS concentration used for this location was not truly representative of actual conditions. The model would have interpolated the initial TDS concentration data based upon available data points from the nearest adjacent grids that contained higher TDS actual data.

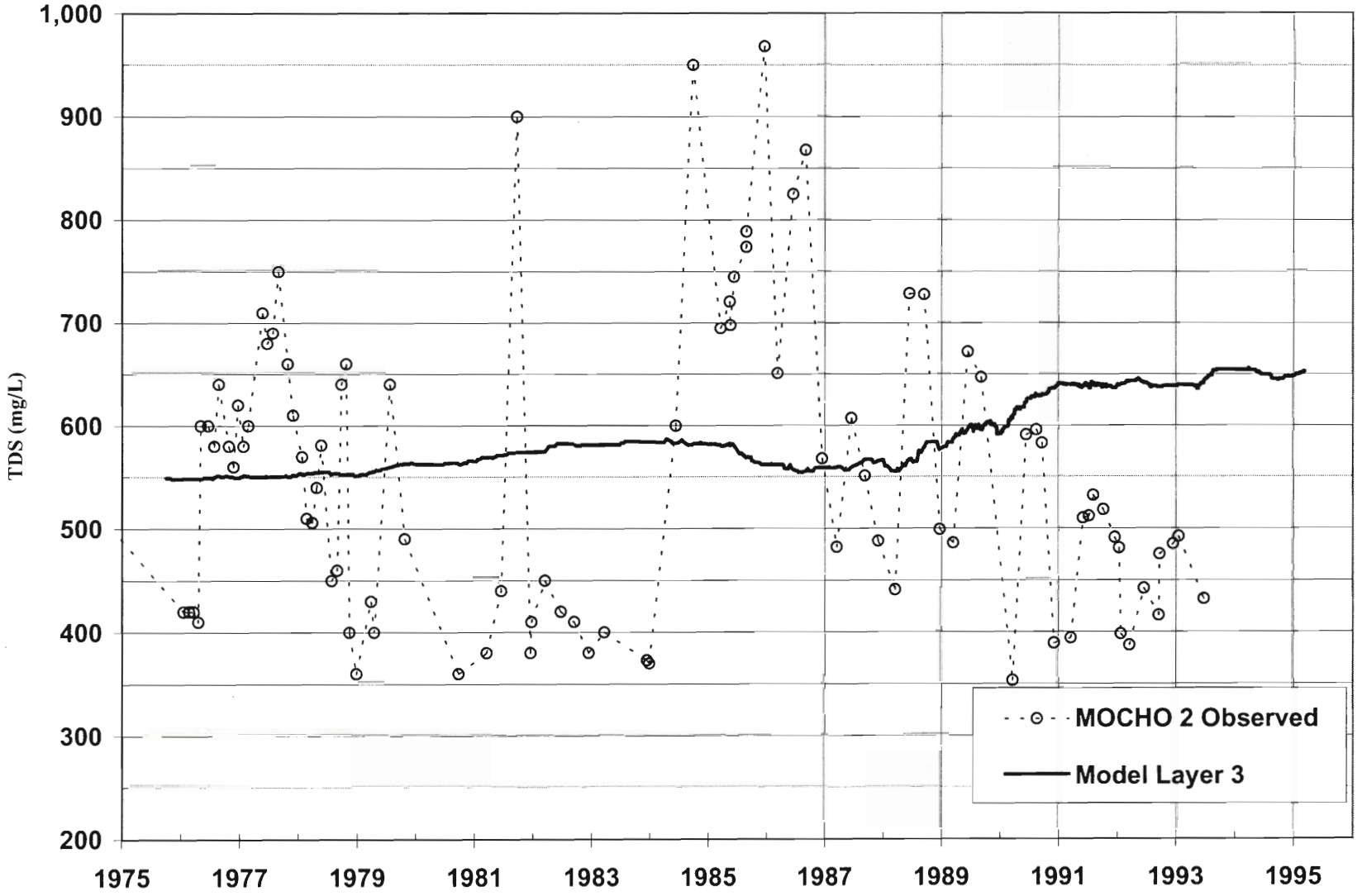
Hopyard-4 & 6 Well Chemograph: Layer 3



6/16/00

FIGURE 3.29

Mocho-2 Well Chemograph: Layer 3



6/16/00

FIGURE 3.30

The simulated and observed TDS lines for the Hagemann key well (Figure 3.32) appear to show a good correlation. This well had the same initial concentration issues as the Mohr Avenue well since the observed data does not begin until 1979. Although the model initial TDS concentration does not seem to reflect the actual TDS for this location, the simulated TDS line matches very well during the latter part of the calibration period.

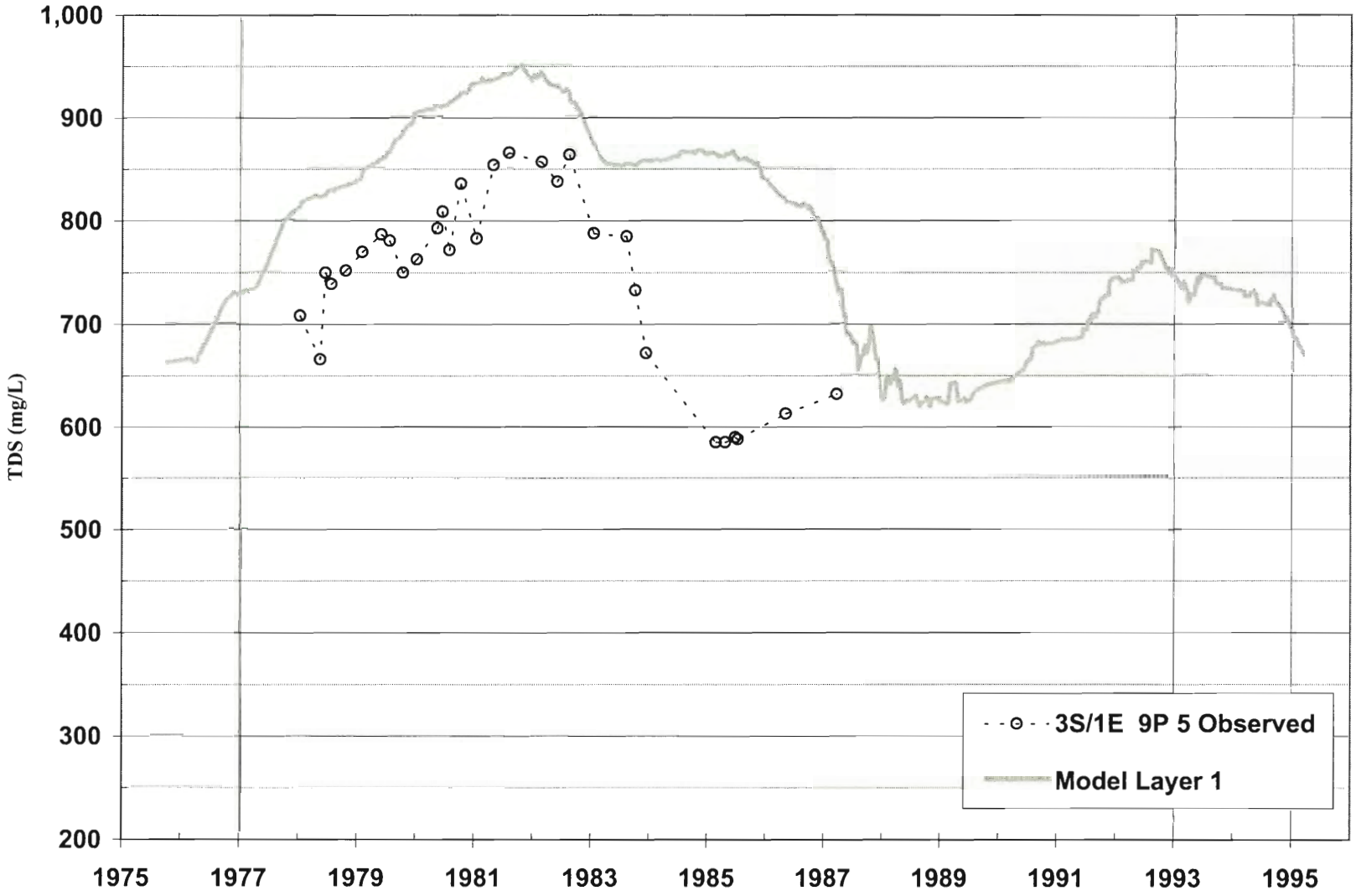
Groundwater TDS Maps - The TDS chemographs are useful in comparing the changes over time in simulated and observed TDS at a particular location. The groundwater TDS maps are useful in comparing the areal variations in simulated and observed concentrations at any time for any model layer.

Figures 3.33 and 3.34 present the observed and simulated groundwater TDS maps for the upper aquifer at approximately 1994 conditions. For the most part the two maps match reasonably well. For example, the Dublin Sub-basin has a low TDS of 400-500 mg/L in the north portion and a high TDS in the south portion in both the simulated and observed maps. Lower groundwater TDS exists along both the Arroyo Valle and Arroyo Mocho recharge zone areas on both maps.

Figure 3.35 and 3.36 present the observed and simulated groundwater TDS maps for the deep aquifer. Due to the general lack of deep aquifers in the fringe basins, the observed TDS maps present the TDS only for the Main Basin. The deep aquifer TDS maps match even better than in the upper aquifer. The blue shade on both maps represents groundwater TDS below 500 mg/L. The pink shade on the observed TDS map (Figure 3.35) represents groundwater of 500 mg/L to 700 mg/L. This same 500-700 mg/L TDS range is shown in green on the simulated TDS map (Figure 3.36). Comparing both maps, it can be concluded that there is a good overall match with the exception of one small high TDS (800-1000 mg/L) area on the simulated map in the Bernal Sub-basin near the Fairgrounds.

The technical memorandum from CH2M Hill "Livermore Valley Groundwater Basin Model v2.0, June 29, 1998" describes the model calibration in more detail (Reference E).

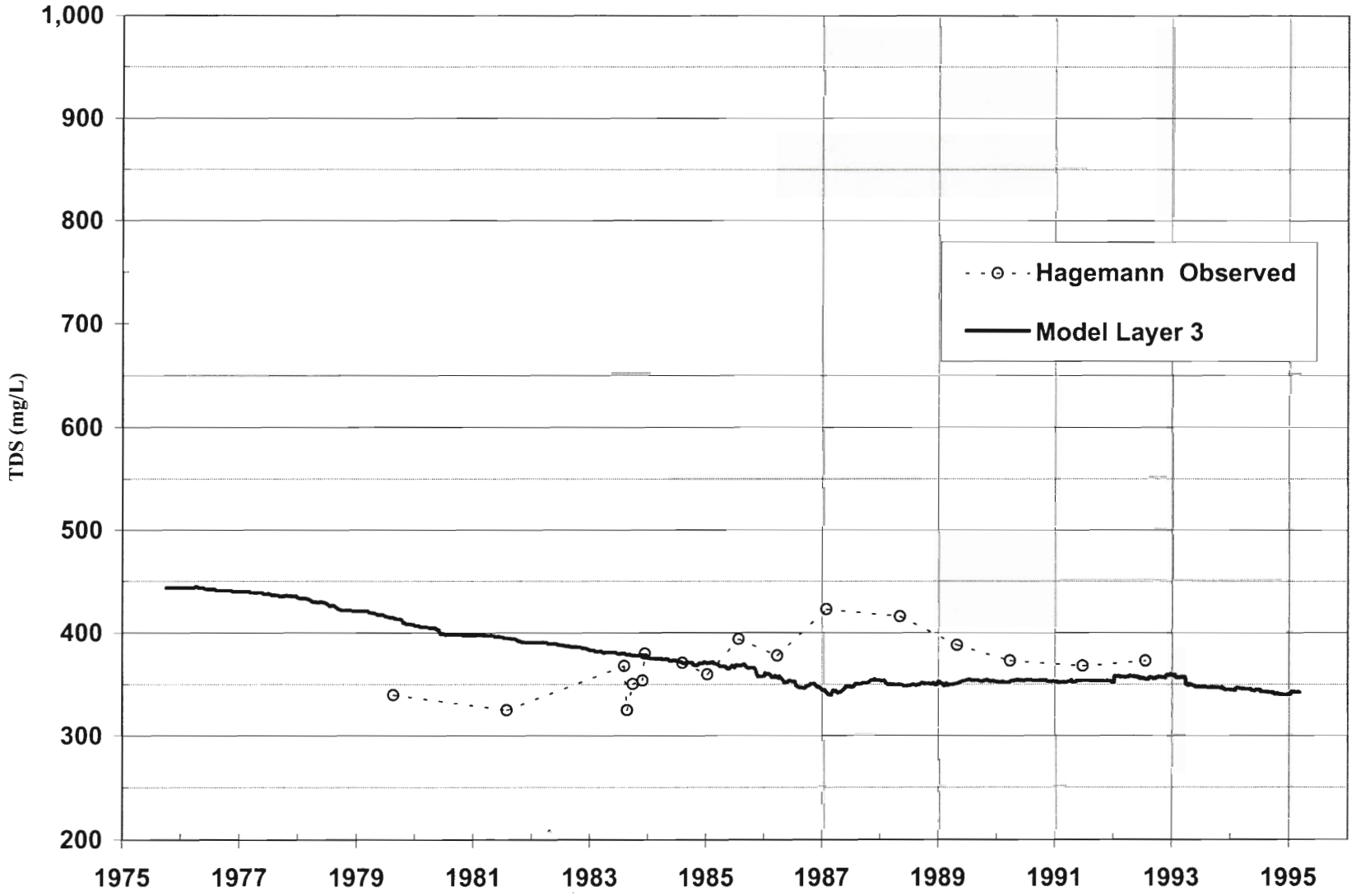
Well 3S/1E 9P 5 Chemograph: Layer 1



6/16/00

FIGURE 3.31

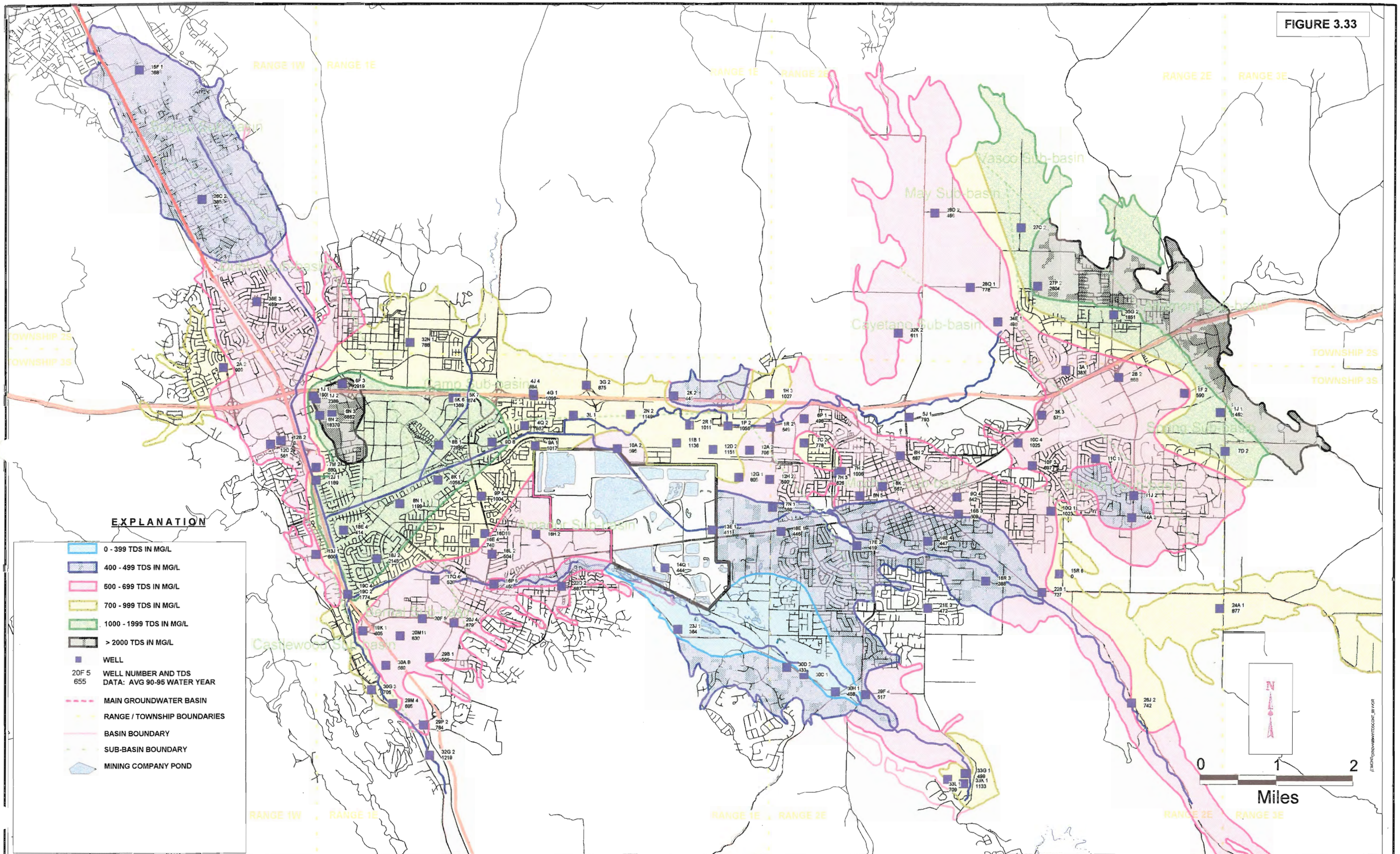
Hagemann Well Chemograph: Layer 3



6/16/00

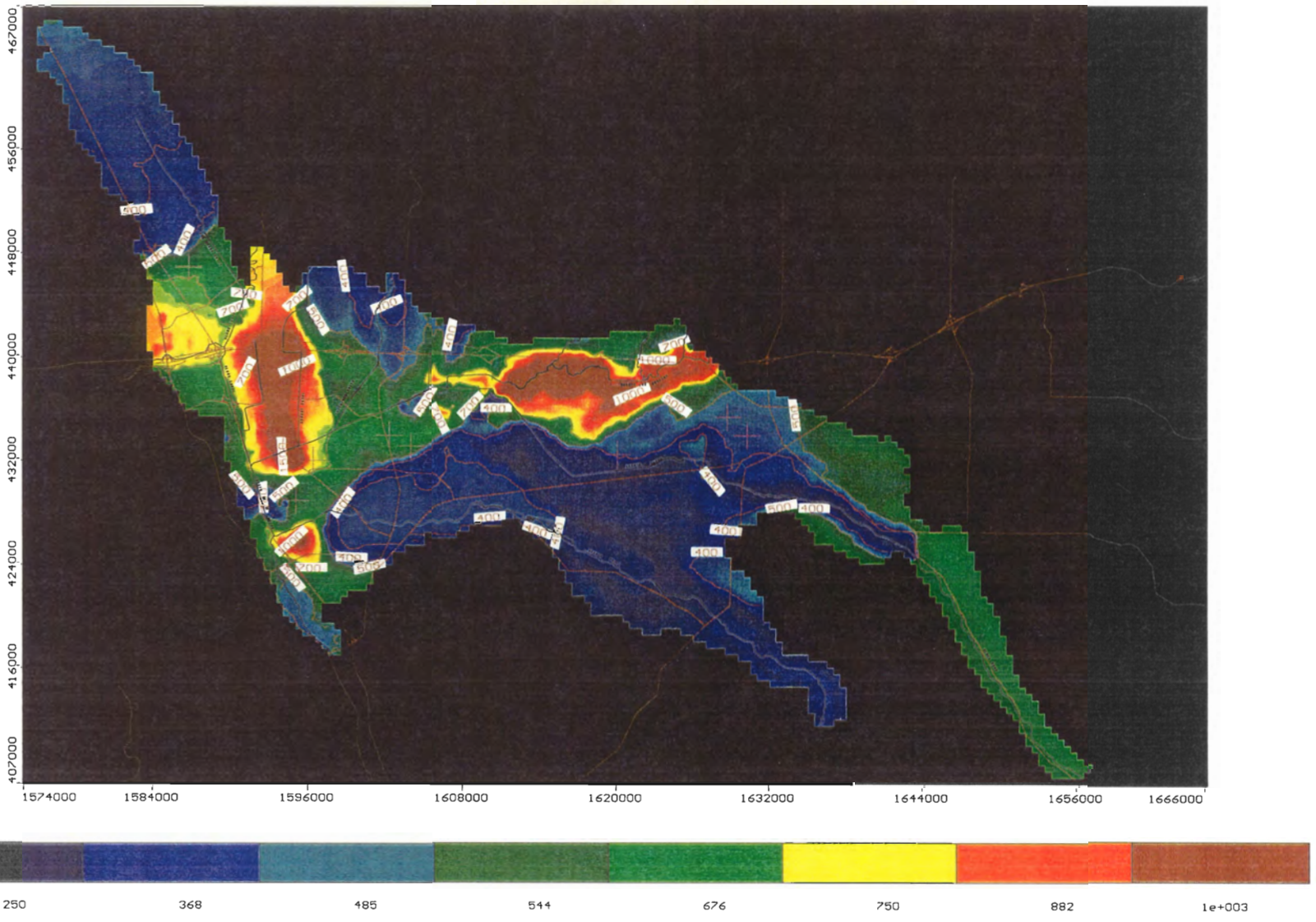
FIGURE 3.32

FIGURE 3.33



ZONE 7 WATER AGENCY 5997 PARKSIDE DRIVE PLEASANTON CA 94588	DRAWN BY: GERALD GATES DESIGNED BY: D. LUNN CHECKED BY: APPROVED BY:	WATER RESOURCES ENGINEERING UPPER AQUIFER TDS CONTOUR MAP AVERAGE 1990-1995 TOTAL DISOLVED SOLIDS

SCALE: 1" = 6000' (ON ORIGINAL)
DATE: 7 JULY 1997
FILE NO.: H:\SMP\FIG4-6.WOR



Zone 7 Water Agency – Pleasanton, CA
Project: LVGWB Model V 2.0.55
Description: L1 TDS Fall 1995 (SP40)
Modeller: CH2M HILL & Zone 7
5 Oct 00

Visual MODFLOW v.2.61, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 184 NR: 120 NL: 4
Current Layer: 1

FIGURE 3.34

FIGURE 3.3e

RANGE 1W RANGE 1E RANGE 2E RANGE 3E

TOWNSHIP 3S

Vasco Sub-basin

May Sub-basin

Cayetano Sub-basin

Tassajara Sub-basin

Dublin Sub-basin

Camp Sub-basin

Spring Sub-basin

Livermore Sub-basin

Arroyo Mocho Sub-basin

36F 3 331

3Q 1 704

2N 3 704

2P 3 395

1P 3 407

9D 5 476

9B 439

10A 1 516

9M 2 504

9P 4 1123

12F 1 495

12J 1 328

7P 8N 2

8F 511

8G 1 526

9L 1 527

8P 1 517

3P 2 445

9Q 1 177

16B 1 465

16C 1 471

18B 1 396

18A 537

17D 2 418

18A 1 729

18A 5 526

16D 6

16D 7 231

16L 5 484

15L 7 408

16A 2 407

14A 2 350

12P 5 332

13G 1 409

15J 5 476

14K 2 309

13P 1 385

16R 1

EXPLANATION

- 0 - 399 TDS IN MG/L
- 400 - 499 TDS IN MG/L
- 500 - 699 TDS IN MG/L
- 700 - 999 TDS IN MG/L
- 1000 - 1999 TDS IN MG/L
- > 2000 TDS IN MG/L
- WELL
- 20F 5 / 655 — WELL NUMBER AND TDS DATA: AVG 90-95 WATER YEAR
- MAIN GROUNDWATER BASIN
- RANGE / TOWNSHIP BOUNDARIES
- BASIN BOUNDARY
- SUB-BASIN BOUNDARY
- MINING COMPANY POND

N

E:\WORK\FIG\WORK\FIG7.DWG

ZONE 7 WATER AGENCY

5997 PARKSIDE DRIVE PLEASANTON CA 94588

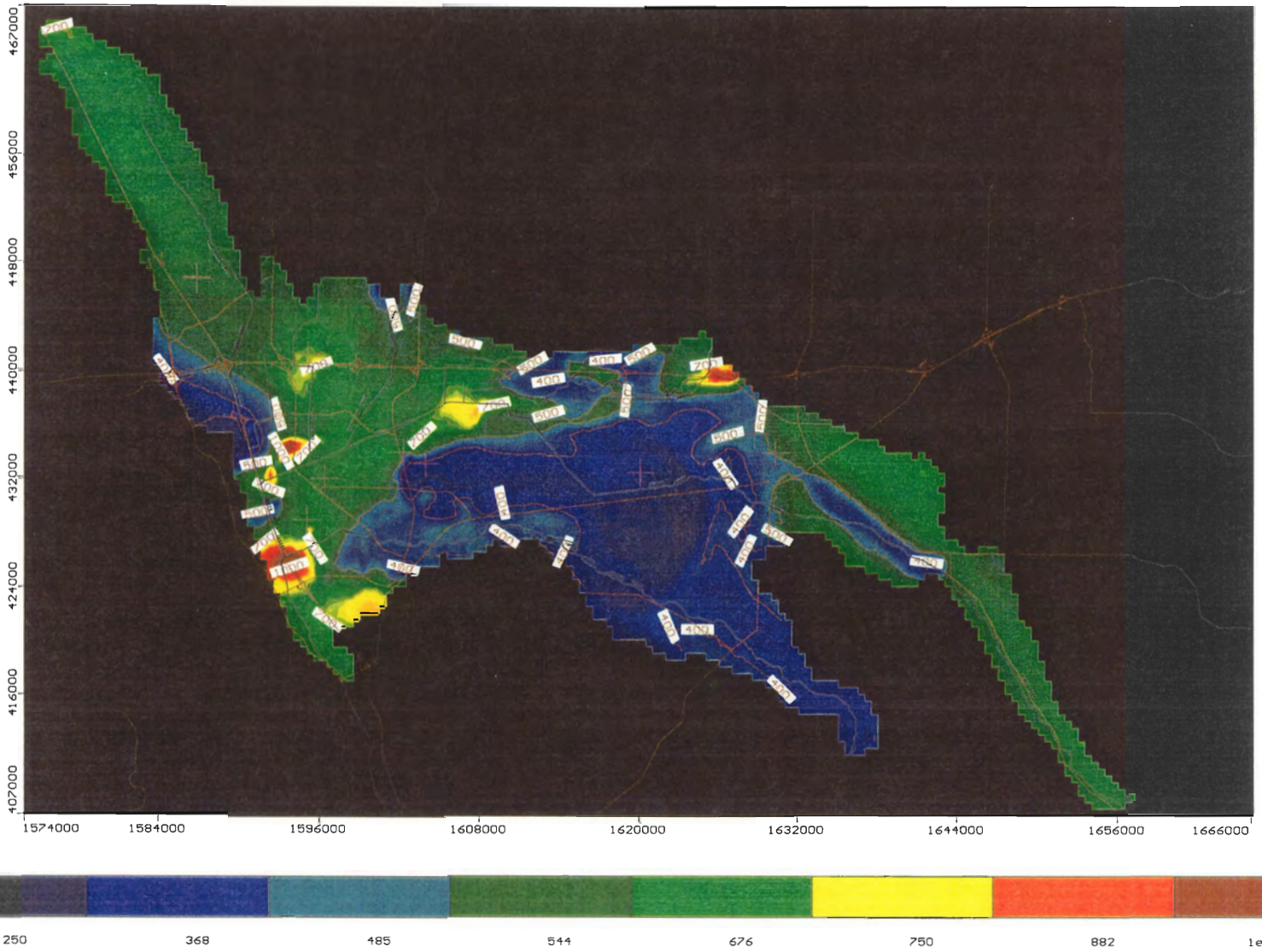
DRAWN BY: GERALD GATES
DESIGNED BY: D. LUNN, G. GATES
CHECKED BY:
APPROVED BY:

WATER RESOURCES ENGINEERING

MAIN BASIN LOWER AQUIFER TDS CONTOURS

AVERAGE 1990-1995 TOTAL DISOLVED SOLIDS

SCALE: 1" = 6000' (ON ORIGINAL)
DATE: 7 JULY 1997
FILE NO.: H:\SMP\FIG4-7.WOR



Zone 7 Water Agency – Pleasanton, CA
Project: LVGWB Model V 2.0.55
Description: L3 TDS Fall 1995 (SP40)
Modeller: CH2M HILL & Zone 7
5 Oct 00

Visual MODFLOW v.2.61, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 184 NR: 120 NL: 4
Current Layer: 3

FIGURE 3.36

Chapter 4

Mineral Water Quality

Chapter 4

Mineral Water Quality

4.1 Introduction

Zone 7 operates several water quality monitoring programs which collect and evaluate an extensive amount of water quality data. The focus of this effort historically has been on collecting the relevant data necessary to accurately track trends in spatial variations in groundwater quality. Water quality monitoring has primarily been concerned with general dissolved mineral (ion) composition. In general, laboratory analyses for most samples include Calcium (Ca), magnesium (Mg), Sodium (Na), Potassium (K), Bicarbonate (HCO_3), Sulfate (SO_4), Chloride (Cl), Nitrite (NO_3), Silica (SiO_2), alkalinity, boron (B), electrical conductivity (EC), pH, total dissolved solids (TDS), and hardness. In the late 1990's arsenic (As) and manganese (Mn) were added to the list of analytes. Sampling frequencies typically are monthly or quarterly for new sites, and are usually reduced to quarterly, biennially or annually for well characterized sites. Dissolved mineral data are used to track sources of water and water quality trends, as well as to calculate annual and long-term salt loading to the Main Basin.

The purpose of this chapter is to summarize historic water quality data as they relate to groundwater salt impacts, to provide a synopsis of the most significant water quality trends, and to explain how the water that Zone 7 delivers to its customers is affected by changes in local and imported water quality. Zone 7 delivered water is a combination of groundwater, imported surface water, and local surface water. The water quality of each of those components varies geographically, seasonally, and annually. Section 4.6 describes delivered water quality and the historic variability of that delivered water quality.

Section 4.7 briefly describes tertiary recycled water quality and RO recycled water quality produced by the Livermore and DSRSD treatment plants and membrane filtration/reverse osmosis (RO) facilities. Comparisons are shown between raw (untreated) and treated water and the RO recycled water.

Reference F contains extensive monitoring data prepared by Zone 7 in the form of a groundwater annual report. Data from these monitoring programs are used not only to describe historic and current water quality and quantity, as described in this chapter, but are also used to calculate current and predict future salt loading to the Main Basin. Salt loading to the Main Basin directly impacts groundwater quality, which in turn impacts Zone 7 delivered water quality. Salt loading calculations are discussed in detail in Chapter 5. Chapter 6 presents recommended extensions to current monitoring programs aimed at

tracking changes in future water quality and quantity associated with increased urban and agricultural irrigation.

4.2 Imported Water

Zone 7 currently has a maximum entitlement from the State Water Project of 80.619 TAF per year. State Water Project (SWP) water is imported from the Sacramento-San Joaquin Delta at the Banks Pumping Plant and delivered through the South Bay Aqueduct (SBA) along which Zone 7 has several turnouts. This imported surface water is then: 1) treated and delivered to M&I retailers; 2) used to artificially recharge the Main Basin aquifers; or 3) delivered as untreated water for agricultural irrigation.

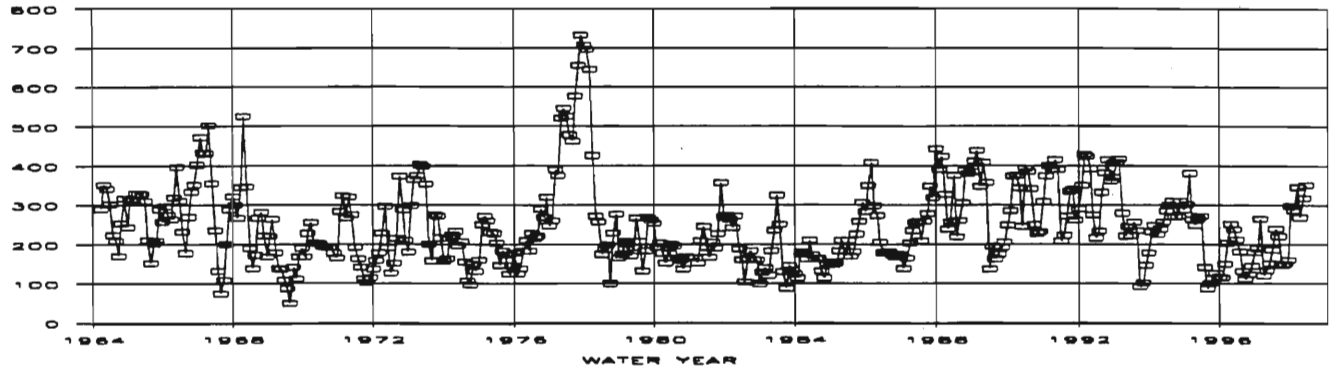
The actual volume of SWP water, which Zone 7 has access to, varies annually with climatic conditions. Historically during wet years it was likely that Zone 7's full entitlement would be delivered. However, during periods of drought, deliveries may be restricted by the State to as low as 10% of entitlement. Other restrictions can, and have been imposed for environmental protection purposes. Based upon the State Department of Water Resources Simulation Model for State Water Project deliveries studies, the long-term average SWP deliveries are expected to be about 75% of maximum entitlements. When Zone 7 supply exceeds the 75% average, Zone 7 stores the excess in the groundwater basin. When Zone 7 demand exceeds the available State Project supply, Zone 7 makes up the difference by using Lake del Valle water, pumping stored groundwater, and/or requesting pumpback from Zone 7 storage in the Semitropic Groundwater Basin.

In addition to quantity, imported water quality from the State Water Project also varies. Figure 4.1 presents historic monthly average TDS and percent sodium values for South Bay Aqueduct water above and below Lake del Valle. Figure 4.1 shows that between 1962 and 1999 the historic monthly average TDS ranged from less than 100 mg/L to over 700 mg/L, that the TDS varied significantly between years, and that the TDS also commonly varied significantly between months in the same year. The percent sodium shows similar variations as did TDS between months and years. Hardness increases with the increase in TDS and decreases with the increase in the percentage of sodium.

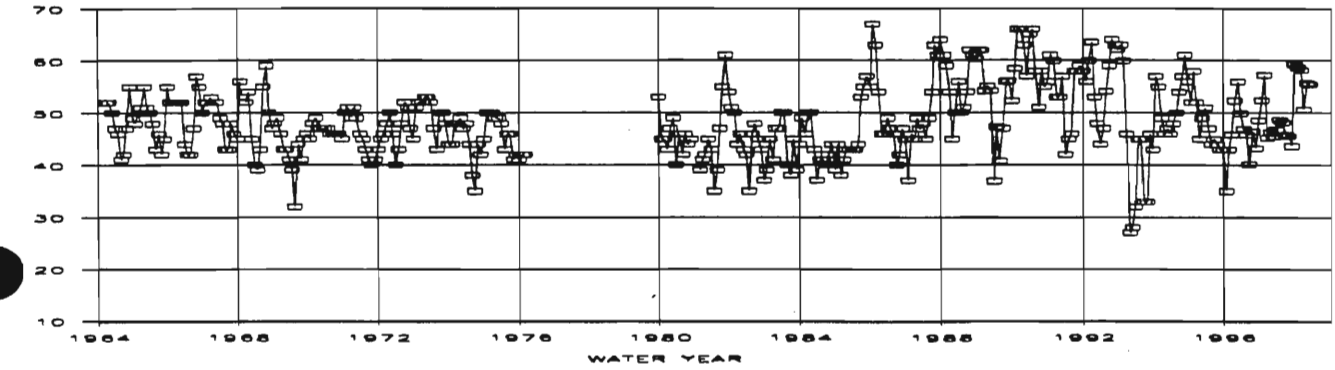
Figure 4.2 illustrates in greater detail the variability that can be expected from SBA water. Monthly average TDS values for SBA water delivered to the Patterson Pass Water Treatment Plant and the Del Valle Water Treatment Plant for the 1993-1998 water years ranged from less than 100 mg/L to over 410 mg/L. The time period shown in Figures 4.1 and 4.2 covers typical climatic conditions ranging from very wet years to drought conditions.

ZONE 7
WATER RESOURCES ENGINEERING
ARTIFICIAL GROUNDWATER RECHARGE WATER QUALITY
HISTORIC RECORD

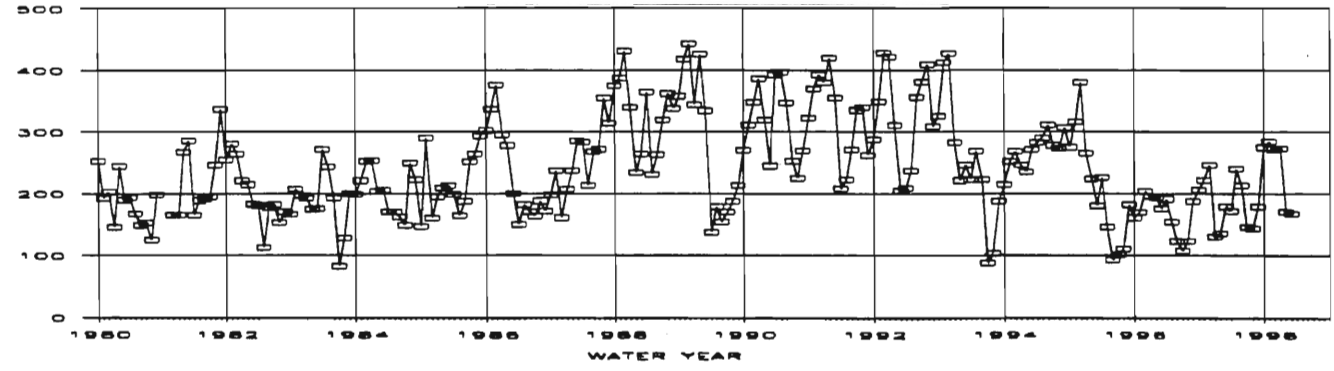
SOUTH BAY AQUEDUCT TURNOUT ABOVE LAKE DEL VALLE (PPWTP)
TOTAL DISSOLVED SOLIDS



PERCENT SODIUM



SOUTH BAY AQUEDUCT TURNOUT BELOW LAKE DEL VALLE (DVWTP) 1980 - 1995
TOTAL DISSOLVED SOLIDS



PERCENT SODIUM

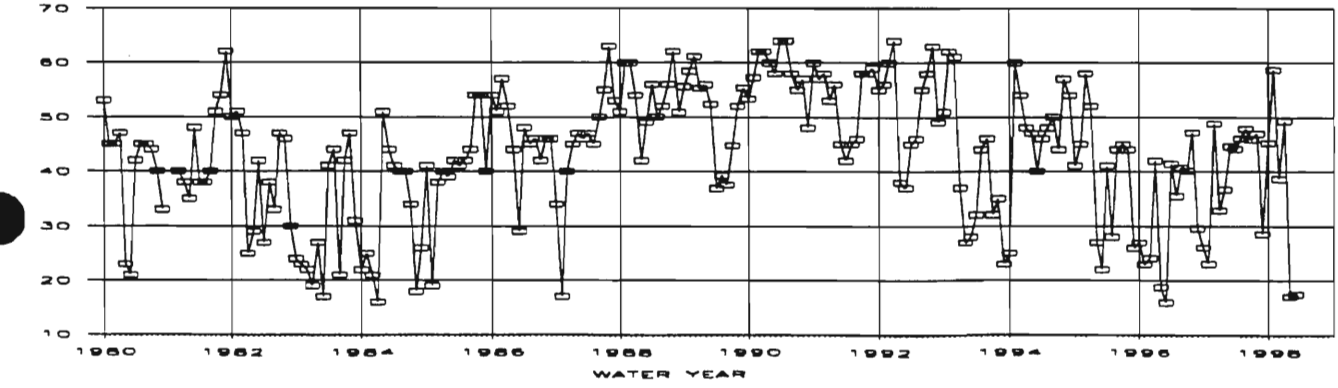
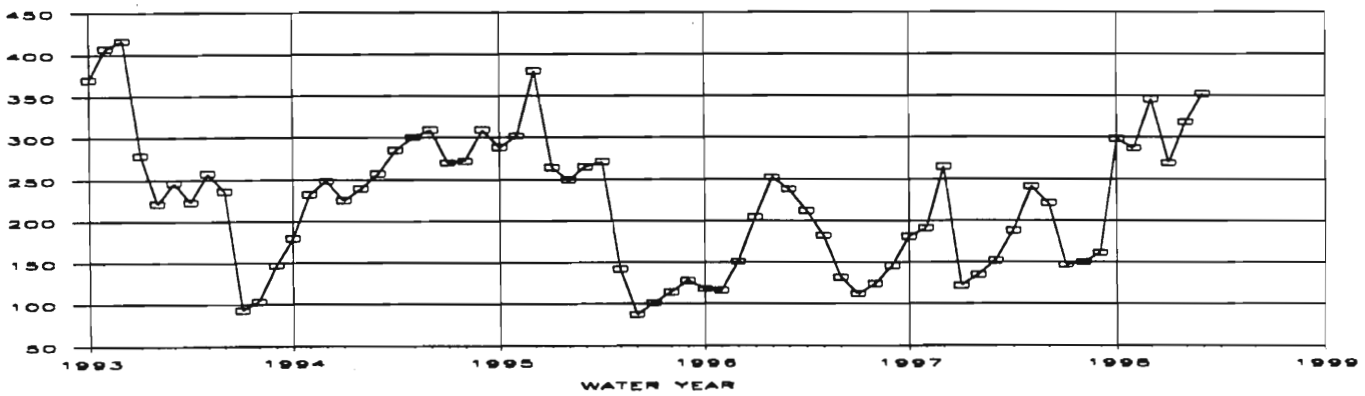


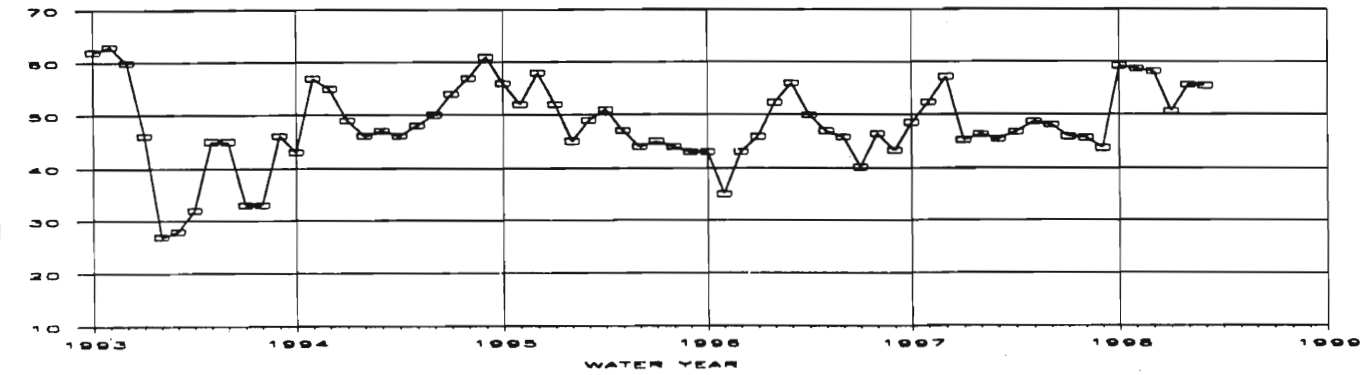
Figure 4.2

ZONE 7
WATER RESOURCES ENGINEERING
ARTIFICIAL GROUNDWATER RECHARGE WATER QUALITY
1993-1998 WATER YEARS

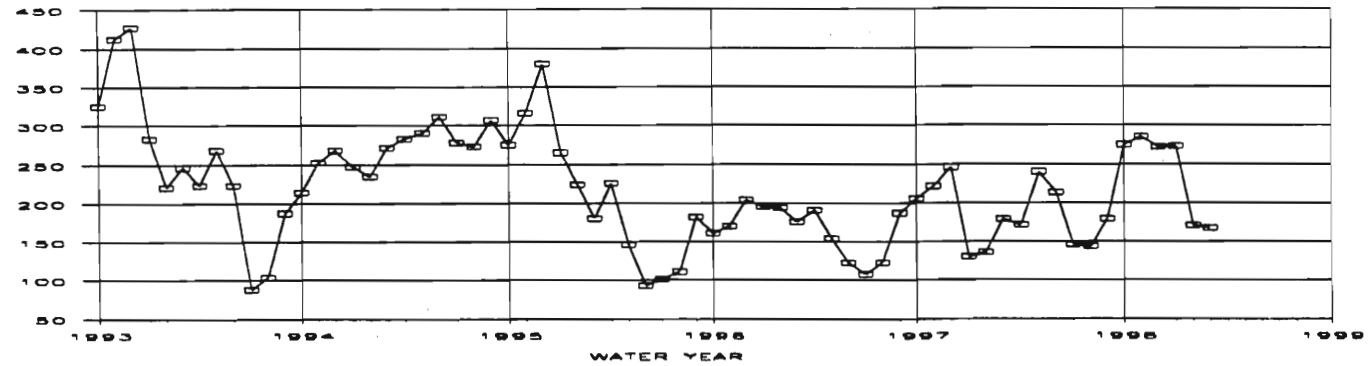
SOUTH BAY AQUEDUCT TURNOUT ABOVE LAKE DEL VALLE (PPWTP)
TOTAL DISSOLVED SOLIDS



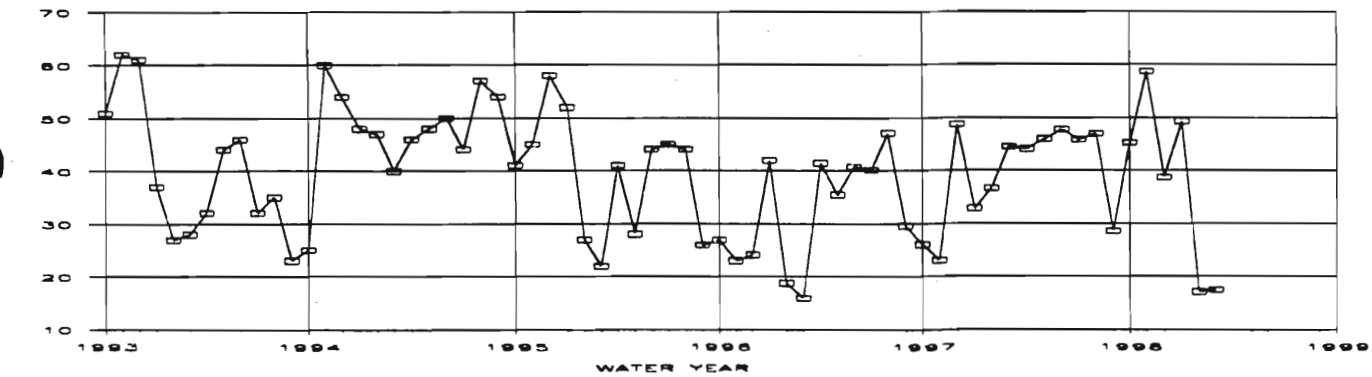
PERCENT SODIUM



SOUTH BAY AQUEDUCT TURNOUT BELOW LAKE DEL. VALLE (DVWTP)
TOTAL DISSOLVED SOLIDS



PERCENT SODIUM



4.3 Local Surface Water

Zone 7 local surface water consists of upper Del Valle watershed runoff into Lake Del Valle, local natural runoff into four major streams (Arroyo del Valle, Arroyo Mocho, Arroyo las Positas, and Arroyo de la Laguna), water from several quarry ponds, rainfall and urban runoff, and applied irrigation water seepage and runoff. Zone 7 monitors (and in a few cases estimates) the quantity and quality of each component and uses the information to calculate the annual hydrologic inventory (groundwater recharge and pumpage), and salt accumulation in the groundwater basin. Water quality data results are the focus of this section. Additional information on specific monitoring programs is discussed in Chapter 6.

Lake del Valle

Lake del Valle is used to capture stream outflow and rainfall runoff from the upper Del Valle watershed. In addition, State Water Project (SWP) water is diverted into the reservoir by the California Department of Water Resources (DWR) for recreational use and for storage to meet seasonal peak demands on the South Bay Aqueduct (SBA). On occasion, particularly as the reservoir approaches full levels, the DWR makes flood control releases from the reservoir to the SBA and to the Arroyo Valle. Zone 7 and ACWD share the "water rights" for the natural inflow to the reservoir and can take it either through the various SBA turnouts or by direct release to the Arroyo Valle for "artificial" recharge of the groundwater basin.

The water quality in Lake del Valle is a combination of rainfall runoff and SWP water quality. The quality of flood releases is measured at the Zone 7 Del Valle Water Treatment Plant inlet or at the Arroyo Valle near Livermore (AVNL) gaging station. Average TDS concentrations of the flood releases have ranged from 130 mg/L to 240 mg/L between 1993 and 1998. The quality of the Arroyo Valle recharge releases (release from upper turnouts over 10 cfs) and the natural seepage from the lake is measured at the Arroyo Valle near Livermore gaging station. The TDS concentrations measured at this station during base flow conditions (flow less than 2 cfs) between 1992 and 1998 represent the seepage component, and have ranged from 340 mg/L to 710 mg/L.

Local Streams

Water quality in the local streams varies by reach and by season. The streams can contain one or more of the following components: 1) natural inflow, including groundwater seepage (i.e., rising groundwater); 2) imported water from SBA releases; 3) urban runoff; 4) groundwater discharges from aggregate mining operations; and occasionally 5) flood control releases from Lake del Valle. The quantity and quality of each component is monitored by Zone 7. Electrical conductivity, pH and temperature are measured monthly at stream gaging stations throughout the basin and daily at various SBA turnouts to the

Table 4.1
Zone 7 SURFACE WATER MONITORING
1997 WATER YEAR
MONTHLY CONDUCTIVITY SAMPLING
(EC in Micromhos/cm.Flow in CFS)

	ARROYO VALLE Below LANG CANYON		ARROYO VALLE Near LIVERMORE		ARROYO VALLE At PLEASANTON		ARROYO MOCHO Near LIVERMORE		ARROYO MOCHO At LIVERMORE		ARROYO MOCHO Near PLEASANTON		ARROYO LAS POSITAS At LIVERMORE		ARROYO LAS POSITAS At EL CHARRO		ARROYO DE LA LAGUNA Near PLEASANTON		DATE OF SAMPLING
	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	
OCT	DRY	0	680	3.5	910	12	1240	1.1	DRY	0	1020	7.1	1570	2.6	1460	1.3	1110	25.7	15-Oct-96
NOV	520	19	760	1.3	800	11.3	880	1.0	640	9.0	1100	28.7	1570	12.0	1160	18.5	630	146.0	19-Nov-96
DEC	470	41	890	2.4	780	7.5	790	2.4	DRY	0	940	27.0	2040	3.7	1890	4.2	1230	52.0	17-Dec-96
JAN	500	116	520	55	490	96.6	610	17.0	535	13.7	690	291	1140	33.7	755	68.3	650	307.0	15-Jan-97
FEB	525	64	610	3.5	650	14.8	740	9.5	785	0.4	1230	30.4	2110	8.0	1860	11.5	1140	80.0	14-Feb-97
MAR	590	29.0	740	3.9	800	9.3	860	6.4	DRY	0	1380	11.6	1870	4.2	1850	6.0	1150	54.0	19-Mar-97
APR	690	15.0	780	1.2	890	2.9	740	4.2	DRY	0	1100	12.1	1800	3.3	1750	3.3	1210	42.0	14-Apr-97
MAY	710	4.5	850	1.0	900	5.6	1010	1.2	DRY	0	1910	16.2	1620	2.3	1590	0.6	1120	37.0	19-May-97
JUN	740	1.9	870	1.0	DRY	0	1100	0.5	DRY	0	1010	16.0	1470	2.3	1570	0.3	1140	38.0	17-Jun-97
JUL	DRY	0	820	1.0	DRY	0	1180	0.2	DRY	0	990	14.0	1260	2.1	1250	0.5	1100	30.0	17-Jul-97
AUG	DRY	0	770	0.6	860	5.9	1250	0.1	DRY	0	870	18.0	1240	2.1	1420	0.4	1140	46.0	18-Aug-97
SEP	DRY	0	410	20	540	11.3	1190	0.1	DRY	0	1050	14.5	1430	2.1	1320	0.5	1230	44.0	12-Sep-97

Table 4.2
Surface Water Quality Monitoring
1997 Water Year

Station Name	DATE	Flow (cfs)	TEMP	EC	pH	Ca	Mg	Na	K	HCO3	S04	Cl	NO3	SIO2	Hardness	B	Fl	TDS
ALAMO CANAL NEAR PLEASANTON	5/19/97	5.6	28.8	1250	7.9	93	34	145	2	390	137	136	1	22	373	0.6	0.40	769
ALAMO CANAL ABOVE SOUTH SAN RAMON	5/20/97		22.5	1160	7.9													
ARROYO DE LA LAGUNA NEAR PLEASANTO	3/19/97	54.0	18.7	1150	8.0	71	44	113	3	343	112	134	5	15	358	1.1	0.30	673
ARROYO VALLE AT PLEASANTON	3/19/97	9.2	19.4	800	8.2	50	38	65	2	253	65	95	2	13	284	0.6	0.20	463
ARROYO LAS POSITAS AT LIVERMORE	3/19/97	4.2	17.1	1870	8.0	81	51	260	3	466	110	306	23	16	414	4.6	0.70	1089
ARROYO LAS POSITAS AT EL CHARRO	3/19/97	6.0	17.5	1850	8.1	72	47	262	4	434	110	284	20	19	374	4.3	0.70	1042
ARROYO MOCHO NEAR LIVERMORE	3/19/97	6.4	17.1	860	8.4	44	77	34	2	430	73	31	0	16	426	0.3	0.20	515
ARROYO MOCHO NEAR PLEASANTON	3/19/97	11.6	22.5	1380	8.4	61	48	164	3	349	95	204	11	18	351	2.4	0.40	777
DRY CREEK AT ARROYO MOCHO	5/21/97	1.0	23.2	1050	7.8													
ARROYO VALLE BELOW LANG CANYON	3/19/97	29.0	17.8	590	8.1	63	31	23	2	283	69	18	0	11	285	0.2	0.20	366
ARROYO VALLE NEAR LIVERMORE	3/19/97	3.9	16.1	740	7.4	60	32	50	2	239	121	42	0	15	280	0.6	0.20	441
CAYETANO CREEK ABOVE POSITAS	5/20/97	0.1	26.6	1850	7.9	88	34	296	8	464	335	172	0	31	359	1.3	0.80	1203
DSRSD (LINE G-1-1)	5/19/97	0.3	29.4	7700	7.5	156	143	683	4	397	1202	596	0	14	977	3.7	0.80	2999
DUBLIN CREEK AT DUBLIN RD	5/19/97	0.5	18.2	1525	7.4	196	41	112	3	372	440	79	1	34	658	0.3	0.30	1097
SOUTHBAY TRIBUTARY	5/21/97		18.1	621	8.8	34	19	64	2	152	63	78	0	5	162	0.3	0.30	349
SOUTH SAN RAMON CREEK ABOVE SOUTH	5/20/97		23.9	1060	7.9													
TASSAJARA CREEK ABOVE ARROYO MOCHO	5/28/97		25.0	1098	8.2	41	30	165	3	300	124	121	0	4	227	0.7	0.60	641
TASSAJAR CREEK AT EB Park	5/28/97	0.6	22.2	1360	8.2	52	42	197	4	450	134	141	0	8	302	0.9	0.50	808

Zone 7 treatment plants. The electrical conductivity (EC) measurements are used to estimate TDS content using the formula TDS ≈0.56 x EC. Table 4.1 shows the monthly EC data for the 1997 water year for the major streams monitored by Zone 7. Additionally, surface water samples are collected periodically and analyzed for major and total ion content (Table 4.2). See Section 6.2, Existing Monitoring Programs, for additional information regarding the specific surface water monitoring stations.

Natural inflow and groundwater seepage are measured (gaged) by Zone 7 at various gaging stations along the streams. Water quality of the natural inflow/seepage into the upper reach of Arroyo Valle is monitored at the Arroyo Valle near Livermore (AVNL) gaging station, as discussed above. Inflow into the lower reach is essentially a mixture of urban runoff and mining discharges (see below). Water quality of the natural inflow into the Arroyo Mocho is monitored at the Arroyo Mocho near Livermore (AMNL) gaging station. The annual average TDS concentrations measured at AMNL have ranged from 350 mg/L to 580 mg/L between 1992 and 1998.

At various times during average and wet years, surplus SWP water is released into the Arroyo Mocho and Arroyo Valle to supplement the natural recharge of the groundwater basins. This "artificial stream recharge" began in 1962 with the importation of State Water Project water into the valley. Since water quality of the imported water at the stream channel turnouts is essentially the same as the water entering the Zone 7 water treatment plants, the water quality data collected at the treatment plant intakes are used for the artificial recharge component (See Section 4.2 - Imported Water for additional detail). The volume of SBA releases is metered at the respective SBA turnouts.

Natural inflow into the Arroyo las Positas is from the Seco, Upland Positas and the Positas drainage basins (see Reference G) plus seepage or outflow from the Spring and May subbasins. Water quality of the natural inflow into the Arroyo las Positas is monitored at the Arroyo las Positas near Livermore (ALPL) gaging station. The annual average TDS concentrations measured at ALPL have ranged from 1,080 mg/L to 1,590 mg/L between 1992 and 1998. The elevated TDS concentrations in the Arroyo las Positas are mainly due to the contributing subbasin groundwater components, but also due to runoff from the undifferentiated marine formations of the Altamont Hills. The poor quality groundwater flowing into the Arroyo las Positas is believed to get its salts from the particles and clasts of undifferentiated marine formations which help to makeup the alluvial aquifers in the Spring and May sub-basins. Evaporative concentration of these marine salts through the evaporation of shallow groundwater is also a cause of the high TDS in this area.

The Arroyo de la Laguna conveys the outflow from the Livermore-Amador basin. It contains a mixture of outflow from Alamo Canal, Arroyo Mocho, Arroyo las Positas and Arroyo Valle, and groundwater from the Bernal subbasin. Water quality of the various stream outflow components are monitored at the respective gaging stations by Zone 7. The subsurface groundwater outflow water quality is determined by averaging the TDS concentrations of several shallow monitoring wells located in the vicinity of the rising groundwater (near the Arroyo Valle and Arroyo de la Laguna confluence). Between 1995

and 1998 the subsurface groundwater outflow TDS values ranged from 830 mg/L and 980 mg/L. Groundwater seepage into the Arroyo de la Laguna did not occur in significant quantities from 1992 through 1995 (see Section 3.3 discussion). Alameda County Water District monitors the quantity and quality of the Arroyo de la Laguna near Pleasanton.

Natural Stream Recharge—Figure 3.3 has shown the relative recharge capacity associated with each of the major streams in the watershed and the associated water quality in terms of TDS. Note that the dashed lines represent areas of rising groundwater rather than areas of stream recharge. Table 4.1 and Figure 3.3 show that the TDS in the local surface water varies significantly throughout the watershed from approximately 350 mg/L to over 1,000 mg/L TDS. The highest quality surface water recharging the basin occurs through Arroyo Mocho and Arroyo Valle where the TDS is generally less than 500 mg/L. The poorest quality surface water recharging the basin has a TDS of approximately 1,000 mg/L and occurs in Arroyo Las Positas. On average, given 1997 land use conditions, approximately 2,700 AF of natural recharge occurs through Arroyo Mocho, 1,200 AF through Arroyo Las Positas, and 2,700 AF through Arroyo Valle annually.

The volume of flow through each of the major streams varies significantly on a seasonal basis. Further, the EC/TDS values at times of peak flow are often well below those during other times of the year (Table 4.1). For example, base-flow conditions for Arroyo de la Laguna (ADLLP) occurred during the months of April through October when flow was approximately 40 cfs and EC about 1,100 µmhos/cm. During high flow conditions at ADLLP in January (300 cfs), the EC was 650 µmhos/cm.

Rainfall and Urban Runoff

The quantity of local rainfall is monitored by Zone 7 at several rain gage stations located strategically around the basin. For the purpose of salt loading estimates, all of the rainfall is assumed to have a TDS concentration of 0 mg/L.

The quantity and quality of the urban runoff component is empirically determined. Previous studies found a correlation between rainfall and urban runoff. Now simple factors are used to determine the runoff components of several stream reaches. These estimated values are then checked against stream gaging data and adjusted if necessary. The water quality of this runoff component was also monitored in the past, and was found to average about 250 mg/L TDS. This average value is used in the Zone 7 salt loading calculation for the lower reach of Arroyo Valle.

Mining Ponds and Discharges

Zone 7 monitors the water level, electrical conductivity and TDS content of over 25 mining ponds located along the Arroyo Mocho and Arroyo Valle. In addition, Zone 7 monitors the water discharges made to the two Arroyos by the mining companies. Based

on the monitoring results, the flow-weighted average TDS content of the mining export has ranged from 490 mg/L to 550 mg/L between 1992 and 1998.

Applied Irrigation

Urban and agricultural irrigation are monitored separately. The quality of the urban irrigation water is determined by flow-weighting the average of SWP water quality, groundwater quality, and recycled water quality on an annual basis. Agricultural irrigation water quality is determined by flow-weighting the average qualities of the SWP and groundwater components.

4.4 Groundwater

Zone 7 operates a groundwater monitoring program that collects groundwater level and quality data from approximately 200 "program" wells annually. The data is stored in a computerized database for ready retrieval and reporting. A map showing the location of the program wells in the groundwater monitoring program is presented in Figure 4.3. The current Zone 7 groundwater monitoring program and future monitoring plans with respect to the Salt Management Plan are discussed in Chapter 6, Watershed Salt Management Monitoring Program.

In addition to data from the program wells, Zone 7 has compiled a computerized database of historic water level and mineral quality data from other wells within the local watershed. In general, laboratory analyses for most well samples include Ca, Mg, Na, K, HCO_3, SO_4, Cl, NO_3, SiO_2, alkalinity, boron (B), electrical conductivity (EC), pH, TDS, and hardness. In the late 1990's arsenic (As) and manganese (Mn) were added to the list of analytes.

Table 4.3 contains representative summaries of the groundwater quality data collected in each of the main subbasins during 1997. Figure 4.3 shows the locations of the wells with their numbers as listed in Table 4.3. A copy of the 1996 water year groundwater monitoring program annual report is included as Reference F.

Figures 4.4 and 4.5 show the contours of average TDS concentrations in the upper and lower aquifers of the main and fringe basins from the 1990 through 1995 water years. The upper aquifer contour map was created primarily using data from wells having a total depth of 150 feet or less, whereas the lower aquifer contour map uses water quality data from deeper aquifer monitoring wells and the municipal supply wells.

Graphical map-based summaries of the TDS, chloride, hardness, and nitrate concentrations measured in 1997 in the program wells are provided in Figures 4.6, 4.6A, 4.7 and 4.8, respectively. On this series of figures, the size (area) of each symbol (circle or square) is proportional to the concentration of the respective constituent. Larger symbols

ZONE 7
WATER RESOURCES ENGINEERING
GROUNDWATER QUALITY BY BASIN
MAJOR MINERAL SUMMARY
1997 WATER YEAR

SUB-BASIN	WELL	DATE	DTW	TEMP.	EC	pH	Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	SiO2	HARD	B	F	As	Mn	TDS	%Na	LAB
AMADOR EAST SUB-BASIN; LOWER	3S/1E 14A 2	08/12/97	102	22.2	608	7.8	63	30	32	1	234	16	82	7	20	281	0.3	0.1	0	0	368	20	ZONE 7
AMADOR EAST SUB-BASIN; UPPER	3S/1E 11B 1	09/01/97			1630		58	55	200	1	448	120	255	31	33	374	4.6				1110	54	LWRP
AMADOR WEST SUB-BASIN; LOWER	3S/1E 9M 3	06/04/97			650	7.9	49	37	30	2	270	32	41	11	21	274	0.3	0.1	0	0	357	19	ZONE 7
AMADOR WEST SUB-BASIN; UPPER	3S/1E 16P 5	05/29/97	38	17.3	620		37	28	43	2	197	58	52	7	12	206	0.3	0.1			336	31	ZONE 7
BERNAL SUB-BASIN; LOWER	3S/1E 18A 6	06/04/97			1005	7.8	76	43	79	2	381	90	80	9	26	364	0.5	0.1	0	0	594	32	ZONE 7
BERNAL SUB-BASIN; UPPER	3S/1E 19C 4	07/01/97	34.1	17.4	1130	7.1	137	40	47	2	428	126	90	16	20	507	0.3	0.2			690	17	ZONE 7
CAMP SUB-BASIN	2S/1E 32N 1	07/03/97	23.4	20.6	1299	7.1	134	11	115	2	318	24	228	31	28	379	0.5	0.2			729	40	ZONE 7
DUBLIN SUB-BASIN; LOWER	2S/1W 36F 2	01/28/97	26	18.5	882	7.6	41	11	147	1	387	0	88	0	21	147	0.6	0.1	0.11	0.15	501	69	ZONE 7
DUBLIN SUB-BASIN; UPPER	2S/1W 36E 3	07/09/97	4.3	21	861		118	10	48	1	336	88	63	19	38	333	0.2	0.3			550	24	ZONE 7
MAY SUB-BASIN; UPPER	2S/2E 28Q 1	06/26/97	4.2	19.1	1550	7.5	60	34	221	1	323	100	249	12	37	290	0.9	0.6			874	63	ZONE 7
MOCHO2 SUB-BASIN; LOWER	3S/2E 8 E1	08/08/97	43.8	24	780	8.2	47	55	40		337		56	17		343	20				460	20	DWR
MOCHO2 SUB-BASIN; UPPER	3S/1E 1H 3	07/10/97	27.7	20	1412	7.2	70	31	228	2	538	98	189	29	30	302	1	0.4			943	62	ZONE 7
SPRING SUB-BASIN; UPPER	2S/2E 27P 2	06/26/97	1	22.1	4620	7.6	111	47	965	3	204	0	1731	5	27	473	33.1	0.5			2990	82	ZONE 7

VALUES IN MG/L
TEMPERATURE IS DEGREES CELCIUS
DTW IS DEPTH TO WATER IN FEET

FIGURE 4.3

RANGE 1W RANGE 1E RANGE 2E RANGE 3E

TOWNSHIP 2S
TOWNSHIP 3S

Bishop Sub-basin
Dublin Sub-basin
Camp Sub-basin
Arroyo Del Valle Sub-basin
Vasco Sub-basin
May Sub-basin
Cayetano Sub-basin
Altamont Sub-basin
Spring Sub-basin
Mocho Sub-basin
Tassajara Sub-basin
Martinez Sub-basin
Castlewood Sub-basin

EXPLANATION

- MONITORING WELL
- ZONE 7 MUNICIPAL WELL
- ZONE 7 KEY WELL
- 17Q 4 WELL NUMBER
- 84 WELL DEPTH
- RANGE / TOWNSHIP BOUNDARIES
- BASIN BOUNDARY
- SUB-BASIN BOUNDARY
- MINING COMPANY POND

0 3000 6000
FEET

N

ZONE 7 WATER AGENCY

5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN BY:	STEVEN J. ELLIS
DESIGNED BY:	STEVEN J. ELLIS
CHECKED BY:	
APPROVED BY:	

WATER RESOURCES ENGINEERING
MONITORING WELL PROGRAM NETWORK
1997 WATER YEAR

SCALE:	1" = 6000' (ON ORIGINAL)
DATE:	15 JANUARY 1997
FILE NO.:	H:\SMP\FIG4-1.WOR

FIGURE 4.4

RANGE 1W
RANGE 1E
RANGE 1E
RANGE 2E
RANGE 2E
RANGE 3E

Bishop Sub-basin
Dublin Sub-basin
Camp Sub-basin
Vasco Sub-basin
May Sub-basin
Cayetano Sub-basin
Altamont Sub-basin
Spring Sub-basin
Amador Sub-basin
Castlewood Sub-basin
Mocho II Sub-basin

TOWNSHIP 2S
TOWNSHIP 3S

RANGE 1W
RANGE 1E
RANGE 1E
RANGE 2E
RANGE 3E

EXPLANATION

- 0 - 399 TDS IN MG/L
- 400 - 499 TDS IN MG/L
- 600 - 699 TDS IN MG/L
- 700 - 999 TDS IN MG/L
- 1000 - 1999 TDS IN MG/L
- > 2000 TDS IN MG/L
- WELL
- 20F 5 655 WELL NUMBER AND TDS DATA: AVG 90-95 WATER YEAR
- MAIN GROUNDWATER BASIN
- RANGE / TOWNSHIP BOUNDARIES
- BASIN BOUNDARY
- SUB-BASIN BOUNDARY
- MINING COMPANY POND

N

0 1 2
Miles

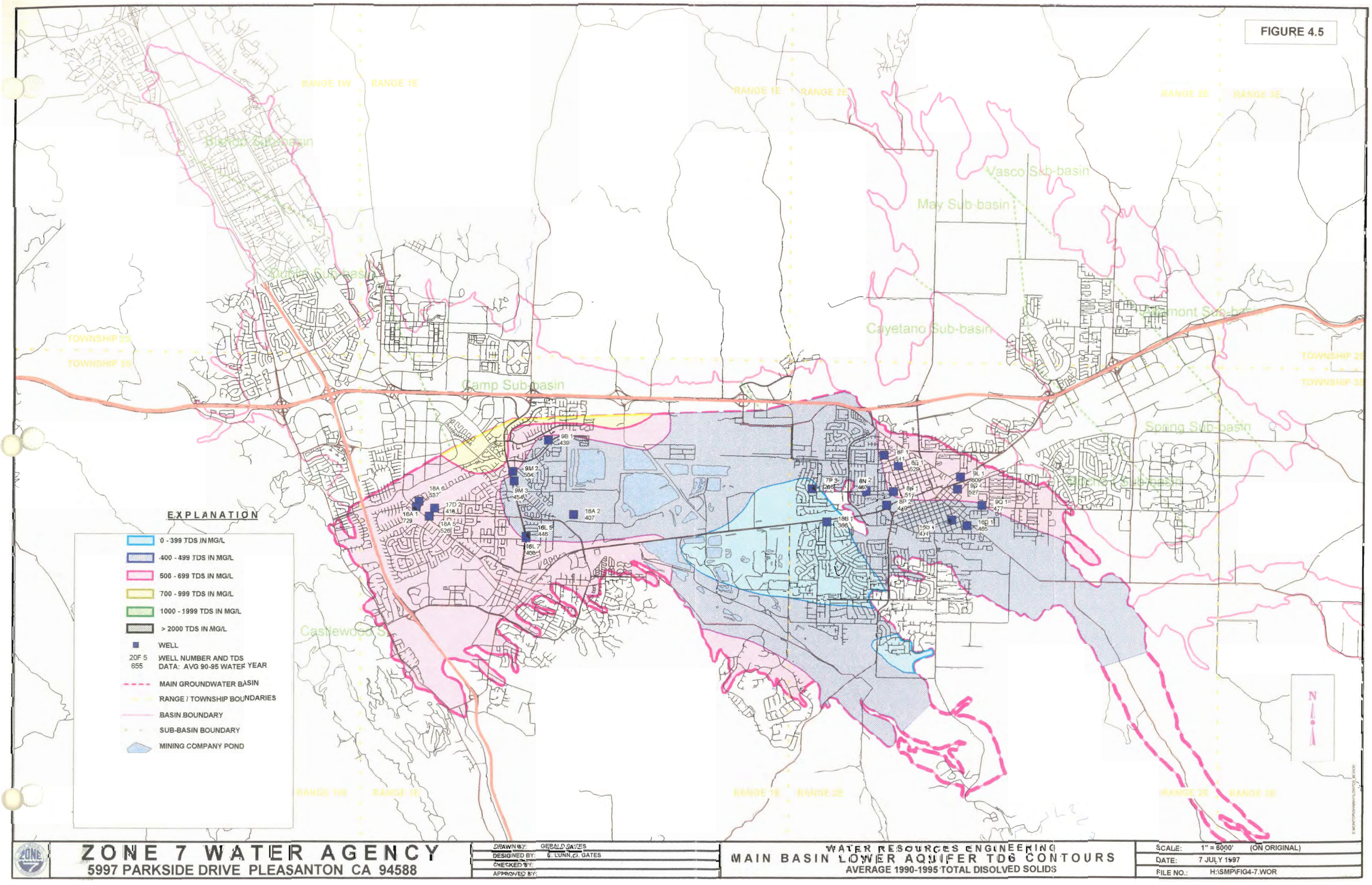
ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN BY: GERALD GATES
DESIGNED BY: D. LUNN
CHECKED BY:
APPROVED BY:

WATER RESOURCES ENGINEERING
UPPER AQUIFER TDS CONTOUR MAP
AVERAGE 1990-1995 TOTAL DISOLVED SOLIDS

SCALE: 1" = 6000' (ON ORIGINAL)
DATE: 7 JULY 1997
FILE NO.: H:\SMP\FIG4-6.WOR

FIGURE 4.5



ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN BY: GERALD GATES
DESIGNED BY: S. LUNN, G. GATES
CHECKED BY:
APPROVED BY:

WATER RESOURCES ENGINEERING
MAIN BASIN LOWER AQUIFER TDS CONTOURS
AVERAGE 1990-1995 TOTAL DISOLVED SOLIDS

SCALE: 1" = 6000' (ON ORIGINAL)
DATE: 7 JULY 1997
FILE NO.: H:\SMP\FIG4-7.WOR

FIGURE 4.6

I-680

I-580

PLEASANTON

LIVERMORE

DRAINAGE BASIN BOUNDARY

GROUNDWATER SUB-BASIN BOUNDARY

DEEP WELLS- TDS

1,000
500
100

SHALLOW WELL- TDS

1,000
500
100

N

ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	GERALD GATES
DESIGNED	GERALD GATES
CHECKED	DAVID LUNN
APPROVED	

WATER RESOURCES ENGINEERING

AVERAGE TDS OF MONITORED WELLS
1997 WATER YEAR

SCALE	1" = 1 MILE
DATE	5 MAY 1998
FILE NO.	H:\smp\FIG4-2.WOR

FIGURE 4.6A
HARDNESS

I-680

I-580

PLEASANTON

LIVERMORE

DRAINAGE BASIN BOUNDARY

GROUNDWATER SUB-BASIN BOUNDARY

SHALLOW WELLS - HARDNESS

750
375
75

DEEP WELLS - HARDNESS

750
375
75

N

ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	GERALD GATES
DESIGNED	GERALD GATES
CHECKED	DAVID LUNN
APPROVED	

WATER RESOURCES ENGINEERING

AVERAGE HARDNESS OF MONITORED WELLS
1997 WATER YEAR

SCALE	1" = 1 MILE
DATE	5 MAY 1998
FILE NO.	B:151 1 Shp#1S4-3.WOR

FIGURE 4.7
CHLORIDES

I-680

I-580

PLEASANTON

LIVERMORE

DRAINAGE BASIN BOUNDARY

GROUNDWATER SUB-BASIN BOUNDARY

DEEP WELLS - CHLORIDE

300
150
30

SHALLOW WELLS - CHLORIDE

300
150
30

N

ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	GERALD GATES
DESIGNED	GERALD GATES
CHECKED	DAVID LUNN
APPROVED	

WATER RESOURCES ENGINEERING

AVERAGE CHLORIDE OF MONITORED WELLS
1997 WATER YEAR

SCALE	1" = 1 MILE
DATE	5 MAY 1998
FILE NO.	H:\smp\FIG4-5.WOR

FIGURE 4.8
NITRATES AS NO3

I-680

I-580

PLEASANTON

LIVERMORE

DRAINAGE BASIN BOUNDARY

GROUNDWATER SUB-BASIN BOUNDARY

DEEP WELLS - NITRATES

60
30
6

SHALLOW WELLS - NITRATES

60
30
6

N

ZONE 7 WATER AGENCY

5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	GERALD GATES
DESIGNED	GERALD GATES
CHECKED	DAVID LUNN
APPROVED	

WATER RESOURCES ENGINEERING

AVERAGE NITRATES OF MONITORED WELLS
1997 WATER YEAR

SCALE	1" = 1 MILE
DATE	5 MAY 1998
FILE NO.	6-151 | emp\FIG4-4.WOR

represent wells with higher concentrations. Upper aquifer values are represented by red-orange circles and lower aquifer values are represented by blue squares. The 1990-1995 average concentration values are printed next to the symbols. These figures demonstrate that the groundwater quality varies with respect to each of these constituents throughout the basin, and that significant variability exists between some wells that are in close proximity to each other.

Upper Aquifer Water Quality

Figure 4.4 shows that upper aquifer TDS values vary significantly throughout the groundwater basin. The contour map shows that groundwater quality is typically best in areas adjacent to the artificial recharge reaches of the local streams. Along the Arroyo Valle southeast of the mining area, TDS is generally less than 400 mg/L. Along much of the Arroyo Mocho, TDS is generally less than 500 mg/L due to the artificial stream recharging operations.

Groundwater of the Bishop subbasin and the northern area of the Dublin subbasin have TDS values between 400 and 500 mg/L, while the main portion of the Dublin subbasin exhibits TDS in excess of 2,000 mg/L. The lower TDS is believed to be the result of irrigation in northern Dublin and San Ramon with low TDS water supplied by East Bay Municipal Utility District (EBMUD). The 800-1,000 mg/L TDS groundwater in the southern portion of the Dublin subbasin is a result of the groundwater flowing through salt-bearing ancient lake deposits in the south Dublin and northwest Pleasanton areas. This relatively high TDS water is of concern to the extent that it is calculated to move into the shallow aquifer portion of the Bernal sub-basin at about 1 TAF/Y degrading the water in that basin, as was discussed in Section 3.3.

Groundwater in the Camp subbasin contains TDS between 700 and 900 mg/L, and may contain pockets of elevated arsenic concentrations due to the presence of alluvial material eroded from the formations in the Tassajara and Alameda Creak drainage basins. Runoff from these two drainage basins that has historically recharged the groundwater basin may also be a source of arsenic. The Spring subbasin, and to some extent the May subbasin, groundwater has TDS in excess of 2,000 mg/L as a result of inflow from the old marine sediments that occur northeast of Livermore.

The Mocho 2 subbasin is divided horizontally in terms of water quality. To the north, the groundwater exhibits the high TDS characteristics of the Arroyo Las Positas, with concentrations approaching 1,000 mg/L. To the south, the groundwater quality is similar to the Arroyo Mocho water quality, with concentrations barely exceeding 500 mg/L. The beneficial effects of artificial stream recharge are evident in the southern Mocho 2 subbasin.

The East Amador subbasin has poor quality in the north, which is the result of recharge from Arroyo Las Positas, and possibly subsurface inflow from the Camp subbasin. To the

south, in East Amador, the water is of noticeably better quality. This higher quality water is from artificial recharge along the Arroyo Valle. The West Amador subbasin has a similar groundwater quality distribution that is accentuated by the effects of the gravel mining operations that essentially separate the East Amador subbasin from the West Amador subbasin.

The normal flow of groundwater brings the waters of the Dublin, Camp, and West Amador subbasins together in the Bernal subbasin. As a result, the quality in the Bernal subbasin is not simple to characterize as the TDS varies from 300 mg/L to over 2,000 mg/L. To the north, the effect of the higher TDS Dublin subbasin is seen. In the southeast, the lower TDS recharge water from the Arroyo Valle is evident.

Lower Aquifer Water Quality

Water quality in the lower Mocho 2 subbasin varies from 400 to 600 mg/L and exhibits the same profile as the upper aquifer, suggesting that vertical mixing is occurring within the two aquifers. See Section 3.4 for additional information regarding aquifer mixing.

The lower East Amador subbasin has good quality water consisting of 300 to 400 mg/L TDS. This is probably the result of historic recharge from the Arroyo Valle and Arroyo Mocho (Figure 4.5). The lower West Amador subbasin has similar water quality.

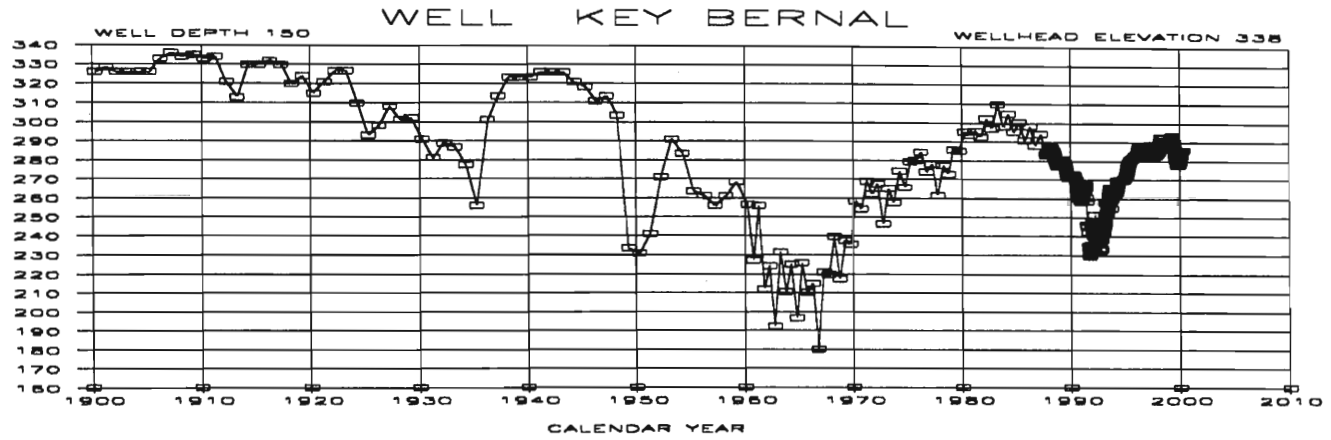
Unlike the upper aquifer in the Bernal subbasin, the lower Bernal subbasin water quality is less variable, ranging from 400 to 700 mg/L TDS. This is most likely the result of lower aquifer pumpage and associated vertical and horizontal mixing.

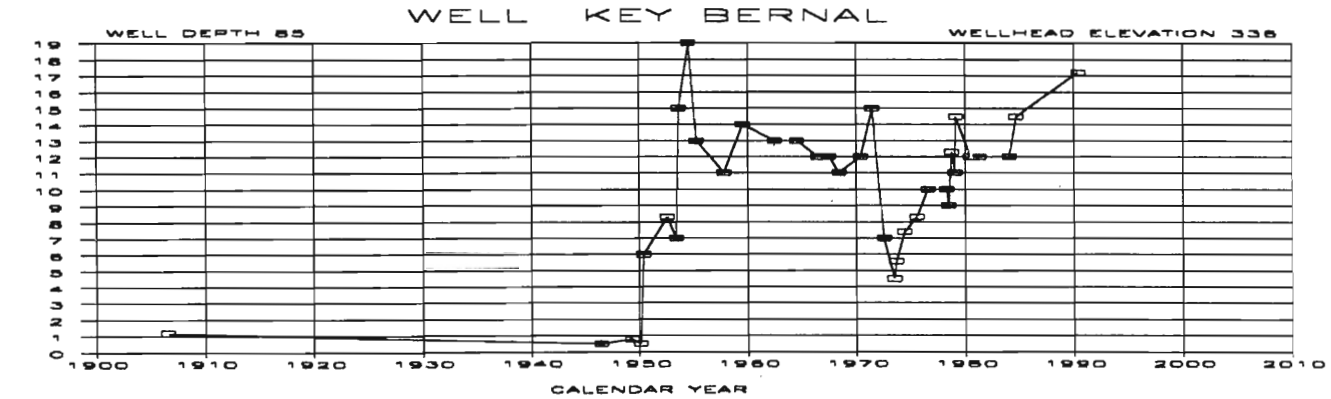
Groundwater Quality Trends

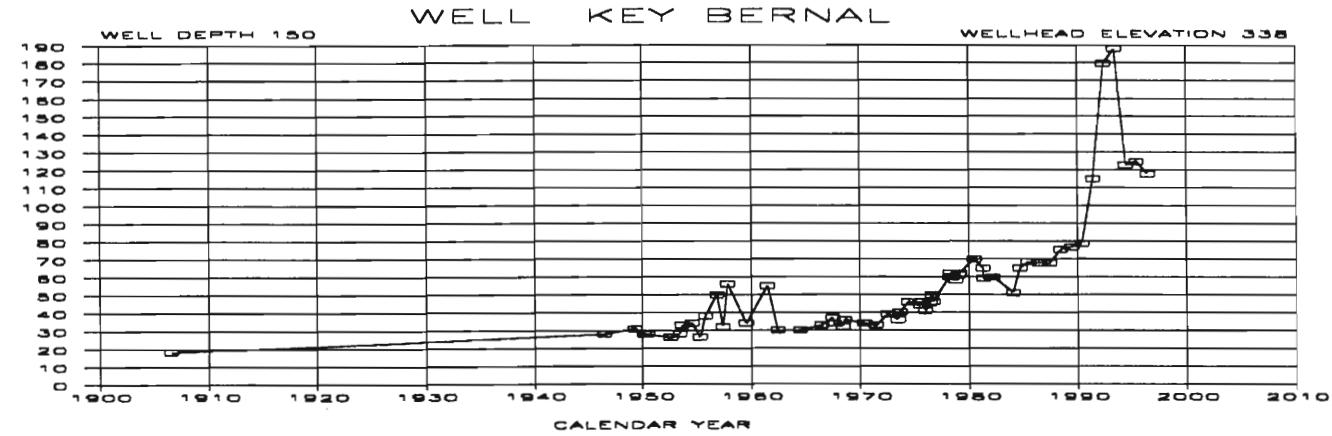
Long-term groundwater quality trends can be difficult to detect. Multiple factors can influence annual groundwater quality including changes in basin level, proximity and volume of groundwater extraction and recharge, and variable recharge water quality. Historic water level and quality records are useful for tracking transport of water within the aquifer and external influences on the groundwater (e.g., streams, mining pits, etc.). Zone 7 tracks trends in key basin areas by routinely producing hydrochemographs of single wells or grouped wells (composite hydrochemographs). Hydrochemographs are time series graphs of individual groundwater water quality constituents.

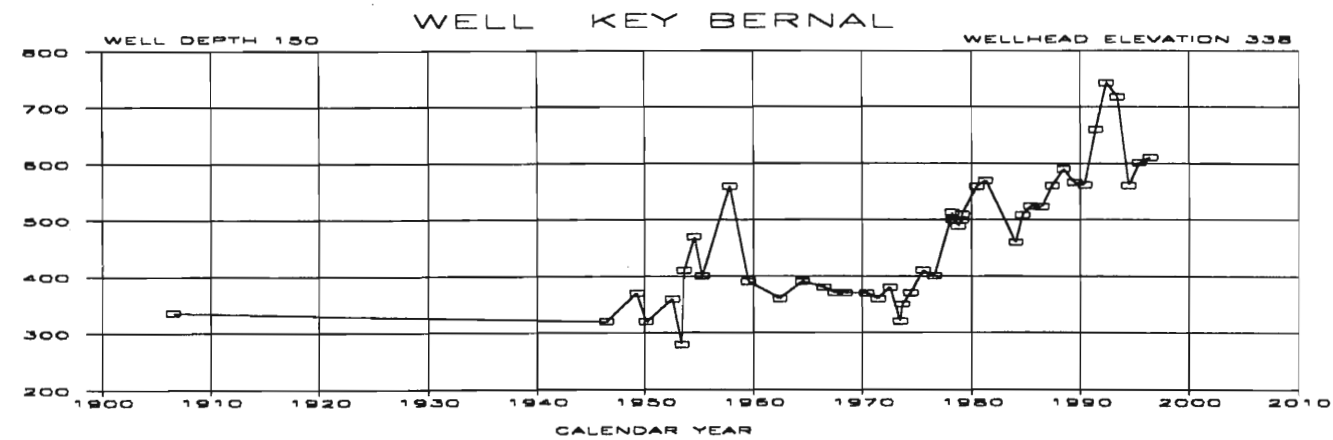
Figure 4.9 contains several composite hydrochemographs representing the Bernal subbasin. Figure 4.10 exhibits hydrochemographs for well 3S/2E 8P 2, a Cal Water well in Livermore, representative of the Mocho 2 subbasin. The data for these two wells span over half a century and show a variable, but overall upward trend in chloride and TDS concentrations. The rate of water quality degradation varies geographically in the basin, and by constituent.

ZONE 7
WATER RESOURCES ENGINEERING
GROUNDWATER HYDROCHEMOGRAPH



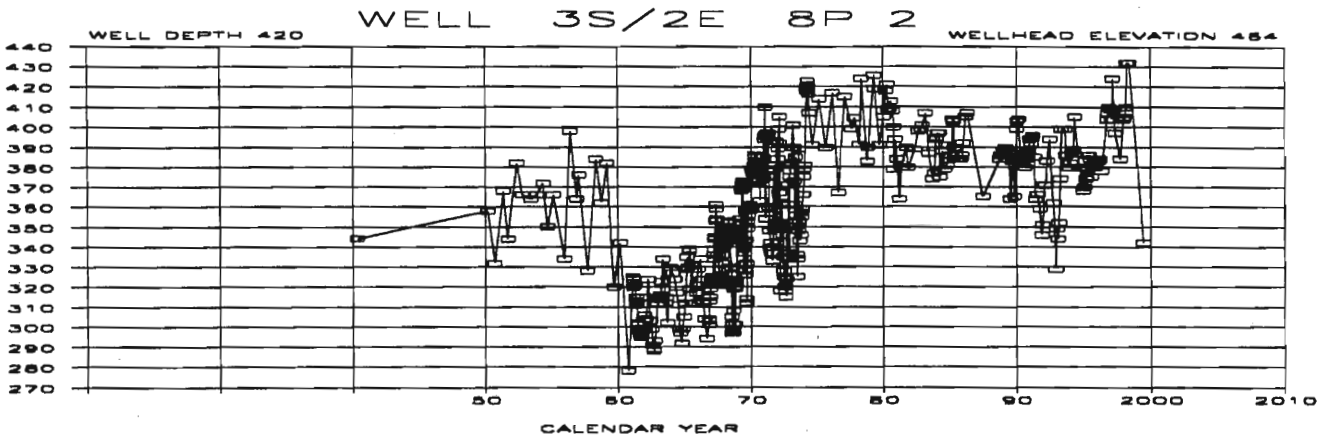


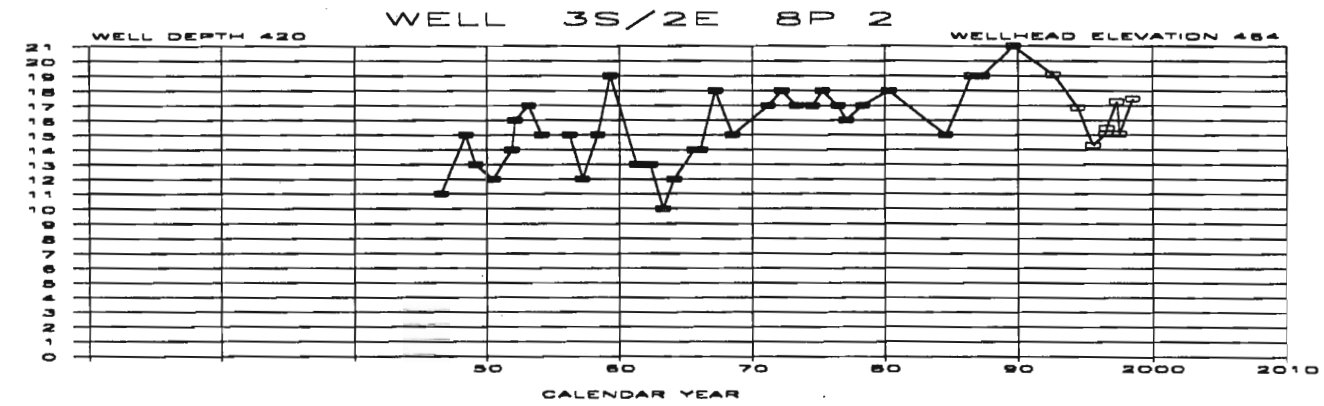


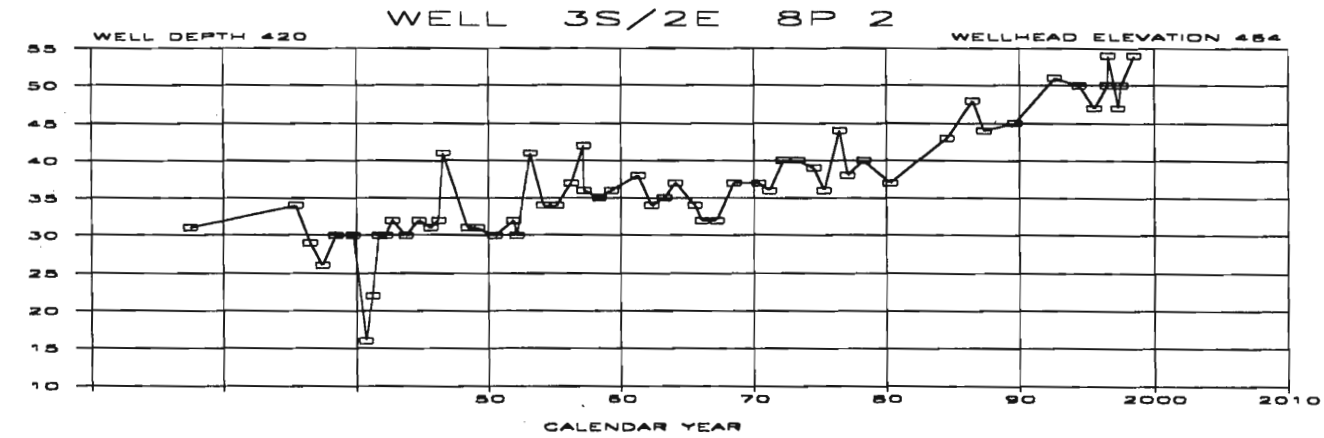


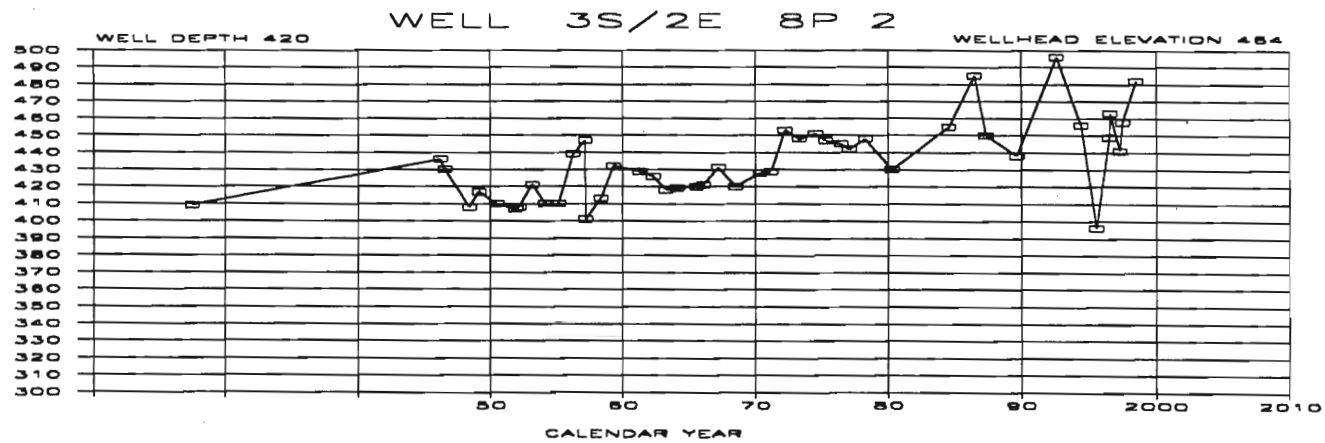
WELL: KEY BERNAL

ZONE 7
WATER RESOURCES ENGINEERING
GROUNDWATER HYDROCHEMOGRAPH









4.5 Production Wells

The City of Pleasanton, California Water Service, San Francisco Water District (SFWD), and Zone 7 all use municipal supply wells to partially or entirely supply municipal and industrial water customers with potable water. The City of Pleasanton, California Water Service, Dublin San Ramon Services District (DSRSD) and the City of Livermore each has an annual groundwater pumping quota, that in aggregate total about 80% of the average safe natural yield of the groundwater basin. However, DSRSD and the City of Livermore are not currently pumping groundwater from the basin. SFWD does not have a pumping quota, but is limited by the relatively fixed demand of their customers. Zone 7 also does not have a maximum pumping quota. However, Zone 7 purchases water and artificially recharges it into the basin to refill the basin and offset its withdrawals. Zone 7's hydrologic inventory tracks the artificial recharge and extraction by Zone 7.

A list of the basin's municipal supply wells, along with the estimated production capacity and current status of each well, is given in Table 4.4. Groundwater pumping quantity and TDS from Zone 7 and retailer municipal supply wells are also summarized in Table 4.5. Reference H provides additional water quality detail for the municipal wells, including hydrochemographs of TDS, chlorides and nitrates. These graphs provide further evidence of the generally increasing concentrations of dissolved salts and minerals throughout the Main Basin groundwater.

Zone 7

Historically, Zone 7 has pumped groundwater solely as seasonal demand dictated, and when needed to meet daily peak demand. Zone 7 has seven wells it can use to pump groundwater for municipal supply. Historic average production from Zone 7's active wells has been approximately 2,500 AF/yr, but has varied from 0 to 7,850 AF/yr for 1987-97 depending on available surface water and annual basin management and delivered water strategies in place. Future plans call for even higher groundwater production by Zone 7.

TDS levels in Zone 7 production wells ranged from 390 to 740 mg/L in 2003, with a flow weighted average of 490 mg/L. The large variation in water quality, seen in the Hopyard Well No.6 (3S/1E 18A6) data is the result of this well being tested as an aquifer storage and recovery (ASR) well. During 1997-98, varying quantities of treated SBA water was injected into this well and the surrounding aquifer and then subsequently pumped during times of higher demand. This particular well operation was part of a pilot test being conducted for possible integration of ASR features into future well projects. Operations in the ASR mode are currently suspended until the cause of clogging of the well that reduced its production capacity is identified.

ZONE 7
WATER RESOURCES ENGINEERING
MUNICIPAL SUPPLY WELLS - 2004

PURVEYOR	WELL	STATE WELL	HP	GPM	STATUS
City of Pleasanton	#5	3S/1E 16L 5	200	2000	ACTIVE
	#6	3S/1E 16L 7	200	2150	ACTIVE
	#7	3S/1E 18A 5	150	1900	INACTIVE
	#8	3S/1E 16A 2	450	3200	ACTIVE
Calif. Water Service					
	004-01	3S/2E 8H 1	50		INACTIVE - N
	005-01	3S/2E 16B 1	20	70	ACTIVE
	008-01	3S/2E 8P 1	25	370	ACTIVE
	009-01	3S/2E 9Q 1	40	730	ACTIVE
	010-01	3S/2E 8F 1	60	725	ACTIVE
	012-01	3S/2E 9P 1	60	850	ACTIVE
	014-01	3S/2E 8N 2	50	1000	ACTIVE
	015-01	3S/2E 16C 1	60	975	ACTIVE
	017-01	3S/2E 9L 1	50	460	ACTIVE
	019-01	3S/2E 8G 1	60	620	ACTIVE
	020-01	3S/2E 18B 1	60	280	ACTIVE
	024-01	3S/2E 7P 3	100	450	ACTIVE
	031-01	3S/2E 7R 3	125	750	ACTIVE
Zone 7	Hopyard 1	3S/1E 18A 1	150	700	ACTIVE
	Hopyard 4	3S/1E 17D 2	150	700	ACTIVE
	Hopyard 6	3S/1E 18A 6	500	3900	ACTIVE
	Mocho 1	3S/1E 9M 2	300	2300	ACTIVE
	Mocho 2	3S/1E 9M 3	250	2200	ACTIVE
	Mocho 3	3S/1E 9M 4		4000	ACTIVE
	Mocho 4	3S/1E 8H 18		3700	ACTIVE
	Stoneridge	3S/1E 9B 1	700	4000	ACTIVE
Camp Parks	Well 1	3S/1E 8H 2	100	550	INACTIVE
	Well 2	3S/1E 8H 3	60	500	INACTIVE
	Well 3	3S/1E 8H 4	60	450	INACTIVE
	Well 4	3S/1E 8H 5	60	NA	DESTROYED
DSRSD		3S/1W 1B 1	40	150	DESTROYED 1984
		3S/1W 1G 2	NA	NA	DESTROYED 1980
		3S/1W 1H 2	NA	NA	DESTROYED 1985
City of Livermore		3S/1E 1P 3		520	INACTIVE
SFWD (Upper Castlewood)	#4	3S/1E 19A 1	30		ACTIVE
	#3	3S/1E 19A 2	30		ACTIVE
	#2	3S/1E 19A 3	30		ACTIVE
	#1	3S/1E 19A 5	30	400	INACTIVE
Fairgrounds		3S/1E 20B 2	40	500	ACTIVE
		3S/1E 20C 3	50	300	ACTIVE
Castlewood Golf Course (Lower)		3S/1E 29E 3	25	350	ACTIVE
		3S/1E 29E 4	50	500	ACTIVE

TABLE 4.5

Municipal GW Pumping and TDS

	STATION	HISTORIC ANNUAL AVG. PRODUCTION in AF	2003 PRODUCTION in AF	GROUNDWATER TDS (mg/l) HISTORIC MIN.	HISTORIC MAX.	2003
PLEASANTON						
3S/IE 16L5	PLEAS #5	1031	585	321	526	460
3S/1E 16L 7	PLEAS #6	1184	656	326	540	460
3S/1E 18A 5	PLEAS #7	545	0	311	714	
3S/1E 16A 2	PLEAS #8	738	2432	376	458	390
TOTAL PLEASANTON						414
CALIFORNIA WATER SERVICE COMPANY (CWS)						
3S/2E 7R 3	CWS# 31(7R3)		313			433
3S/2E 16B 1	CWS# 5(16B1)	52	84	405	530	523
3S/2E 8P 1	CWS# 8(8P 1)	187	450	362	599	535
3S/2E 9Q 1	CWS# 9(9Q 1)	231	0	424	549	524
3S/2E 8F 1	CWS#10 (8F1)	289	0	402	629	
3S/2E 9P 1	CWS#12 (9P1)	92	506	394	590	588
3S/2E 8N 2	CWS#14 (8N2)	482	1044	422	515	485
3S/2E 16C 1	CWS#15 (16C)	339	241	436	511	499
3S/2E 9L 1	CWS#17 (9L1)	66	0	346	670	
3S/2E 8G 1	CWS#19 (8G1)	120	218	391	613	582
3S/2E 18B 1	CWS#20 (18B)	119	402	286	413	387
3S/2E 7P 3	CWS#24 (7P3)	597	717	253	320	282
TOTAL CWS						460
ZONE 7						
3S/1E 18A 1	HOP 1	121	0	233	1015	
3S/1E 17D 2	HOP 9		23	330	534	459
3S/1E 18A 6	HOP 6	402	2280	216	640	503
3S/1E 9M 2	MOCHO 1	448	720	280	993	705
3S/1E 9M 3	MOCHO 2	583	738	326	968	546
3S/1E 9M 4	MOCHO 3		1072	470	644	580
3S/1E 8H 18	MOCHO 4		754	348	470	432
3S/1E 9B 1	STONERIDGE_1	1253	2643	325	525	405
TOTAL ZONE7						496
SFWD						
SF O-line		420	420	501	860	860

City of Pleasanton

The City of Pleasanton currently pumps groundwater from three municipal wells. A fourth well (3S/1E 18A5) has been inactive pending repair or rehabilitation. Pleasanton's current agreement with Zone 7 specifies their groundwater pumping quota as 3,500 AF/yr. The maximum pumpage occurred in 1991 when the city pumped 1,357 million gallons (MG) or 4,165 AF of groundwater (under drought conditions). As shown in Table 4.5, the average TDS of groundwater pumped from Pleasanton's wells in 2003 ranged from 390 to 460 mg/L and averaged approximately 415 mg/L.

California Water Service, Inc.

California Water Service (CWS) currently pumps groundwater from 11 of their 13 wells. High nitrate levels have restricted pumping from some of the CWS wells. Groundwater from those wells must be blended with treated surface water to reduce the total nitrate concentration prior to distribution to the transmission system. CWS's contract with Zone 7 specifies an independent pumping quota of 3,069 AF/yr. During 2003, TDS levels from CWS wells ranged from 280 to 590 mg/L with a flow weighted average TDS of 460 mg/L (Table 4.5).

San Francisco Water District

San Francisco Water District currently supplies municipal groundwater to the upper Castlewood Country Club area from the SFWD well field located along Valley Avenue in Pleasanton. Well number 19A3 is currently the primary source of groundwater with the remaining wells available to accommodate peak flow demands. SFWD 2003 municipal supply groundwater averaged 860 mg/L TDS.

Dublin San Ramon Services District

Although DSRSD has an independent pumping quota of 645 AF/yr in the Main Basin, they currently have no production wells of their own. However, they do manage the Camp Parks well field for the U.S. Army, which consists of three wells located near the intersection of Santa Rita and Stoneridge Avenues. These shallow wells were formerly used to supply potable water to the Camp Parks Army facility in Dublin but are now idle. Camp Parks now receives treated water from a Zone 7 turnout. The Camp Parks well field overlaps Zone 7's Mocho well field in aerial extent. However, the wells are generally not completed in the same aquifers with the Mocho wells being completed deeper than the Camp Parks wells. DSRSD has the option to purchase the Mocho No. 4 production well from Zone 7.

As shown in Figures 4.4 and 4.5, TDS is relatively high in the shallow groundwater in the vicinity of the Camp Parks well field. Because of the location of the well field and the high levels of TDS in the groundwater in this location, this site has been considered a potential site for a wellhead demineralization project (see Chapter 10).

City of Livermore

The City of Livermore possesses an independent pumping quota of 31 AF/yr, but has no municipal wells connected to their M & I distribution system. Livermore has a single well located at the Livermore Municipal Airport and has used it in the past to supply irrigation water to the city-operated Las Positas golf course.

4.6 Delivered Water Quality and Variability

The relationship between imported water, groundwater quality, and Zone 7 delivered water quality was introduced at the beginning of this chapter. Since 75–85% of the water delivered by Zone 7 is imported water, and because the quality of the imported water varies as a function of annual climatic conditions as well as seasonally, Zone 7 delivered water quality varies correspondingly.

The quality of Zone 7 deliveries also varies as a function of the surface water to groundwater ratio. The ratio of groundwater to surface water can vary by season, by day, and by turnout depending on demand. Table 4.6 shows typical summer and winter water ratio percentages of Zone 7 deliveries under three climatic conditions: dry, average and wet years.

Table 4.6
Typical Delivered Water TDS
Under Historic Basin Management Strategy

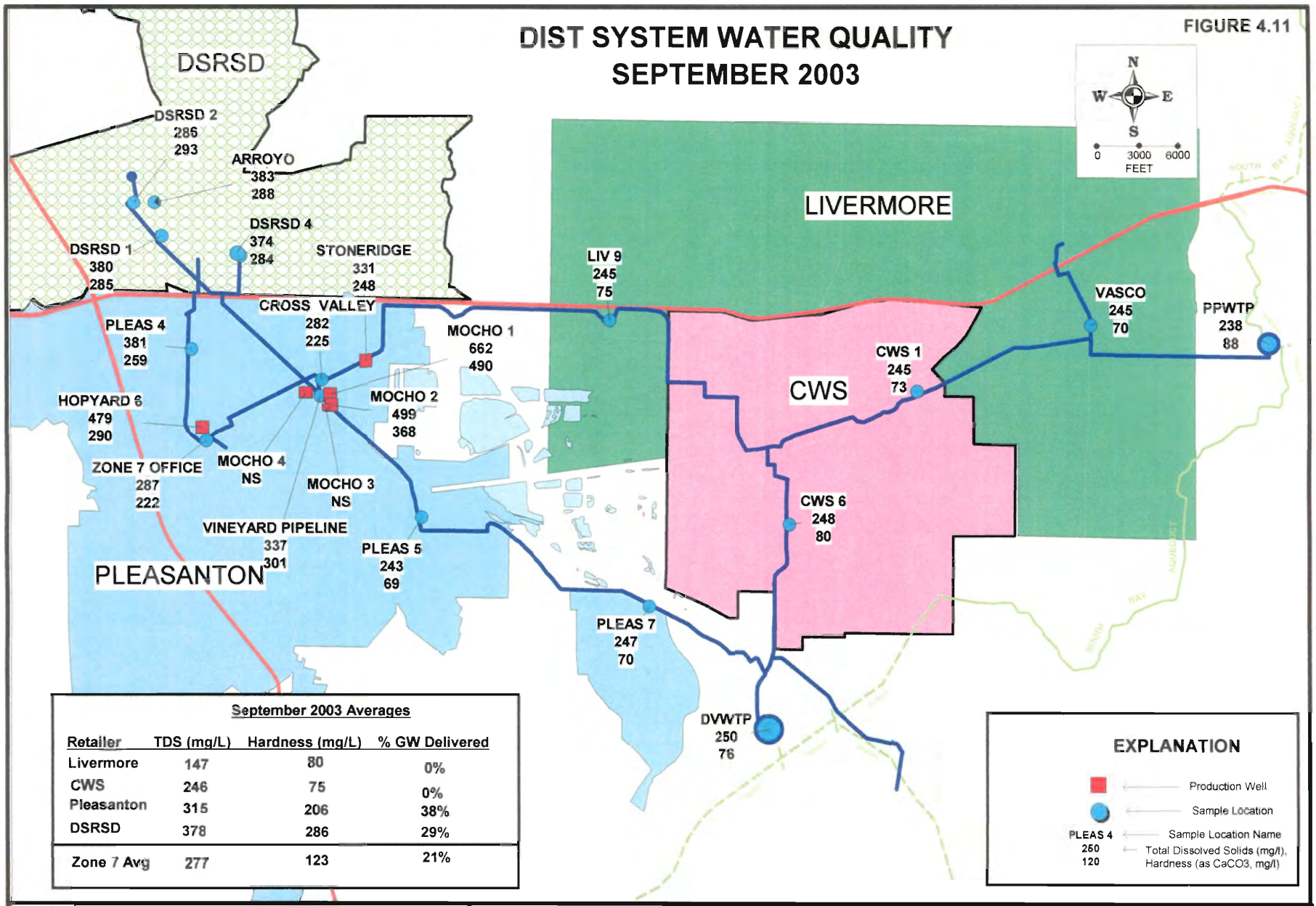
Climatic	Delivered Water %SBA		Zone 7delivered (mg/L)	
Conditions	Winter	Summer	Winter	Summer
Dry	30%	30%	470	470
Average	100%	90%	270	240
Wet	100%	90%	170	180

Climatic	SBA TDS (mg/L)		GW
Conditions	Winter	Summer	TDS
Dry	500	500	450
Average	270	220	450
Wet	170	150	450

Water quality also varies within the Zone 7 distribution system. The blend of surface to groundwater varies between turnouts because of the locations of the wells relative to the turnouts and because of their intermittent use. Figure 4.11 shows TDS and hardness

DIST SYSTEM WATER QUALITY
SEPTEMBER 2003

FIGURE 4.11



September 2003 Averages

Retailer	TDS (mg/L)	Hardness (mg/L)	% GW Delivered
Livermore	147	80	0%
CWS	246	75	0%
Pleasanton	315	206	38%
DSRSD	378	286	29%
Zone 7 Avg	277	123	21%

EXPLANATION

- Production Well
- Sample Location
- PLEAS 4 / 250 / 120 — Sample Location Name; Total Dissolved Solids (mg/l), Hardness (as CaCO3, mg/l)

ZONE 7 WATER AGENCY

5997 PARKSIDE DRIVE, PLEASANTON CA 94588

DRAWN BY:	A. Florendo
DESIGNED BY:	SSegura
CHECKED BY:	S. Segura
APPROVED BY:	D. Lunn

WATER RESOURCES
DISTRIBUTION SYSTEM WATER QUALITY
TOTAL DISSOLVED SOLIDS (mg/l) & HARDNESS(as CaCO3, mg/l)

SCALE:	1" = 10,000'
DATE:	10 October 2003
FILE NO.:	E:\PROJECTS\GMP\SMP REPORT\ CHAPTER4\DISTWQ FIG4.11.WOR

FIGURE 4.11

variation in the distribution system under one groundwater water production scenario. Because Zone 7 production wells are all located in the western portion of the basin, the City of Pleasanton and DSRSD receive most of the groundwater pumped by Zone 7. California Water Service, the City of Livermore and the untreated customer demands are met almost entirely using imported surface water and local surface water.

California Water Service and the City of Pleasanton also operate wells and blend groundwater with their Zone 7 deliveries adding to the variability of *their* delivered water quality. Typical percentages of each type of water (i.e., surface water, Zone 7 pumped groundwater, retailer pumped groundwater) delivered by each retailer to their customers is shown in Figure 4.12.

Figure 4.13 shows Zone 7 treated water deliveries and annual average TDS for 1974 through 1997. The figure shows five graphs. The first graph shows the annual amount of surface water delivered. The second graph shows the annual amount of groundwater delivered. The third and fourth graphs show the annual average TDS of surface water and groundwater, respectively. The annual average TDS of imported surface varied from 100 to nearly 600 mg/L between 1974 and 1997, while the TDS of the delivered groundwater varied between 400 and 550 mg/L.

The fifth graph shows the annual average TDS of the total Zone 7 deliveries. The result of all the annual variations, many of which are not under Zone 7 control, is that the TDS of the delivered water can vary considerably on an annual basis. Similarly, Figure 4.14 illustrates the extent to which TDS can vary on a monthly basis (using 1997 data). The monthly variation may change from year to year based upon climatic conditions and the ratio of surface water to groundwater delivered.

Another variable not immediately discernable from these figures is which wells Zone 7 chooses to pump from. Historically, Zone 7 has typically chosen to pump from wells with the lowest TDS water, to deliver the highest quality groundwater available. As will be discussed in Chapter 8 in more detail regarding ASR wells, while viable in the short-term, this basin management strategy, without other offsetting measures, is not sustainable and will result in continued groundwater degradation.

4.7 Tertiary and RO Recycled Water Quality

To date there has been relatively limited use of recycled water in the Livermore-Amador Valley due in part to concerns about impacts on groundwater quality. The May 1992 Livermore-Amador Valley Water Recycling Study, the December 1993 RWQCB Master Water Recycling Permit, and this Salt Management Plan provide a framework where additional water recycling could be implemented while protecting groundwater beneficial uses.

FIGURE 4.12

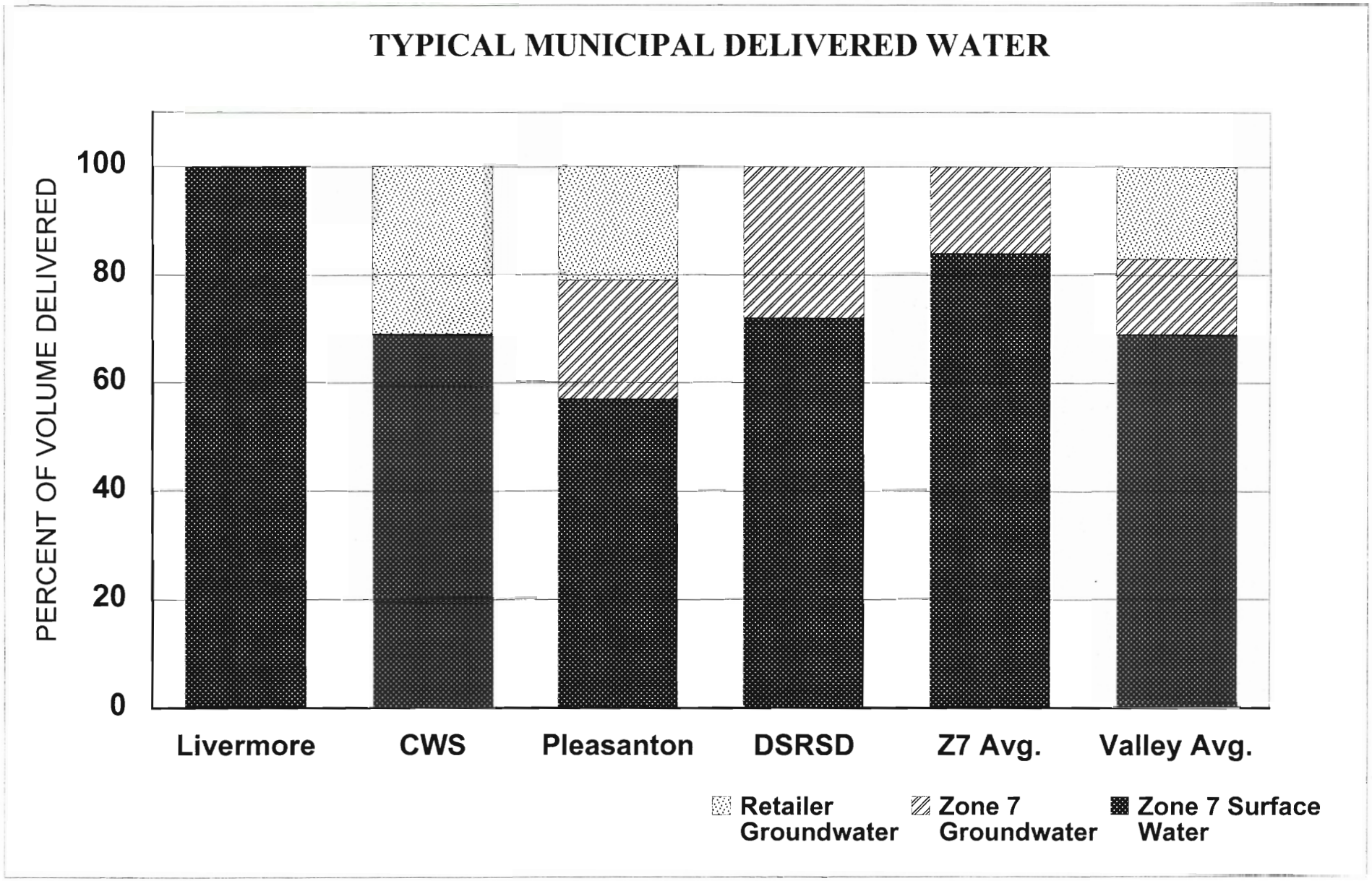

TYPICAL MUNICIPAL DELIVERED WATER
PERCENT OF VOLUME DELIVERED
100
80
60
40
20
0
Livermore
CWS
Pleasanton
DSRSD
Z7 Avg.
Valley Avg.
Retailer Groundwater
Zone 7 Groundwater
Zone 7 Surface Water

FIGURE 4.13

TREATED WATER DELIVERIES & WATER QUALITY
1974-97 WATER YEARS

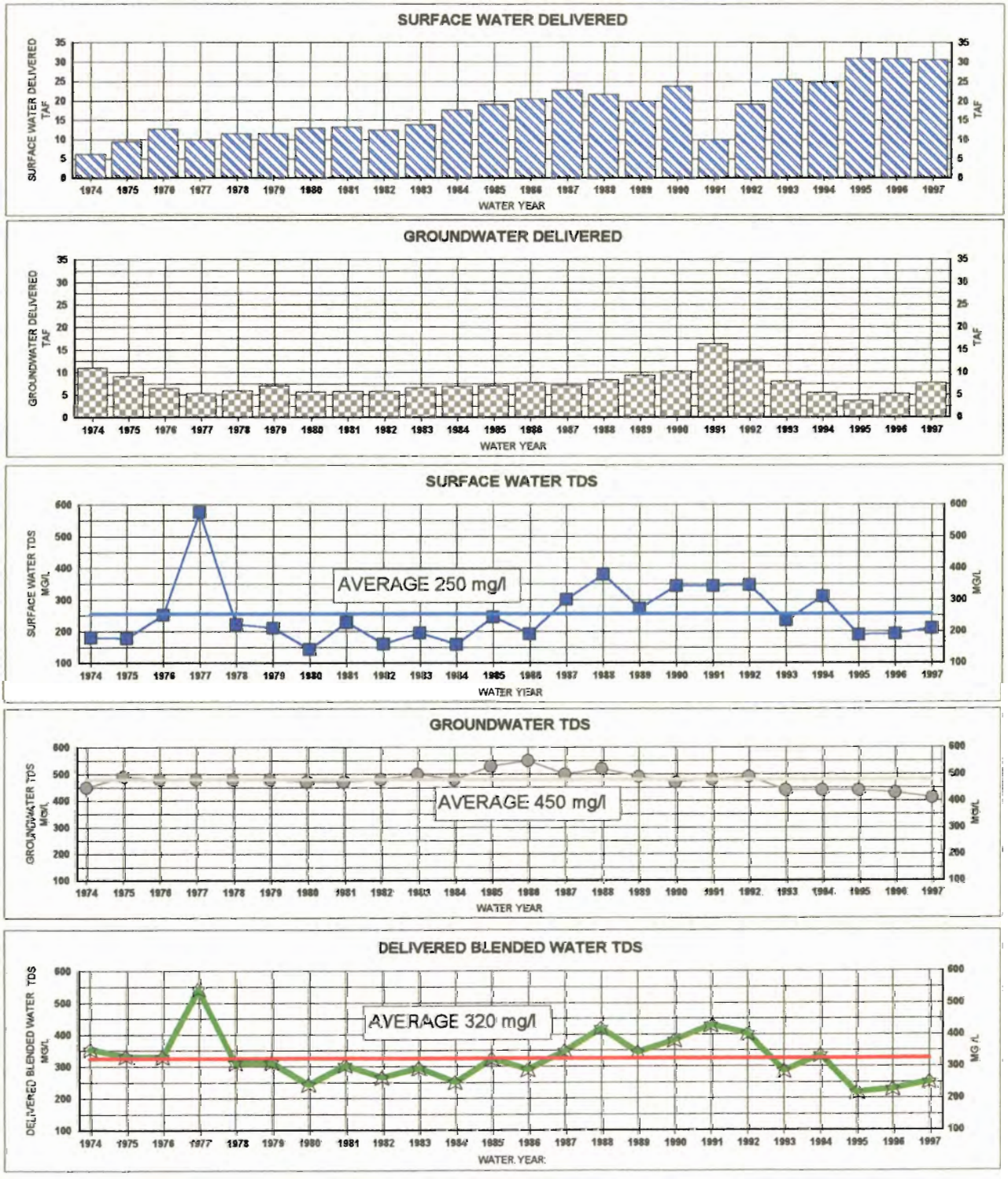


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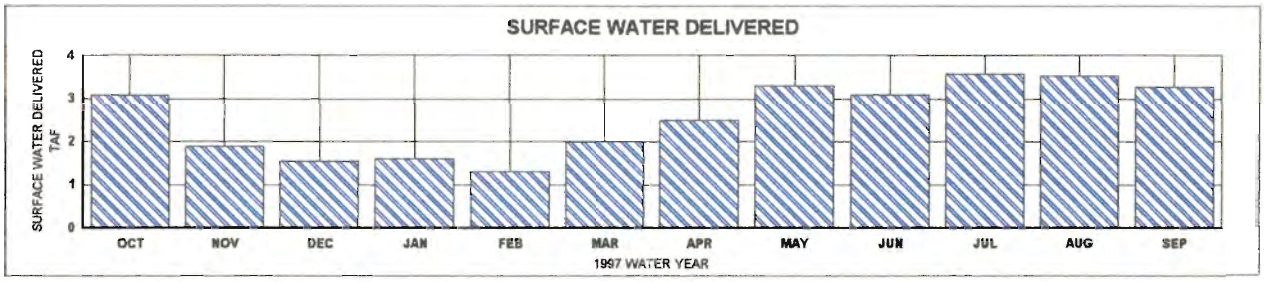
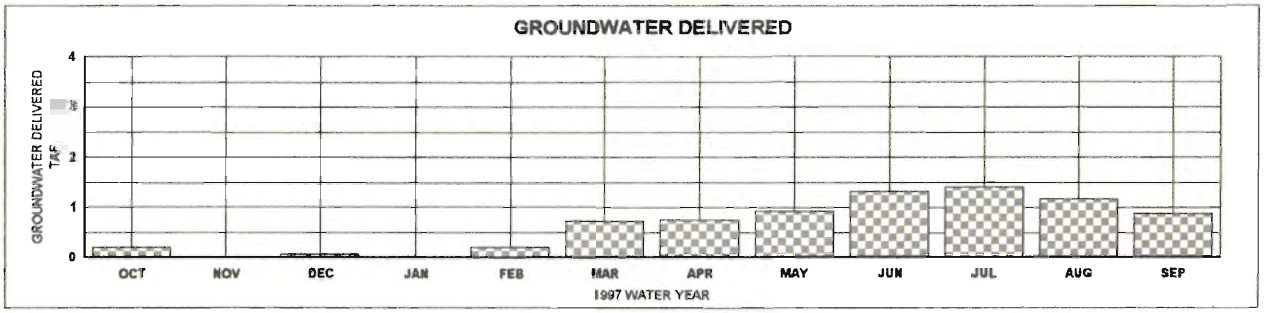
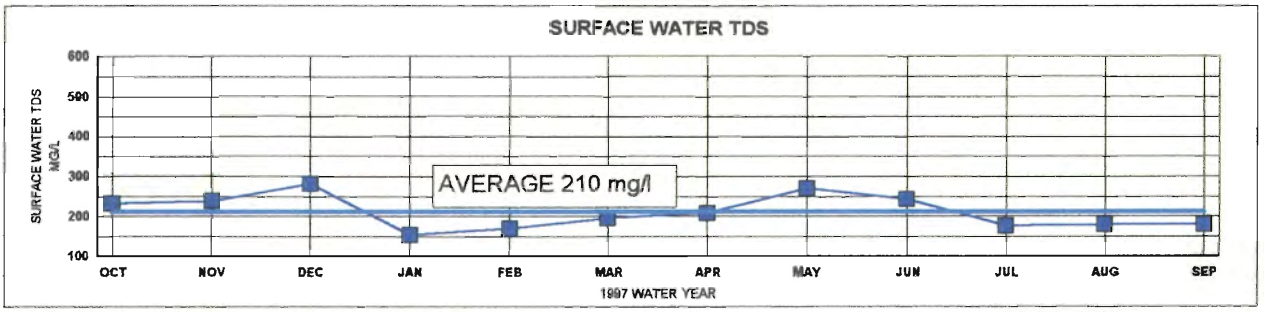
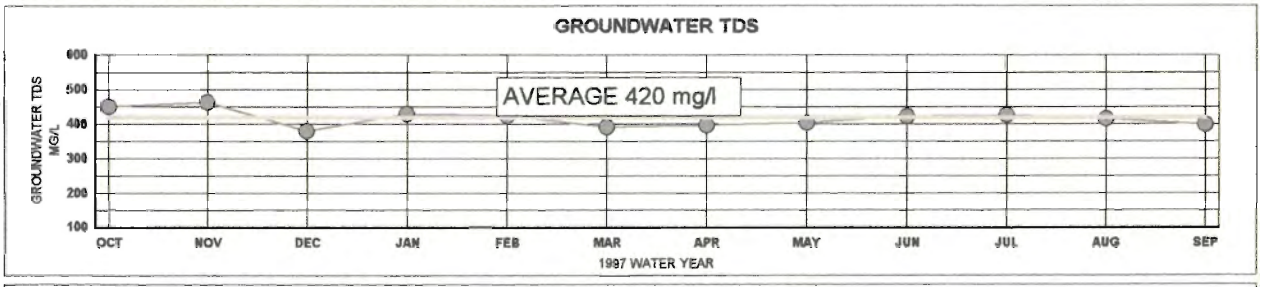
FIGURE 4.14

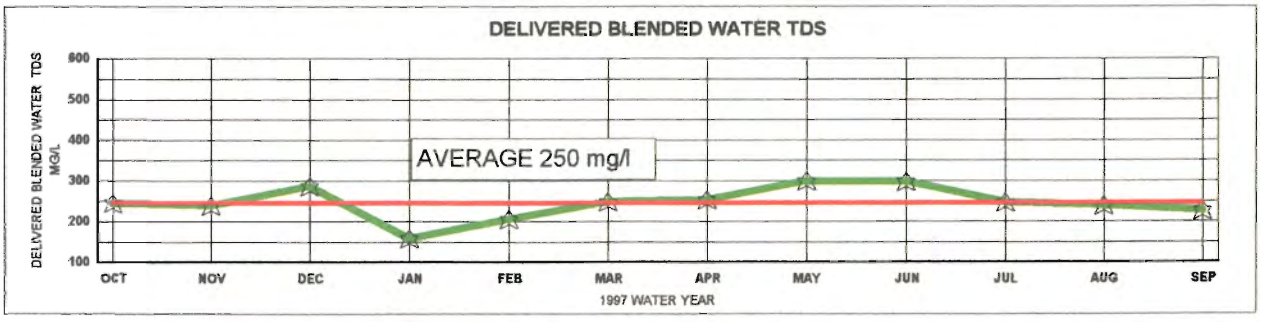
TREATED WATER DELIVERIES & WATER QUALITY
1997 WATER YEAR











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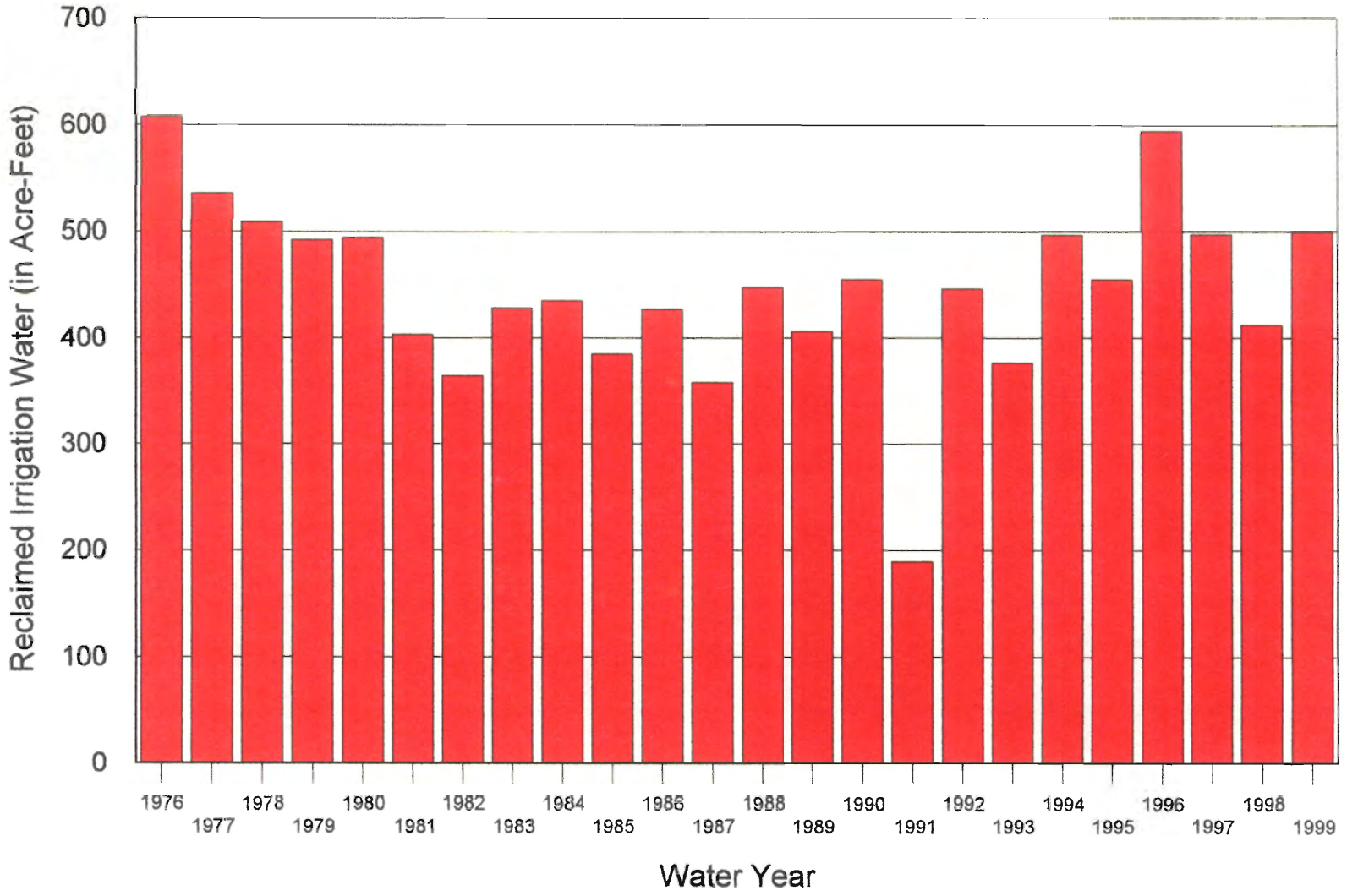
LWRP RECLAIMED IRRIGATION WATER

FIGURE 4-15



Historically, the Livermore Water Reclamation Plant (LWRP) has recycled about 450 AF/year of tertiary recycled water (disinfected, filtered, secondary treated effluent). The annual volumes of recycled water spray irrigated on the Las Positas Golf course are shown in Figure 4.15. LWRP recycled water had an average TDS of 560 mg/L during the 1999 calendar year which is about twice the concentration in the long-term average 320 mg/L Zone 7 delivered water. This is as expected due to the typical 200 to 300 mg/L "salt increment" added to potable water as it is used in a household for various domestic purposes.

A portion of this recycled water is applied over the Main Basin where 100% of the applied salts are assumed to reach the Main Basin while the remainder is applied over a 33% salt impact zone (see discussion in Chapter 11 and Fig. 11.1).

Proposed expansion of Livermore tertiary recycled water deliveries to serve urban and agricultural development in North and South Livermore are summarized in Section 6.7. DSRSD began delivering tertiary recycled water (membrane filtered, ultraviolet disinfected) for irrigation of the Dublin Sports Grounds in 1999. Chapter VI also describes DSRSD plans to distribute tertiary recycled water for irrigation in DSRSD and EBMUD service areas north of I-580 as part of the DSRSD EBMUD Water Recycling Authority (DERWA) project. A majority of this irrigation will take place outside of the Main Basin and have minimal impact to the Main Basin salt load.

Both Livermore and DSRSD have constructed reverse osmosis (RO) recycled water demineralization facilities with a future goal of injecting RO treated recycled water into the groundwater basin for groundwater replenishment, to improve groundwater quality, and to offset net salt loading. The Livermore RO facility has a design capacity of 0.75 mgd and the DSRSD facility of 2.5 mgd. Performance studies of both facilities have been conducted to document the water quality of the RO product water. Due to concerns expressed by the general public neither of these groundwater injection projects is operating.

Table 4.7 compares key constituents of Zone 7 treated water, Zone 7 untreated inlet water, LWRP tertiary recycled water, LWRP RO product water, and the water quality results from a 16 week DSRSD performance evaluation testing of the CWR RO facility. Reference I presents the more detailed water quality comparison.

Chapter 5

Zone 7 Salt Balance Calculations

Chapter 5
Zone 7 Salt Balance Calculations

5.1 Introduction

Maintaining a sustainable water supply and a sustainable water quality are key components of successful groundwater basin management and stewardship. To provide a sustainable water supply, a basin must be managed to prevent overdraft. To provide sustainable water quality, a basin must be managed to have a neutral or negative salt balance. The purpose of this chapter is to describe and summarize the salt balance calculations used to monitor the loading to, and thus the sustainability of, the Main Basin groundwater quality.

A sustainable water supply has been assured through Zone 7's practice of maintaining the groundwater basin in long-term hydrologic balance. Overdraft is prevented through a combination of monitoring, detailed inventory tracking, contracts that limit pumping, education/negotiation with prospective extractors, and finally, a commitment to artificially recharge the basin as needed to maintain the basin hydrologic balance.

Attaining sustainable groundwater quality is a Zone 7 goal that has yet to be fully achieved. Zone 7 believes that this goal can be achieved through the control and adjustment of the computed salt balance of the basin. Zone 7 annually computes a basin salt balance using a fundamental salt balance equation: inflow of salts dissolved in water minus outflow of salts dissolved in water equals the change in dissolved salts in the basin.

Zone 7 computes the magnitude of components in the salt balance equation using its extensive hydrologic inventory database. Salts are added to the basin in via various sources of recharge. Natural stream recharge adds water and salt from the Arroyo Valle, Arroyo Mocho and Arroyo Las Positas. Irrigation of urban and agricultural lands adds salt dissolved in the irrigation water. Subsurface inflow from the fringe basins adds water and salts as groundwater flows into the basin. Artificial stream recharge adds water and salts dissolved in the recharge waters. Rainfall does not add salt. However it helps dilute and transport the salts added from urban and agricultural irrigation down to the water table.

Salts are removed from the basin by several hydrologic outflow components. Salts are removed from the Main Basin as water is pumped from wells or gravel mining pits. Some of the extracted municipal pumpage and associated salt (25-30%) is returned to the basin in that portion used for irrigation over the Main Basin. The remainder of the pumpage and salts is either used inside the home and then exported as wastewater in the LAVWMA pipeline or used for irrigation in fringe basin areas where the applied salts do not impact

the Main Basin. Some of the mining pumpage is returned to the Main Basin through stream recharge. However, most of this pumpage leaves the basin and valley as stream outflow. Irrigation within the basin removes water through evaporation. However, no salt is removed (the salt remains with the excess irrigation water (percolate) in the soil). Similarly, evaporation removes water from the mining ponds but leaves behind dissolved minerals.

5.2 Salt Loading Calculation Assumptions

One of Zone 7's groundwater basin management tools is the tracking and annual calculation of salt loading to the Main Basin. These salt balance calculations take into account the addition and removal of salt in the Main Basin based on annual water supply and demand. The influx of salts into the Main Basin comes from natural stream recharge, urban irrigation, agricultural irrigation, subsurface groundwater inflow, and artificial recharge. The removal of salts from the Main Basin occurs through groundwater pumpage from the basin for municipal and agricultural purposes, gravel mining related stream exports and off-haul, and groundwater basin outflow. Therefore, the salt balance presents an estimate of the overall effect of salt loading on groundwater quality in the basin based on salt loading at the surface. The final results of the salt balance are presented as annual cumulative changes in the basin-wide TDS concentration and salt loading.

The salt balance calculations include several fundamental and intentionally simplifying assumptions as part of this screening level "spreadsheet" model of the Main Basin. It is assumed that the main groundwater basin is well mixed. Supply and demand components each have associated TDS concentrations based on the given year's monitoring data, some historic data, and a few assumed (otherwise unmeasurable) values. Perhaps the most important simplifying assumption is that all salts applied through irrigation eventually make their way to the underlying groundwater (while in actuality vadose zone processes can delay salt transport for decades). Salts removed by plant uptake and by the application of fertilizers are considered negligible. Percolate quality is assumed to be primarily a function of the differing percent of applied water that recharges throughout the area due to site specific variations in soil characteristics.

Zone 7 performs salt loading calculations in two ways. The first method uses a given year's (e.g., 1998) actual rainfall and recharge volume and water quality data plus that year's land use conditions. This actual annual salt balance is computed using Zone 7's detailed hydrologic inventory data and has been calculated since 1974. The actual balance in any one year is not indicative of long-term trends since there can be substantial year to year variations in recharge and extraction components and also significant changes in basin storage. Very wet years, for example, may show a negative salt balance. A large drop in basin storage due to a drought for example will result in less water in the basin and generally a net loss of salts even though the concentration of salts may increase.

Conversely, large net salt loads will be shown in years following drought and basin drawdown when the basin is being refilled and there is less mining export.

Given the limitations of annual salt loading calculations for long-term planning and salt management decision-making purposes, Zone 7 also calculates what is called the steady state salt balance. These steady state calculations yield the average expected recharge and salt loading for a given set of land use conditions (e.g., water demand and urbanized acreage over the Main Basin). The steady state salt balance is a normalized salt balance, not a simple moving average of the measured values reported in each of the annual salt balances that have been calculated since 1974.

It is normalized in the sense that changes that would permanently alter a parameter (such as increased channelization increasing Arroyo Mocho recharge capacity) are not just averaged in but are incorporated into the underlying calculations. A specific example of the need for normalization is salt outflow via agricultural pumpage. From 1974 through 1990, annual agricultural pumpage ranged from about 1400 AF to almost 5000 AF (Reference J, Table 3A). Since 1990 values dropped to about the 200 AF range as groundwater was replaced with untreated SBA water, and reached a low of about 100 AF in high rainfall 1998. Using the simple long-term 1974-1998 average of 1734 AF would be unrepresentative of current and likely future average conditions, as would using 100 AF from the wet 1998 year. Therefore, for the steady-state calculations for 1998 land use conditions in Table 5.2, Zone 7 staff chose to use a value of 200 AF as representative of current average conditions.

This normalization reflects the fact that these types of operational and land use changes (and other changes such as the amount of irrigated urban and agricultural acreage) will alter salt loading from that year forward. This steady state approach provides a more accurate and useful reflection of average conditions that would exist in the future compared to a simple moving average. The steady state salt balance is thus designed to be more of a predictive rather than retrospective indicator of salt loadings.

The normalized salt balance is adjusted to balance supply and demand hydrology so there is no net change in storage. This adjustment eliminates changes in predicted concentration and loading simply due to changes in Main Basin volume.

Water quality (TDS) values for each component are adjusted each year to the long-term flow weighted average. Values for parameters that are primarily weather dependent, such as natural stream recharge, are also long-term average values. For example, the steady-state rainfall recharge of 4,100 AF would be the average rainfall recharge if 1998 land use conditions had existed for a series of years experiencing weather conditions equivalent to those occurring in 1974-1998.

These steady state salt balances constructed using current land characteristics describe what should be expected given current land use, average weather, and average groundwater supply and demand. The steady state calculations are useful in part for

tracking long-term expected TDS impacts on the basin. They are also useful, as described in Chapter IX, when adjusted for future year (i.e., 2010) land use and operational conditions, to evaluate the impacts of alternative salt management strategies.

5.3 Explanation of Salt Balance Summary Tables

This section provides a short description of the major components included in computing the 1998 Main Basin salt balance. A more detailed explanation including copies of the various worksheets documenting the underlying calculations and assumptions is contained in the Zone 7 June 2, 2000 memorandum "Main Groundwater Basin Salt Balance, 1974-1998 WY" (Reference J). The salt balance tables 5.1 (1998 Water Year) and 5.2 (Steady State) from the salt balance memo are broken into Supply and Demand Subsections. The Supply subsection has columns corresponding to applied water, recharge water, salt load in tons, and salt load in tons per 1,000 acre-feet of recharge. The Demand subsection has columns for water removed, salt load removed in tons, and salt removed in tons per 1,000 AF of recharge.

The applied water and recharge water values in the supply subsection are generally the same for each of the components except in cases of irrigation water. Variable amounts of applied water end up recharging the basin (based on site specific soil type, irrigation efficiencies, and other variables), so that calculated recharge water (i.e., percolate) quality varies. All the salts applied in irrigation water are assumed to reach the basin. The salt load and salt load in tons per 1,000 acre-feet of recharge are computed using the values in the recharge water columns. Each of the major line items is briefly described below.

Salt Sources (Supply Components)

Rainfall recharge is calculated using a Zone 7 simulation model and is assumed to contain no salt. Rainfall recharge therefore adds no new salts to the Main Basin. The rainfall recharge for 1998 steady state conditions was determined using 1998 land use conditions and 1974-1998 hydrology.

Arroyo Valle recharge is divided into four sub-components: Lake/imported water recharge, flood release recharge, upper reach natural inflow recharge, and lower reach natural inflow recharge. Each flow component is calculated on a daily basis. The TDS of lake imported water recharge and flood release recharge water are assumed to be the same as the monthly TDS of Del Valle Water Treatment Plant inflow. The TDS of upper reach natural inflow recharge water is determined from the monthly electrical conductivity at the Arroyo Valle near Livermore gaging station, and the TDS of lower reach natural recharge water is assumed to be 250 mg/L. The annual TDS for each of these sub-components is calculated as a flow-weighted monthly average.

Arroyo Mocho natural recharge and **Arroyo Las Positas natural recharge** are determined as a part of the Zone 7 hydrologic inventory. Flow components are calculated daily and the TDS of the recharge water for each month is determined from the monthly electrical conductivity at the Arroyo Mocho near Livermore and Arroyo Las Positas near Livermore gaging stations, respectively. Based upon monthly recharge and monthly TDS, flow weighted average TDS values are then determined.

Urban irrigation volume is calculated by using purveyors' metered water use (Zone 7 deliveries plus purveyor pumpage), the ratio of urban area inside the Main Basin to the total urban area serviced by each purveyor, and the assumption that water used in a month in excess of the minimum use month for the year is used for external irrigation. It is assumed that a given percentage of each type of irrigation water evaporates without recharging, and that all of the applied salts concentrate in the remaining, recharging water (see Reference J for a more detailed description of the calculations and assumptions).

LWRP reclaimed water volume used for irrigation is metered and reported monthly along with corresponding TDS. Based upon the monthly applied water amount and monthly TDS, a flow-weighted average TDS is determined. Future recycled water irrigation would be added to and tracked under this category.

SBA agricultural irrigation volume is determined using monthly metered deliveries for agricultural use and the ratio of SBA agricultural irrigated area inside the Main Basin to the total SBA agricultural irrigated area. This ratio of the area is determined from the current land use map. Most of the **groundwater agricultural irrigation** over the Main Basin is not metered. The amount of this component is determined using the Zone 7 Rainfall and Applied Water Recharge Model. The TDS of this component is assumed to be the same as the TDS of municipal pumpage.

Subsurface groundwater inflow (from the northwest portion of the fringe/main basin interface) is included as part of the hydrologic inventory and the TDS is estimated as approximately 1500 mg/L based on monitoring well data.

Artificial supplemental recharge on Arroyo Valle, Arroyo Mocho and Injection Well Recharge are the only three artificial recharge components at this time. The daily amounts of recharge for these three sub-components are determined as part of the Zone 7 hydrologic inventory. Monthly TDS of PPWTP inflow is designated as the TDS of artificial recharge at Arroyo Mocho and monthly TDS of DVWTP inflow is designated as the TDS of artificial recharge at Arroyo Valle plus injection at the Hopyard #6 ASR well. Based upon the monthly recharge amounts and monthly TDS, flow weighted TDS values are determined.

Salt Export (Demand Components)

Municipal groundwater pumpage consists of the pumpage by Zone 7, Pleasanton, CWS, DSRSD, SFWD, domestic users, Alameda County Fairgrounds, Livermore, Castlewood Golf Course and Tri-Valley Golf Center. Most of the municipal pumpage is metered and reported monthly by well. Based upon the available quarterly or annual data, a TDS value is assigned to each well contributing to the municipal pumpage. The TDS and the annual production from each well are used to determine a flow weighted average municipal pumpage concentration. Assumptions are the same as for urban irrigation (above) about the relative amount of pumpage and salts exported based on how and where the water is used.

Agricultural groundwater pumpage inside the Main Basin is mostly calculated from annual land use measurements, because most of this pumpage is not metered. The TDS of this pumpage is assumed to be the same as the TDS of the Zone 7 pumpage. The volume of **mining export** is determined as a routine part of the Zone 7 hydrologic inventory. Based upon the monthly mining area monitoring program, a monthly representative TDS for each gravel mining company's exports is assigned. Flow-weighted annual average TDS for water exports are determined based upon the monthly export amounts and TDS. The volume of **gravel mining off-haul** water by gravel mining companies is estimated at 700 AF per year. The TDS of this water is assumed to be 500 mg/L. The amount of **subsurface groundwater outflow** is determined as part of the Zone 7 hydrologic inventory. The TDS of the outflow water is determined by averaging the TDS of shallow wells in the vicinity of the Arroyo Valle and Arroyo de la Laguna confluence.

5.4 Actual 1998 Water Year Salt Balance Results

Table 5.1 presents the main groundwater salt balance for the 1998 water year. The 1998 water year was an unusually wet (only a 10% chance that a given year would be wetter) and therefore very favorable year for the salt balance. There was an estimated increase in storage of approximately 3,800 AF and decrease in (i.e., negative) salt loading to the Main Basin of 4,760 tons. The average TDS of recharged water in 1998 was 310 mg/L. The main factors causing the favorable 1998 salt balance are the 12,868 AF of rainfall recharge with no salts and above normal water and salt exports (12,617 AF with 9,080 tons of salt) by the gravel mining companies. For comparison, the normal steady state rainfall recharge at 1998 land use conditions, based on weather from 1974 through 1998 is 4,100 AF and average water and salt export by gravel mining companies is about 8,700 AF and 6,150 tons, respectively (see Table 5.2).

Figures 5.1 – 5.3 present a condensed tabular and schematic summary of Table 5.1 (actual 1998) data plus the relative percent salt loading contributed or removed by the major sources. The figures are intended to help convey a fundamental understanding of where the salts come from (gross loading), how salts get removed from the basin, and how net

TABLE 5.1

Main Basin Salt Balance
1998 WATER YEAR

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FOOT OF RECHARGE
NATURAL						
RAINFALL RECHARGE	12868		12,868	0	0	
ARROYO VALLE						
Lake/imported water recharge	958	190	958	190	250	260
Flood releases recharge	2,145	180	2,145	180	520	240
Upper reach natural inflow	1,214	340	1,214	340	560	460
Lower reach natural inflow	1,043	250	1,043	250	350	340
Total Arroyo Valle	5,360	232	5,360	232	1,680	
ARROYO MOCHO NATURAL RECHARGE	4,560	370	4,560	370	2,290	500
ARROYO LAS POSITAS NATURAL RECHARGE	1,572	820	1,572	820	1,750	1,110
URBAN IRRIGATION						
SBA water	5,298	200	570	1,859	1,440	2,530
Groundwater						
Zone 7 Groundwater, extraction only wells (NO RO	421	400	40	4,210	230	5,750
Zone 7 Groundwater, extraction only wells (RO)	0		0		0	
Zone 7 Groundwater, ASR wells	0		0		0	
Groundwater, others (no RO)	3,183	480	330	4,630	2,080	6,300
Domestic groundwater pumpage	68	450	68	450	40	590
LWRP reclaimed water irrigation	412	490	40	5,048	270	6,750
Total urban irrigation	9,382	319	1,048	2,851	4,060	
AGRICULTURAL IRRIGATION						
SBA water	1,212	170	288	715	280	970
Groundwater	108	470	15	3,384	70	4,670
Total agricultural irrigation	1,320	195	303	848	350	
Subsurface groundwater inflow	810	1,500	810	1,500	1,650	2,040
Total Natural Supply	35,872		26,521		11,780	
ARTIFICIAL SUPPLEMENTAL RECHARGE						
Arroyo Valle	182	190	182	190	50	270
Arroyo Mocho	1,930	150	1,930	150	390	200
Injection Well Recharge	571	230	571	230	180	320
RO Recycled Water Injection / Stream Recharge	0				0	
RO Recycled Water Irrigation	0				0	
Total artificial recharge	2,683		2,683		620	460
TOTAL SUPPLY	38,550	240	29,204	310	12,400	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FOOT OF EXPORT
MUNICIPAL PUMPAGE				
Zone 7 municipal pumpage, ASR wells	0			
Zone 7 municipal pumpage, extraction only wells	1,682	400	910	540
Other municipal pumpage	8,585	480	5,600	650
Total municipal pumpage	10,267	470	6,510	
AGRICULTURAL PUMPAGE	108	470	70	650
MINING EXPORT	12,617	530	9,080	720
MINING OFFHAUL	700	530	500	710
POND EVAPORATION	925			
SUBSURFACE GROUNDWATER OUTFLOW	750	980	1,000	1,330
TOTAL DEMAND	25,367	500	17,160	
NET RECHARGE/ NET SALT BALANCE	**3,837**		**(4,760)**	

1998 Groundwater Main Basin Salt Load

	Applied Water		Recharge Water		Salt Load	
Salt source	**Volume (AF)**	**TDS (ppm)**	**Volume (AF)**	**TDS (ppm)**	**TONS**	**Percent**
Rainfall	12,868	0	12,868	0	0	0%
Natural Stream Recharge	11,492	367	11,492	367	5,720	46%
Artificial Recharge	2,683	170	2,683	170	620	5%
Urban Irrigation	9,382	319	1,048	2,851	4,060	33%
Agriculture Irrigation	1,320	195	303	848	350	3%
Subsurface Inflow	810	1,500	810	1,500	1,650	13%
TOTAL	**38,555**		**29,204**		**12,400**	

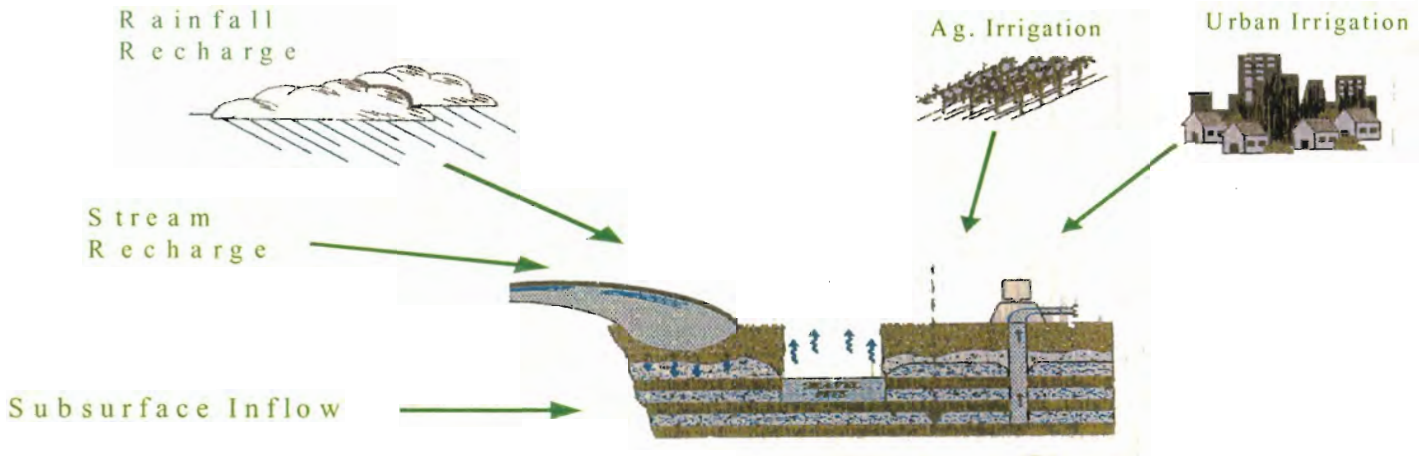


Figure 5.1

1998 Groundwater Main Basin Salt Removal

Removal Component	Volume (AF)	TDS (ppm)	Salt Removed Tons	Salt Removed Percent
Municipal Pumpage	10,267	470	6,510	38%
Agricultural Pumpage	108	470	70	0%
Mining Expot/Offhaul	13,317	530	9,580	56%
Mining pond Evaporation	925	0	0	0%
Subsurface Outflow	750	980	1,000	6%
TOTAL	**25,367**		**17,160**	

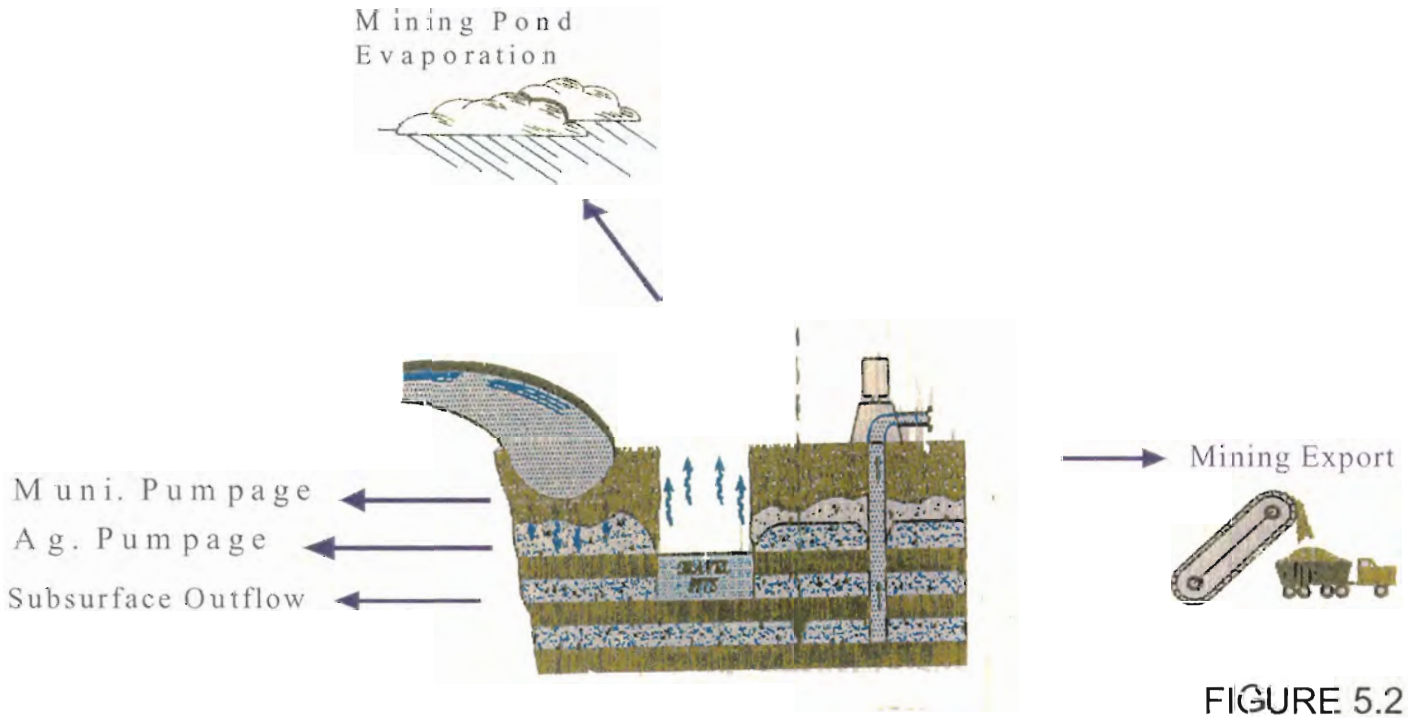
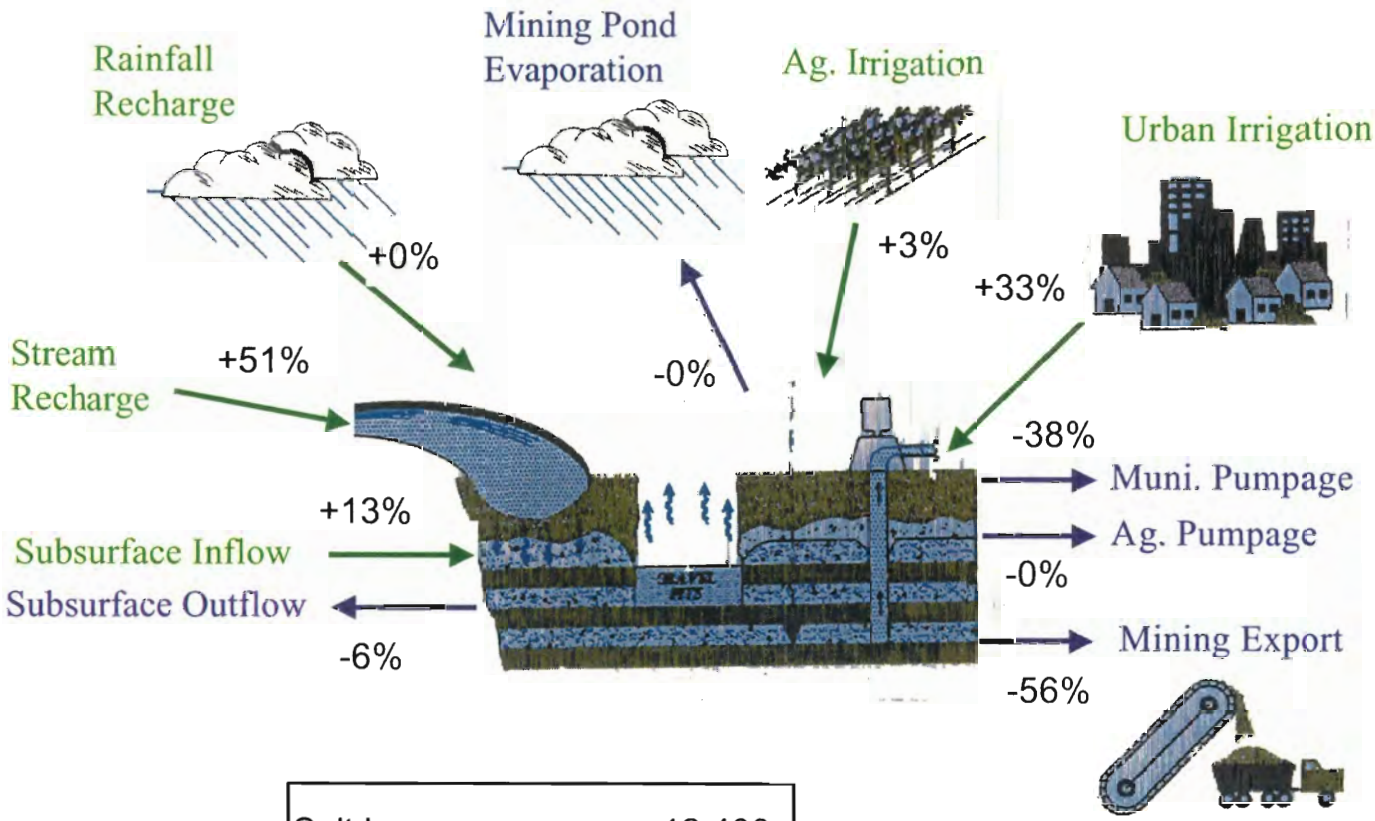


FIGURE 5.2

Main Basin Salt Balance
1998 Water Year Net Salt Loading



Salt In	+12,400
Salt Out	-17,160
Net Salt Load (In Tons)	-4,760

Figure 5.3

loading is determined. A parallel series of three figures is presented in the following section 5.5 showing results under calculated steady state conditions to illustrate the significant differences that can occur between a given (e.g., wet) year and long-term average conditions.

Figure 5.1 shows the major sources of salt loading: rainfall, natural stream recharge, artificial recharge, urban irrigation, agricultural irrigation, and subsurface inflow. The recharge values are generally more informative than the applied values since they reflect the quality and quantity of water actually entering the Main Basin (versus applied at the ground surface). The 12,868 AF of rainfall recharge (with zero TDS) was a very significant contributor to the total recharge in the Main Basin and the favorable salt balance for the year. Natural stream recharge of 11,492 AF was the next most significant contributor to recharge in the Main Basin (39% of total volume) with an average TDS of 370 mg/L and a salt load of 5720 tons (46% of total salt load).

Since the basin was near the top of managed storage levels, the reduced artificial recharge (stream & ASR) program contributed only 2,683 AF (9%) at an average TDS of 170 mg/L and a salt load of 620 tons (5% of total salt). Urban irrigation contributed 1,048 AF (3.5%) to the Main Basin recharge but had the highest average TDS by a factor of two at 2,850 mg/L and contributed 4,060 tons (33% of total salt). Agriculture irrigation contributed 303 AF (1%) to the Main Basin recharge at an average TDS of 848 mg/L with 350 tons (3% of total salt). Subsurface inflow contributed 810 AF (2.7%) to the recharge at an average TDS of 1,500 mg/L with 1,650 tons (13% of total salt).

Figure 5.2 presents a summary of groundwater demand and salt removal components for the 1998 water year. Municipal pumpage and water export by gravel mining companies were the two dominant components. Municipal groundwater demand was 10,267 AF (40% of total volume) at an average TDS of 470 mg/L and removed 6,510 tons (38%) of salt. Groundwater export by gravel mining companies exported 13,317 AF (52%) at 530 mg/L with 9,580 tons (55%) of salt. Water and salt export by agricultural irrigation was negligible. Subsurface outflow was 750 AF (3%) at 980 mg/L with 1,000 tons (6%) of salts.

Figure 5.3 summarizes the net salt loading to the Main Basin during water year 1998. Total salt loading was 12,400 tons, and a total of 17,160 tons of salt were removed, for a net removal of 4,760 tons. This significant net removal (compared to the steady state increase of 2,200 tons/year) is due to both lower salt inputs and greater exports (see Figure 5.6). Stream recharge and urban irrigation were the major salt contributors at 48% and 35% respectively. Mining export and municipal pumpage were the major removal mechanisms at 49% and 46%, respectively.

5.5 Steady State Results at 1998 Land Use Conditions

This section presents the steady state salt balance calculation results under current (1998) land use conditions. As discussed in Section 5.2, these steady state calculations are more useful for tracking long-term expected TDS impacts on the basin than actual year-to-year salt balances. Detailed supply, demand and individual component loading results are presented in Table 5.2 and in Figures 5.4 –5.6 (same format as for actual 1998 results).

Figure 5.4 presents a summary of the recharge water supply and salt loading components at steady state conditions and under 1998 land use conditions. The major contributors to gross salt loading are urban irrigation, natural stream recharge, and artificial stream recharge at 35%, 30%, and 18% respectively of the total loading. Of these, only urban irrigation is considered potentially "controllable." Natural recharge is a function of rainfall and artificial recharge is necessary to offset groundwater extractions and keep the basin full.

The 4,100 AF of rainfall recharge at zero TDS is a significant contributor to the total recharge of 22,050 AF. As expected for average weather conditions, it is about one-third the rainfall recharge experienced in the unusually wet 1998 (Figure 5.1). Under these steady state conditions, natural stream recharge would contribute 6,600 AF, (30% of the recharge volume) to the Main Basin with an average TDS of 530 mg/L and a salt load of 4,750 tons (30% of the total salt load). The artificial recharge program would contribute 8,500 AF (39%) at an average TDS of 250 mg/L with 2,890 tons (18%) of salt. Urban irrigation would contribute 1460 AF (6.6%) to the Main Basin recharge at the highest average TDS of 2780 mg/L and 5520 tons (35%) of salt. Agriculture irrigation would contribute 390 AF (1.7%) to the Main Basin recharge at TDS of 1,090 mg/L with 580 tons (4%) of salt. Subsurface inflow would contribute 810 AF (2.7%) to the recharge at 1,500 mg/L with 2,040 tons (13%) of salt.

Figure 5.5 presents a summary of groundwater demand and salt removal components for the 1998 steady state conditions. Municipal pumpage and water export by gravel mining companies represent by far the two largest components of water and salt export. Municipal groundwater demand would be 10,220 AF (46% of total groundwater pumpage) at an average TDS of 450 mg/L and it would remove 6,240 tons (46%) of salt. Groundwater export by gravel mining companies would export 9,400 AF (43%) at 520 mg/L with 6,640 tons (49%) of salt. Evaporation from the mining pond would remove about 1,700 AF (8%) at zero TDS. Salt export by agriculture irrigation over the Main Basin would be about 1% of the total. Subsurface outflow would be 500 AF (2%) at 900 mg/L with 610 tons (4%) of salt.

Figure 5.6 schematically presents the major salt percentage contributions to and extractions from the main groundwater basin under 1998 steady state conditions. The major input difference when compared to actual 1998 values (Figure 5.3) is that the stream recharge contribution is lower. Removals via municipal pumpage are higher and by mining export lower under these more typical steady state conditions. The total salt

TABLE 5.2

Main Basin Water Balance and Salt Balance
Current Steady State Conditions at 1998 Land use

WATER SUPPLY COMPONENTS	APPLIED WATER		RECHARGE WATER		SALT	SALT LOAD IN TONS PER
	ACRE-FEET	TDS IN mg/l	ACRE-FEET	TDS IN mg/l	LOAD IN TONS	1000 ACRE-FOOT OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,000	250	1,000	250	340	340
Natural recharge	1,700	440	1,700	440	1,016	600
Total Arroyo Valle	2,700		2,700		1,356	500
Arroyo Mocho natural recharge	2,700	480	2,700	480	1,761	650
Arroyo las Positas natural recharge	1,200	1,000	1,200	1,000	1,630	1,360
Urban Irrigation						
SBA urban irrigation	8,830	250	970	2,276	2,999	3,090
Groundwater						
Zone 7 Groundwater, extraction only wells (NO RO)	640	450	70	4,114	391	5,590
Zone 7 Groundwater, extraction only wells (RO)	0		0		0	
Zone 7 Groundwater, ASR wells	0	300	0		0	0
Groundwater, others (no RO)	2,830	450	310	4,108	1,730	5,580
Domestic groundwater pumpage	70	450	70	450	43	610
LWRP reclaimed water irrigation	400	650	40	6,500	353	8,830
Total Urban Irrigation	12,770		1,460	17,448	5,516	
Agricultural Irrigation						
SBA water	1,350	250	340	993	458	1,350
Groundwater agricultural irrigation	200	450	50	1,800	122	2,440
Total agricultural irrigation	1,550		390	2,793	580	
Subsurface groundwater inflow	1,000	1,500	1,000	1,500	2,038	2,040
Total Natural Supply	21,920		13,550		12,881	950
ARTIFICIAL RECHARGE						
Stream Recharge						
Arroyo Valle	0		0		0	
Arroyo Mocho	7,000	250	7,000	250	2,377	340
Injection Well Recharge	1,500	250	1,500	250	509	340
RO Recycled Water Injection / Stream Recharge	0	100	0	100	0	0
RO Recycled Water Irrigation	0	100	0	100	0	0
TOTAL SUPPLY	30,420	380	22,050	530	15,767	

WATER DEMAND COMPONENTS	WATER REMOVED		SALT	SALT REMOVED IN TONS PER
	ACRE-FEET	TDS IN mg/l	LOAD IN TONS	1000 ACRE-FOOT OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR wells	0	300	0	0
Zone 7 municipal pumpage, extraction only wells	2,000	450	1,220	610
Other municipal pumpage	8,220	450	5,020	610
Total municipal pumpage	10,220		6,240	610
Agricultural pumpage	200	450	120	600
Mining export	8,700	520	6,150	710
Mining offhaul	700	520	490	700
Pond evaporation	1,700	0	0	0
Subsurface groundwater outflow	500	900	610	1,220
Total Demand	22,020	450	13,610	
WATER/SALT BALANCE	0		2,160	

Main Basin Salt Load
Steady State Conditions at 1998 Land Use

	Applied Water		Recharge Water		Salt Load	
Salt source	**Volume (AF)**	**TDS (ppm)**	**Volume (AF)**	**TDS (ppm)**	**TONS**	**Percent**
Rainfall	4,100	0	4,100	0	0	0%
Natural Stream Recharge	6,600	530	6,600	530	4,750	30%
Artificial Recharge	8,500	250	8,500	250	2,890	18%
Urban Irrigation	12,770	320	1,460	2,780	5,520	35%
Agriculture Irrigation	1,550	280	390	1,090	580	4%
Subsurface Inflow	1,000	1,500	1,000	1,500	2,040	13%
TOTAL	**34,520**		**22,050**		**15,780**	

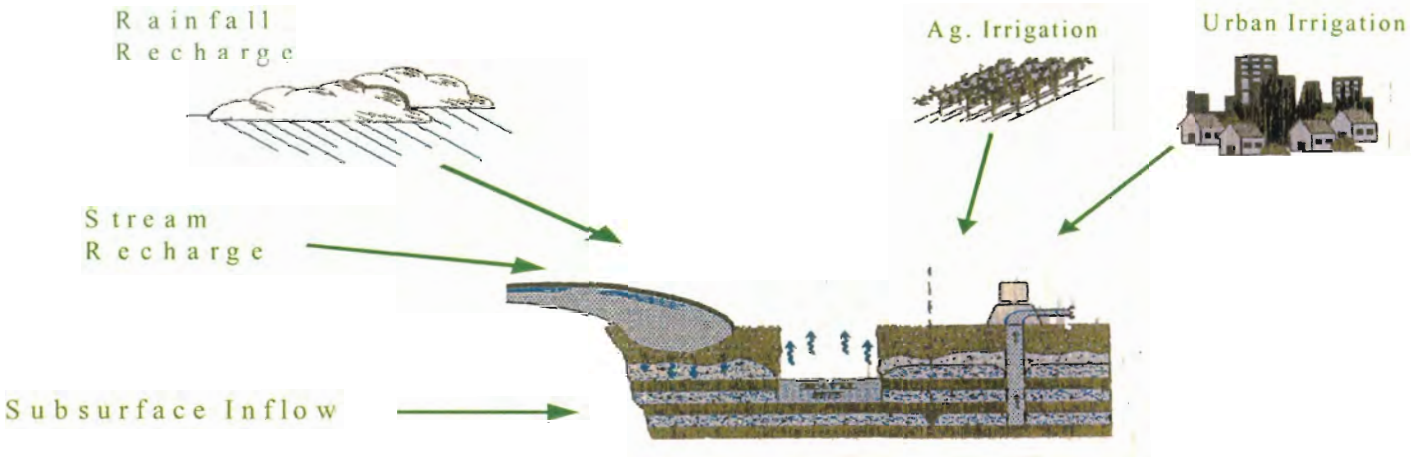


Figure 5.4

Main Basin Salt Removal

Steady State Conditions at 1998 Land Use

Removal Component	Volume (AF)	TDS (ppm)	Salt Removed Tons	Salt Removed Percent
Municipal Pumpage	10,220	450	6,240	46%
Agricultural Pumpage	200	450	120	1%
Mining Expot/Offhaul	9,400	520	6,640	49%
Mining pond Evaporation	1,700	0	0	0%
Subsurface Outflow	500	900	610	4%
TOTAL	**22,020**		**13,610**	

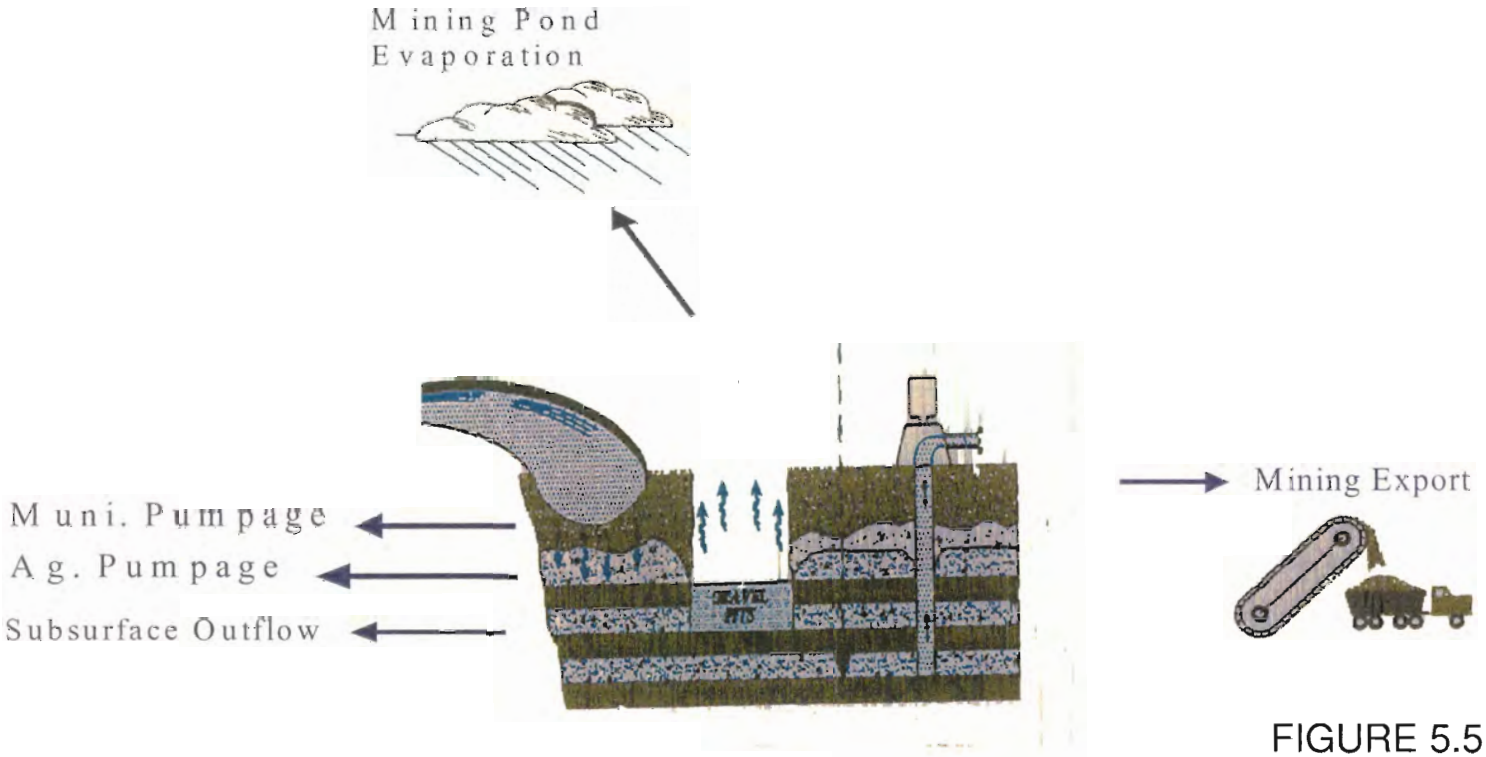
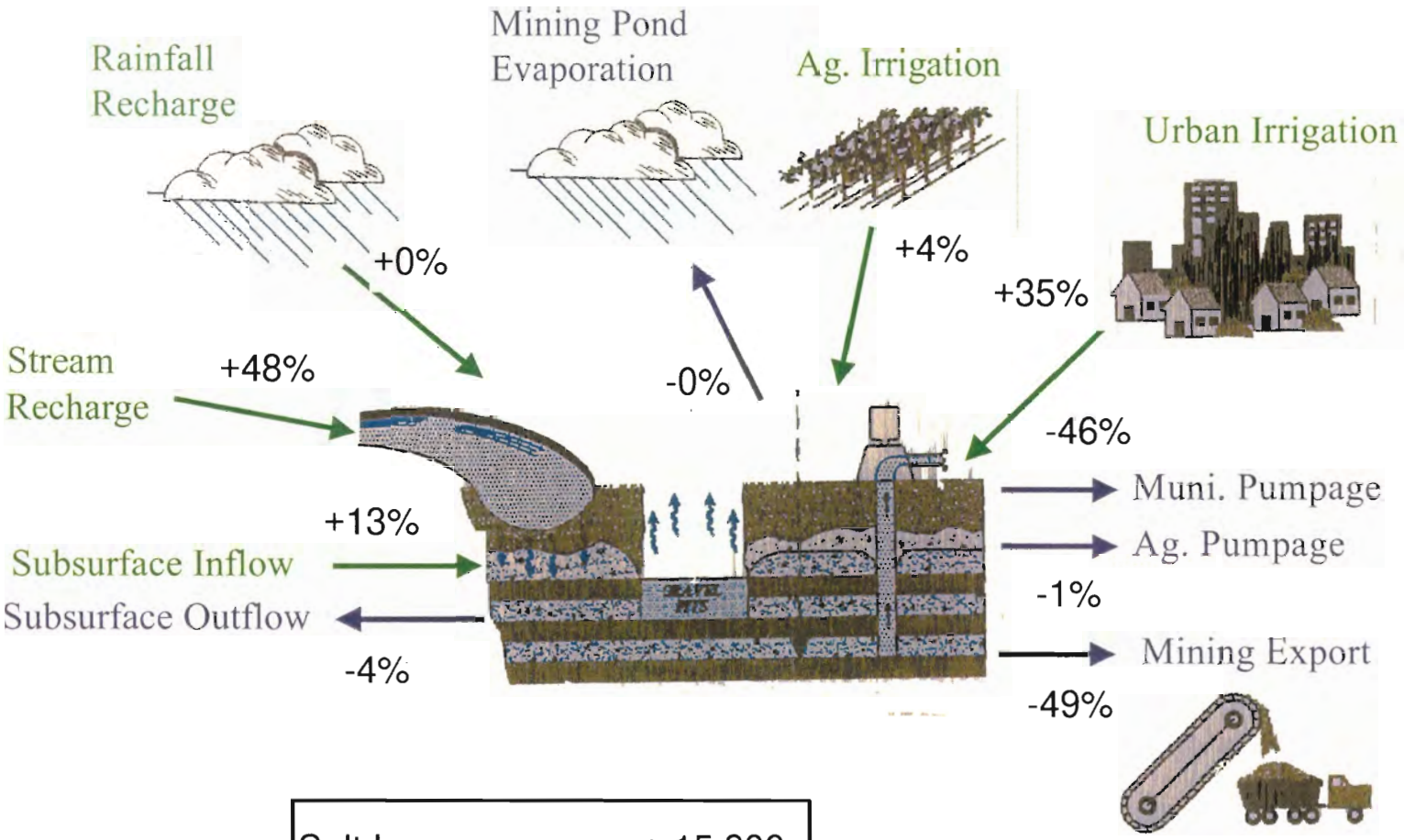


FIGURE 5.5

Main Basin Salt Balance
Steady State Conditions at 1998 Land Use



Salt In	+ 15,800
Salt Out	-13,600
Net Salt Load (In Tons)	+ 22,00

Figure 5.6

loading to the Main Basin would be 15,800 tons and the total salt removal would be 13,600 tons, for a net salt loading of 2,200 tons. These steady state results are the basis for the 2,200 tons/year net salt loading used in this Salt Management Plan to define current salt loading. As discussed above relative to 1998 actual data and as shown in the historic annual average loadings presented below (Figure 5.7), year-to-year loadings can vary considerably.

5.6 Historic Annual Average Salt Loading

A summary of the annually calculated salt loadings and associated cumulative salt loading to the Main Basin for the 25-year hydrologic inventory period, 1974 through 1998 is presented in Figure 5.7. Annual net loadings varied from 11,781 to a negative 4,760 tons, with a 25-year average of about 2,550 tons/year, which is interestingly fairly close to the 1998 steady state value of 2,200 tons/year. The cumulative salt loading to the Main Basin during that time period was approximately 63,500 tons and there were only six years in which there was a negative salt accumulation in the Main Basin, three of them being 1996-1998.

The complete 25-year dataset can be found in Reference J, Tables 3A, 3B, and 3C. Review of that complete dataset helps understand the multiple and sometimes independent factors influencing the observed annual variability. For example, part of the reason for the elevated loadings during 1974-1980 was the treated wastewater discharges that terminated with start-up of the LAVWMA export pipeline in 1980. Mining exports were also relatively low in this period as the gravel companies were mining in the shallower zone gravel areas.

The highest net loading of 11,781 tons occurred in 1978 when significant natural and artificial recharge began to refill the basin and mining exports remained low following the 1976-1977 drought. The large negative loading in 1983 occurred when the basin had been refilled to an elevation of 240 feet resulting in significant mining export and the highest subsurface basin outflow. The increased loadings during 1987-1992 were due to drought conditions when basin groundwater elevations dropped. Mining exports therefore decreased considerably, urban irrigation loading increased due to the greater percentage of groundwater used, and subsurface inflow increased due to the lower basin elevations. The peak of 7,820 tons in 1993, a wet year, was primarily due to considerable natural and artificial recharge and reduced municipal pumpage. The low and negative loadings in 1995-1998 were primarily due to high rainfall and recharge, increased mining export and subsurface outflow, and also increased municipal pumping.

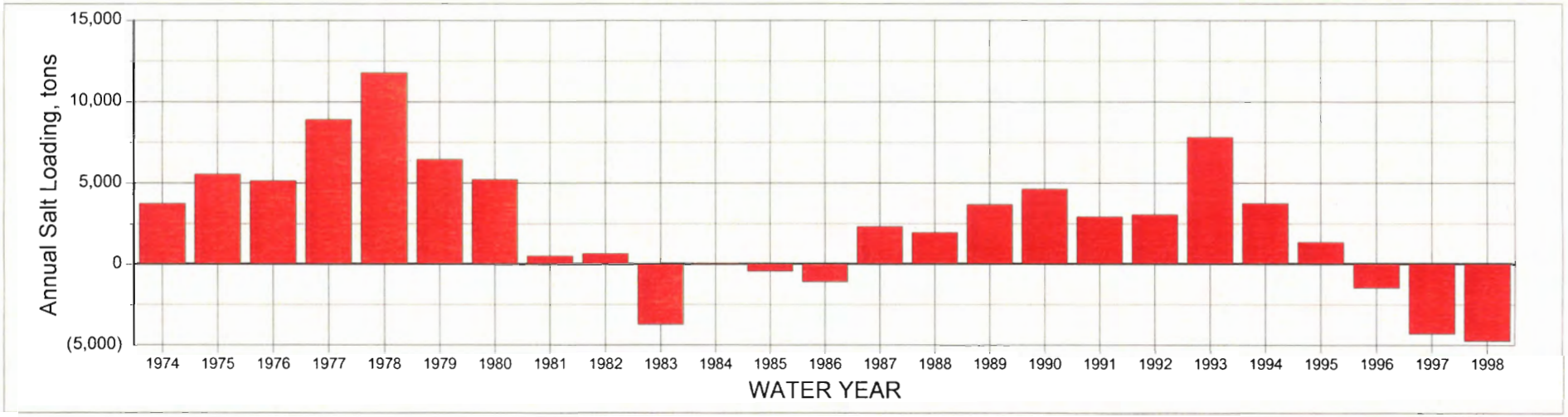
Figure 5.8 shows the theoretical effect of the above cumulative mass salt loading on the TDS concentration in the Main Basin. The cumulative impact graph is calculated assuming a beginning groundwater basin storage volume of 212,000 AF and an initial TDS of 450 mg/L. Subsequent end-of-year TDS values are the result of changes in the net recharge and the salt influx for that year. Yearly values are calculated using the cumulative

SALT_INV.123

Figure 5.7

LIVERMORE - AMADOR VALLEY MAIN GROUNDWATER BASIN

1974 - 98 SALT LOADING



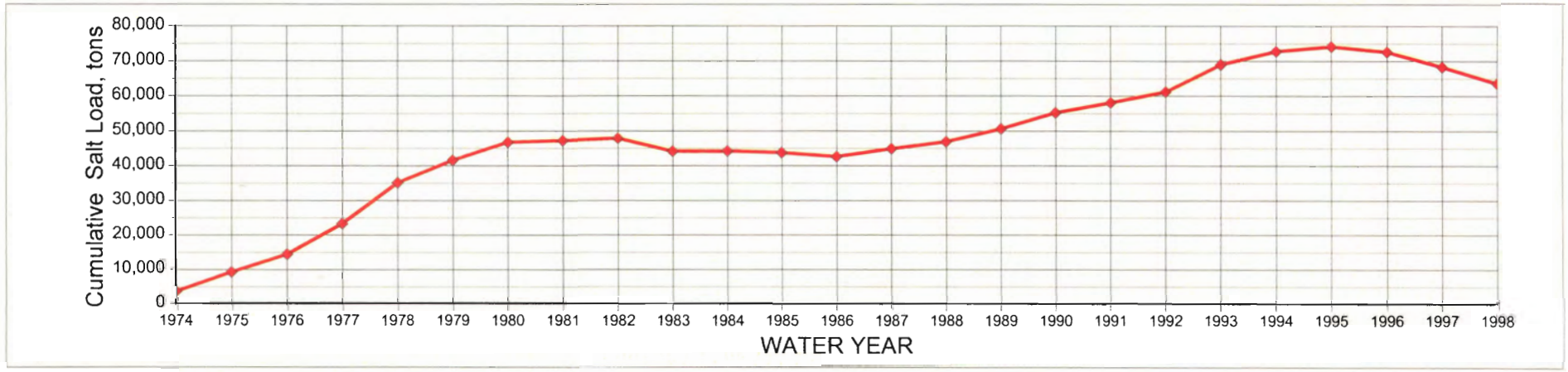


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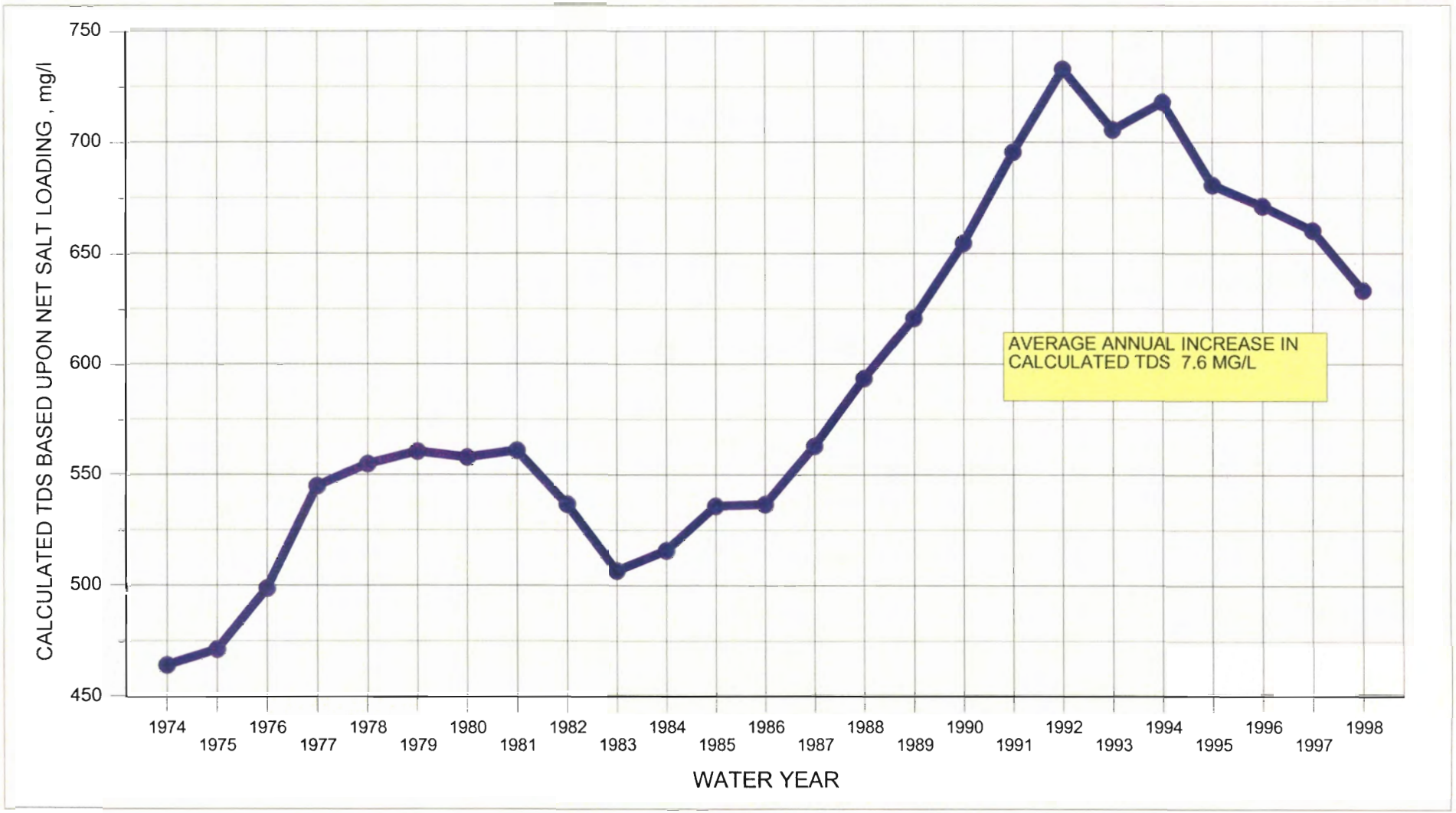
FIGURE 5.8

LIVERMORE - AMADOR VALLEY MAIN GROUNDWATER BASIN
CALCULATED BASIN TDS DUE TO SALT LOADING AT LAND SURFACE



mass loading through that year (since 1974) divided by the actual end-of-year storage volume existing for that year.

The cumulative salt loading from 1974 through 1998, given the assumptions of 100% mixing and negligible permanent vadose zone attenuation, would result as shown in Figure 5.8 in an average basin TDS of 635 mg/L in 1998. This is equivalent to a total increase of about 183 mg/L over the 25-year period, equal to about a 7.3 mg/L increase per year or about a 1.5% increase per year over the initial 450 mg/L.

This graph is a highly simplified representation of the relative changes in groundwater basin quality actually occurring due to the addition or reduction of salts since it assumes rapid, complete, and uniform mixing throughout the basin. It also assumes complete mixing between both shallow and deep aquifers. Shallow groundwater in many areas has higher TDS than the underlying deep aquifer due to high TDS irrigation recharge and in some cases historic high TDS soils or deposits. In actuality, the existence and relative thickness of clay soils in certain areas may greatly retard the salts applied from irrigation in moving through the vadose zone, reaching, and completely mixing with the Main Basin aquifers.

Other factors can also affect the actual TDS change occurring in a given portion of the basin as measured at a given well. These include individual well depth, proximity and capacity of adjacent wells, amount and timing of pumping and recharge, time of sampling, source of recharge water, and as for any measurement, sampling technique. Given these variables, the cumulative salt loading based TDS concentration estimates should, therefore, be viewed as an indicator of the relative magnitude of overall potential TDS change in the Main Basin and not necessarily as representative of site specific changes.

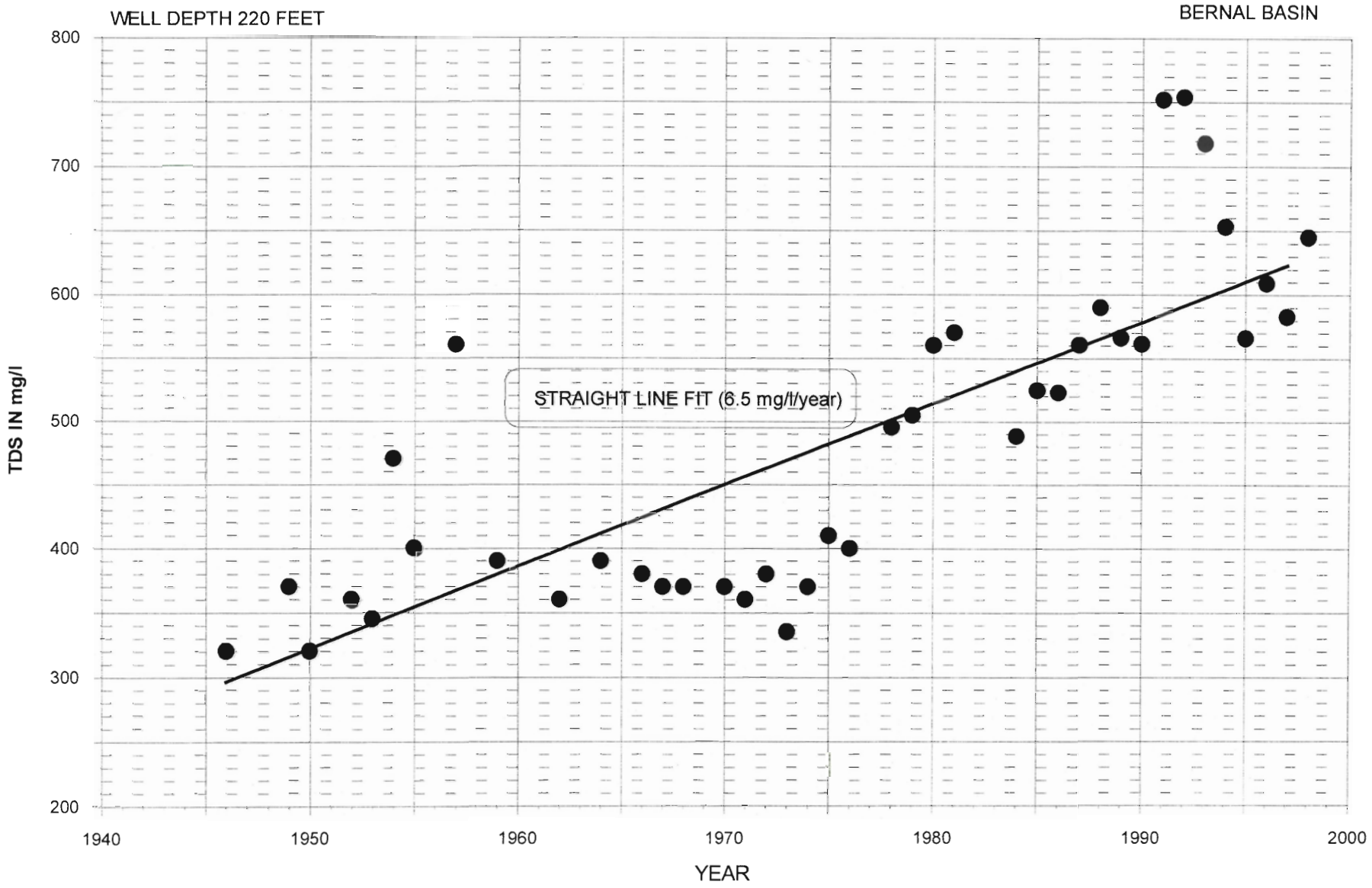
Actual monitoring results from two wells in widely different areas of the basin are presented (figures 5.9 & 5.10) to bracket the range of TDS variability existing due to some of these factors and the heterogeneity of the basin. While the respective rates of TDS increase vary, both wells show a continuing upward trend in TDS.

Figure 5.9 presents measured groundwater TDS data from San Francisco Water Department (SFWD) wells pumping into a common header from a depth of 220 feet in the central portion of the Bernal sub-basin. The wells deliver about 400 AF per year to serve the Castlewood residential community. Measured TDS values ranged from near 300 mg/L in 1950 to the 650 mg/L range in the 1990's. A cluster of values above 700 mg/L in the early 1990's may not be representative due to sampling problems (e.g., not allowing sufficient purging prior to collecting samples). A straight line regression fit to the data indicates an increase of 6.5 mg/L per year, fairly close to the 7.6 mg/L per year derived from the salt loading based basin-wide data shown in Figure 5.8.

This southwestern portion of the Main Basin is not pumped heavily and is believed to be primarily influenced by salts from local irrigation and rainfall recharge. There are areas of high TDS shallow groundwater in the vicinity that could migrate downward faster if the

Figure 5.9

GROUNDWATER TDS FROM SFWD O-LINE

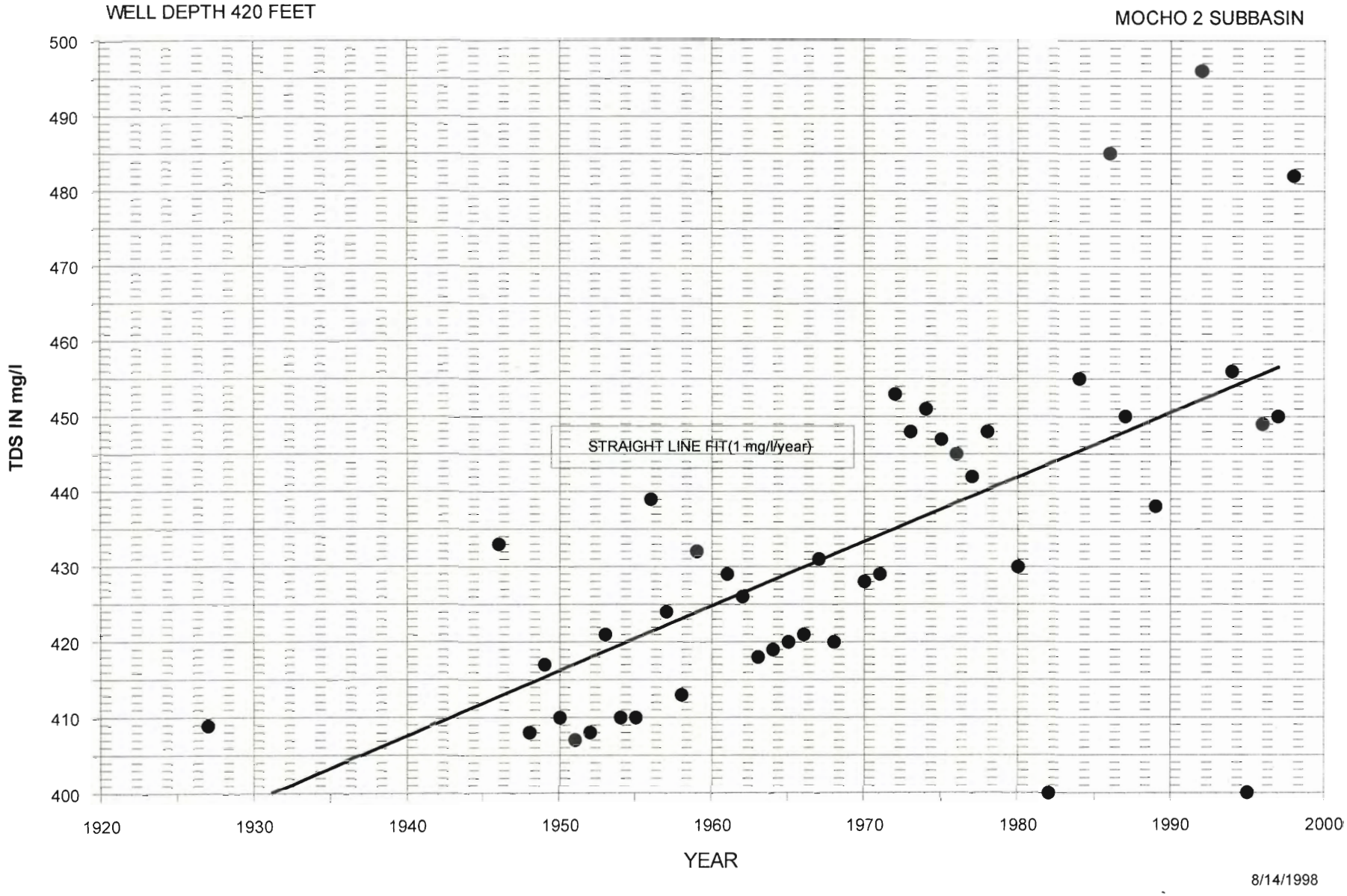


8/14/98

NOTE: ALL DATA IS FROM O-LINE (DEEP AND SHALLOW WELLS)

Figure 5.10

GROUNDWATER TDS FROM WELL 3S/2E 8P2 (CWS#03)



basin elevation were to be lowered significantly (in a drought). The Bernal subbasin is also believed to be influenced somewhat by the low TDS recharge on Arroyo Mocho and by high TDS subsurface inflow from the north.

In contrast to the above SFWD well, Figure 5.10 presents measured data from a California Water Service (CWS) deep well located in the eastern portion of the Mocho II subbasin at a depth of 420 feet. This well also has a capacity of about 400 AF per year. TDS values range from just over 400 mg/L in 1950 to around 450 mg/L in the mid-1990's. Sampling inconsistencies similar to the SFWD well may account for some of the unusually high and low data points observed since 1980. A straight line regression fit to the data shows an average TDS increase of about 1 mg/L per year. This well is significantly influenced by the large amount of low TDS natural and artificial recharge that occurs in the nearby Arroyo Mocho.

5.7 Projected Year 2010 Salt Loading

The "spreadsheet model" used for these salt balance calculations is useful for providing annual estimates of the basin-wide salt inventory and estimating potential long-term impacts on average groundwater TDS concentrations. As discussed in Section 3.7, Zone 7 developed a groundwater and solute transport computer model for the basin to be able to evaluate the more detailed impacts on individual areas and wells within the Main Basin.

The salt balance results presented in this chapter demonstrate that cumulative salt loading and groundwater TDS will continue to increase unless measures are taken to offset the current 2,200 tons/year salt loading and additional increases due to likely future development. To begin the process of evaluating potential salt management strategies, Zone 7 used this steady state methodology to identify that the magnitude of salt loading to the Main Basin might be by the year 2010 if no changes were made in Zone 7 basin management practices.

The salt loading impacts under steady state conditions at year 2010 land use conditions and under historic Zone 7 operations (Status Quo) are shown in Table 5.3 and Figure 5.11. The results show that in 2010 the average net salt loading would increase by approximately by 3,200 tons to 5,400 tons per year. The increase from 2,200 tons under 1998 land use conditions to 5,400 tons under 2010 conditions is due primarily to the cessation of water and salt export by the gravel mining companies. The lack of gravel mining exports alone will increase 2010 loading by about 2,700 tons per year. Recent information indicates that the GW export due to mining operations will cease as soon as 2003. The increase in 2010 loading over 1998 due to planned urban and agricultural development and associated irrigation (land use data from CDM *November 1996* Water and Land Use Memorandum) was predicted to be about *500 tons* per year. Table 5.4 presents the major differences in water supply, land use, and salt loading between 1998 and 2010 conditions.

STUDY 1A

TABLE 5.3

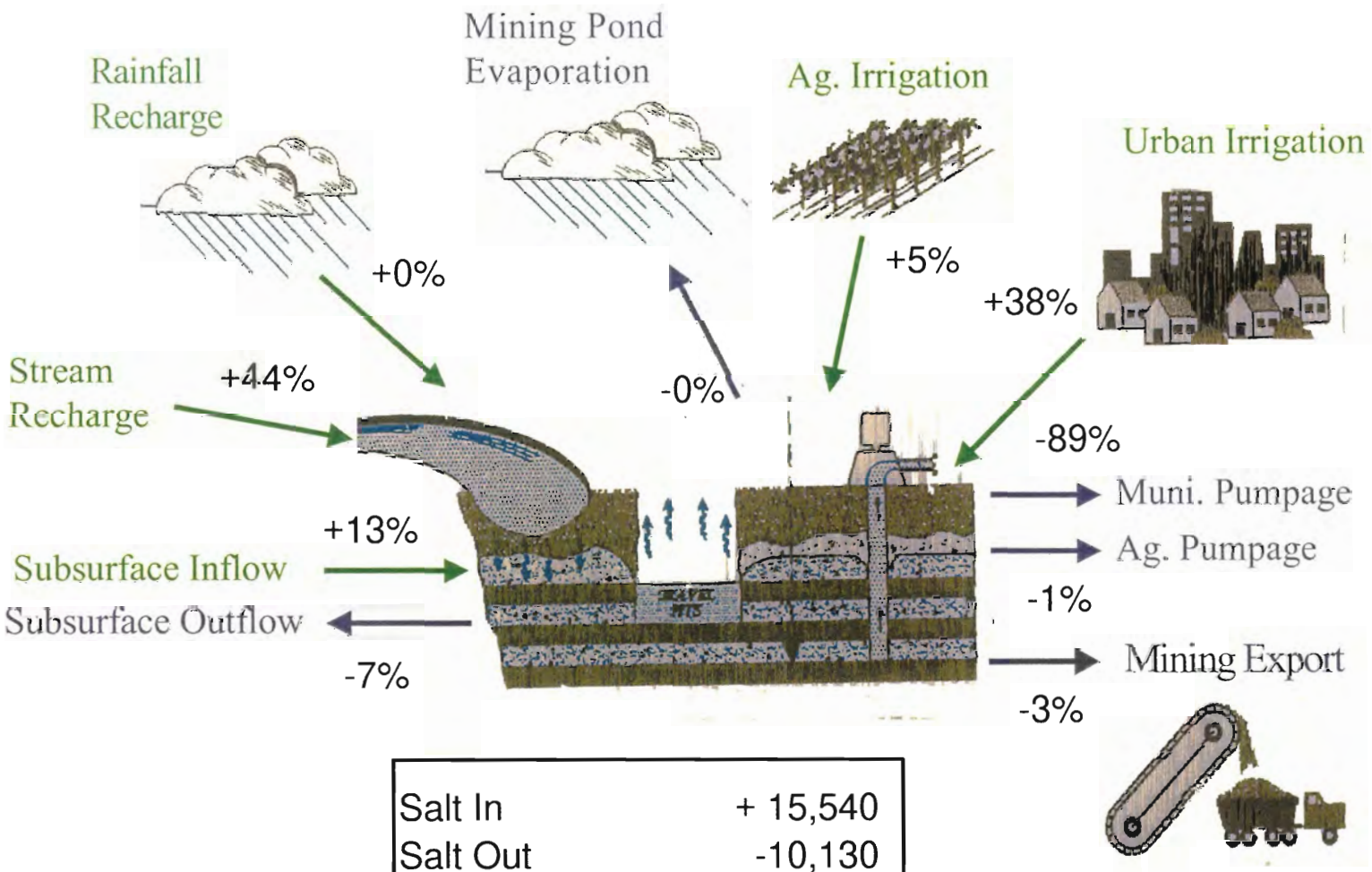
Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

WITH NO ATTENUATION OF SALTS IN APPLIED WATER AND NO CONJUNCTIVE USE PUMPAGE FOR SALT MITIGATION
NO RECYCLED WATER INJECTION

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	9,440	250	880	2,682	3,210	3,650
Groundwater, Extraction only wells	3,370	450	310	4,892	2,060	6,650
Groundwater, ASR wells	600	250	60	2,500	200	3,330
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,935		1,360		5,900	4,340
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	980	1,500	980	1,500	2,000	2,040
Total Natural Supply	23,795		13,870		13,530	980
ARTIFICIAL RECHARGE						
Stream recharge	3,540	250	3,540	250	1,200	340
Injection well recherge (ASR wells))	2,390	250	2,390	250	810	340
Recycled water injection	0	100	0		0	0
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	29,725		19,800		15,540	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,390	250	810	340
Zone 7 municipal pumpage, Extraction only wells	5,110	450	3,130	610
Conjunctive use pumpage, Extraction only wells	0	450	0	0
Pumpage for injected recycled water, Extraction only wells	0	450	0	0
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	15,800		9,020	570
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	590	900	720	1,220
Total Demand	19,790		10,130	
WATER/SALT BALANCE	10		5,410	

Main Basin Salt Balance
2010 Water Year Net Salt Loading



Salt In	+ 15,540
Salt Out	-10,130
Net Salt Load (In Tons)	+ 5,410

Figure 5.11

The 2010 5,400 tons per year salt loading does not include potential future salt loading from new or retrofit recycled water irrigation projects (as has been recently proposed as part of vision 2010 North Livermore Plan), greatly increased irrigated agriculture (viticulture), or significantly increased loading from the fringe basins. For the purpose of these analyses, land use changes above the fringe basins or otherwise outside the Main Basin are assumed to have no impact on salt loading to the Main Basin. Most new development is occurring in these areas, hence the relatively modest increases shown in 2010 salt loading for urban and agricultural irrigation. It is known that over a period of decades, new or increased irrigation in certain portions of the fringe basins may result in some incremental salt loading reaching the Main Basin.

Table 5. 4
Main Basin Salt Loading Major Changes

	Units	1998	2010	Change
Salt Loading				
Urban Over the Main Basin				
Area	Acres	8700	10030	1330
Irrigation	AF	12770	13940	1170
Salt load	Tons	5520	5900	380
Agricultural Over the Main Basin				
Area	Acres	900	1200	300
Irrigation	AF	1550	1940	390
Salt load	Tons	580	710	130
Salt Removal				
Gravel Mining				
Water Export and Off-haul	AF	9400	400	-9000
Salt Export	Tons	3000	270	-2730
Net Main Basin Salt Loading (from all sources)	Tons	2200	5400	3200

This fringe basin issue is evaluated in more detail in Chapter 6 of this SMP where an approach is developed for estimating the relative percent impact from the fringe basin areas. Additional surface and groundwater monitoring is proposed in the Salt Management Monitoring Program (Chapter 6) to verify and track potential loading from future development in the fringe basins (and from recycled water irrigation throughout the valley). This information would be used to refine, as needed, Main Basin salt loading estimates and to implement additional salt management strategies to offset any such increases detected (Chapter 12).

These 2010 calculations are the basis for the projected 5,400 tons/year net salt loading used throughout this SMP to represent year 2010 steady state salt loading. Zone 7 staff used modified versions of this year 2010 "spreadsheet model" to conduct "screening level" evaluations of the impacts of implementing various salt management strategies (see Chapter 12).

Chapter 6

Watershed Salt Management Monitoring Program

Chapter 6

Watershed Salt Management Monitoring Program

6.1 Introduction

This chapter describes the Salt Management Monitoring Program (SMMP), an augmentation of existing Zone 7 monitoring efforts designed to track and quantify new salt loading within the watershed. The SMMP was also designed to comply with the requirements of the Master Water Recycling permit, Regional Board Order No. 93-159, issued jointly to Zone 7, the City of Livermore, and Dublin San Ramon Services District.

The Master Permit states "The permittees shall, pending development of a valley-wide Salt Management Plan, initiate an interim program to further characterize the groundwater basin with particular emphasis on monitoring potential impacts of Phase I projects on TDS concentration gradients throughout the basin. The program may make use of existing data, existing groundwater monitoring wells, monitoring programs for specific reuse sites, or additional data collection as may be necessary. It further states, "The Salt Management Plan shall include a comprehensive groundwater monitoring program. Gathering of data under the monitoring program shall serve three objectives: 1) Evaluation of effects of each project on local groundwater, 2) Evaluating overall trends in groundwater quality throughout the basin and monitoring any effects of water recycling programs on basin-wide groundwater quality, and 3) Enhancing understanding of the hydrogeology of the basin."

Zone 7 currently has extensive surface and groundwater monitoring programs in place with sites primarily located above the Main Basin. The primary purpose of the SMMP is to augment those monitoring programs so that the effects of new salt sources throughout the watershed on the groundwater basin may be estimated. New sources of salt may include additional irrigation associated with new urban and agricultural development, recycled water "retrofit" irrigation projects, and recycled water groundwater recharge projects. The SMMP also includes new monitoring wells to help investigate and better quantify the amount and quality of subsurface flow entering the Main Basin from perimeter areas and fringe sub-basins.

Following is a description of the near-term SMP monitoring program and related background material:

- A summary of the existing surface and groundwater monitoring programs,

- A brief description of the watershed approach taken to characterize existing and new salt loading,
- A description of future monitoring for recycled water recharge and irrigation projects, and
- A summary, as needed, of the annual review process for implementing additional monitoring (based on the actual new development in the watershed).

The estimated costs for the additional watershed monitoring associated with the near-term SMP is included in Section 6.5.

6.2 Existing Monitoring Programs

Zone 7 currently conducts extensive groundwater, surface water, and climatological monitoring programs (Reference K). These programs collect groundwater level and quality data, stream flow and water quality data, and rainfall and evaporation data, respectively. Chapter 4 contains a summary of historic water quality data collected through these programs. The existing surface and groundwater programs are designed primarily to help manage the hydrologic inventory in the main groundwater basin. However, the programs also serve to help Zone 7 protect and operate the groundwater basin and to maintain Zone 7's "water rights" for the Arroyo Valle. Figure 6.1 is a map of existing surface and groundwater monitoring sites.

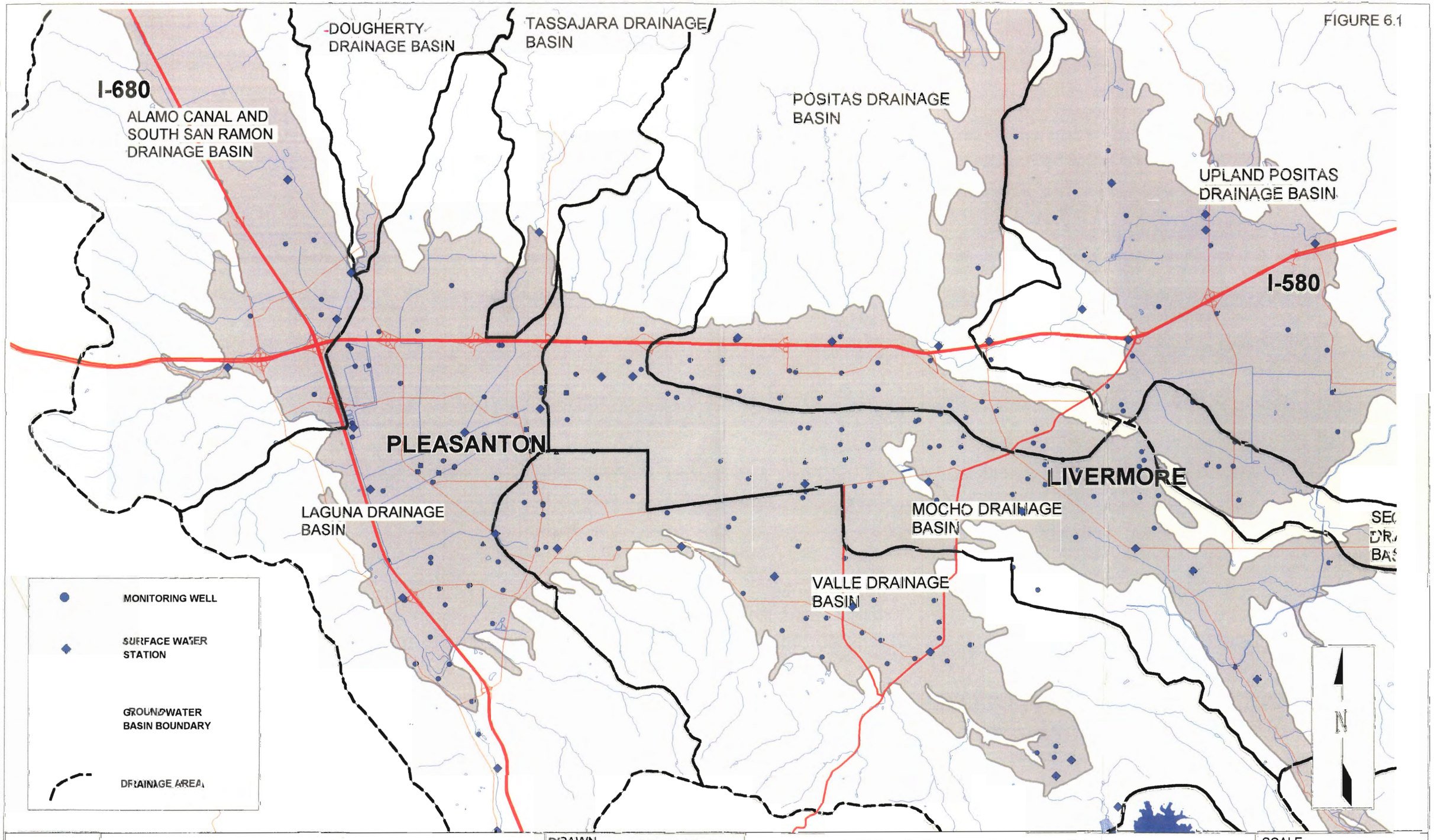
Water quality and quantity data are collected and used to estimate the annual salt loading to the Main Basin. One long-standing groundwater monitoring program/project exists to monitor the effects of irrigation with recycled wastewater at Livermore's Las Positas Golf Course. Another project involves monitoring to establish baseline conditions at DSRSD's proposed Clean Water Revival groundwater injection project location. Additional information on these two projects is provided in Section 6.6. Chapter 5 describes the salt loading calculations used for the Main Basin determinations and presents the historic results.

Existing Groundwater Monitoring

Groundwater quality and level data are collected from a network of approximately 200 wells at regular intervals (monthly, quarterly, semi-annually, or annually). The Zone 7 groundwater-monitoring network for WY 1997 is shown in Figure 6.1. Zone 7, the City of Pleasanton Water Department, or California Water Service Company take groundwater level measurements in these "network" wells. The data are incorporated into Zone 7's groundwater level database.

Zone 7 collects groundwater quality samples from the network wells and submits them to Zone 7's water quality laboratory for analysis. In some cases, the City of Pleasanton and DSRSD sample their wells and provide the analytical results to Zone 7. Generally, wells

FIGURE 6.1



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APPROVED	

WATER RESOURCES ENGINEERING

1997 SURFACE AND GROUNDWATER MONITORING SITES

SCALE	1" = 1 MILE
DATE	16 APRIL 1998
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inside the main groundwater basin are sampled annually and wells outside the Main Basin are sampled semi-annually. All major municipal wells belonging to Zone 7, California Water Service, and the City of Pleasanton are sampled at least annually. The samples sent to the Zone 7 laboratory are analyzed for "major ions" (i.e., Ca, Mg, Na, K, HCO3, SO4, Cl, NO3, SiO2), boron, manganese, arsenic, electrical conductivity, pH, TDS, alkalinity and hardness.

Zone 7 prepares five types of reports during each water year:

1) An annual program design report outlining the planned well monitoring work for the upcoming water-year;
2) A monthly groundwater level report which exhibits hydrographs of all wells that are measured monthly;
3) A monthly groundwater quality report of laboratory results from the previous month's analyses;
4) An annual report summarizing the work performed during the year and the current groundwater conditions/trends; and
5) Annual "data reports" consisting of up-to-date hydrographs, hydrochemographs, and a print-out of all major mineral analysis results for each program and former program well.

In addition, groundwater contour maps are prepared each spring and fall to show regional groundwater levels and gradients within each basin.

Existing Surface Water Monitoring

Zone 7 uses a network of 47 recorder, metering, and staff gage sites to monitor the quality and quantity of surface water recharging the Main Basin and leaving the valley. This network characterizes the flow and water quality in all major tributaries of the watershed. The program emphasis is on base flow water quality since this is most representative of stream flow recharging the groundwater basin.

Daily stream flow data are collected from ten recorder stations that provide continuous records of daily stream flow. Water samples from the ten stream recorder stations are field tested monthly for electrical conductivity and are analyzed annually for major mineral constituents. In addition, samples are collected from two of the stations quarterly and analyzed for major mineral content as required by Zone 7's Arroyo Valle 'water rights.' Two stations also have continuous conductivity monitors. The focus of the effort is on characterizing dry season base flow water quality and quantity. Five valley streams are studied in a synoptic program (i.e., where all sites are measured within a short period of time) to monitor groundwater and surface water exchanges. Variations in flow from station to station generally represent groundwater recharge or rising water.

Two types of routine surface water reports are prepared during the water year. The monthly surface water report includes a summary of stream flows, averaged and recorded daily, a tabulation of stream conductivity, and a summary of synoptic measurements. The annual report documents the program and presents all the finalized data collected during the water year.

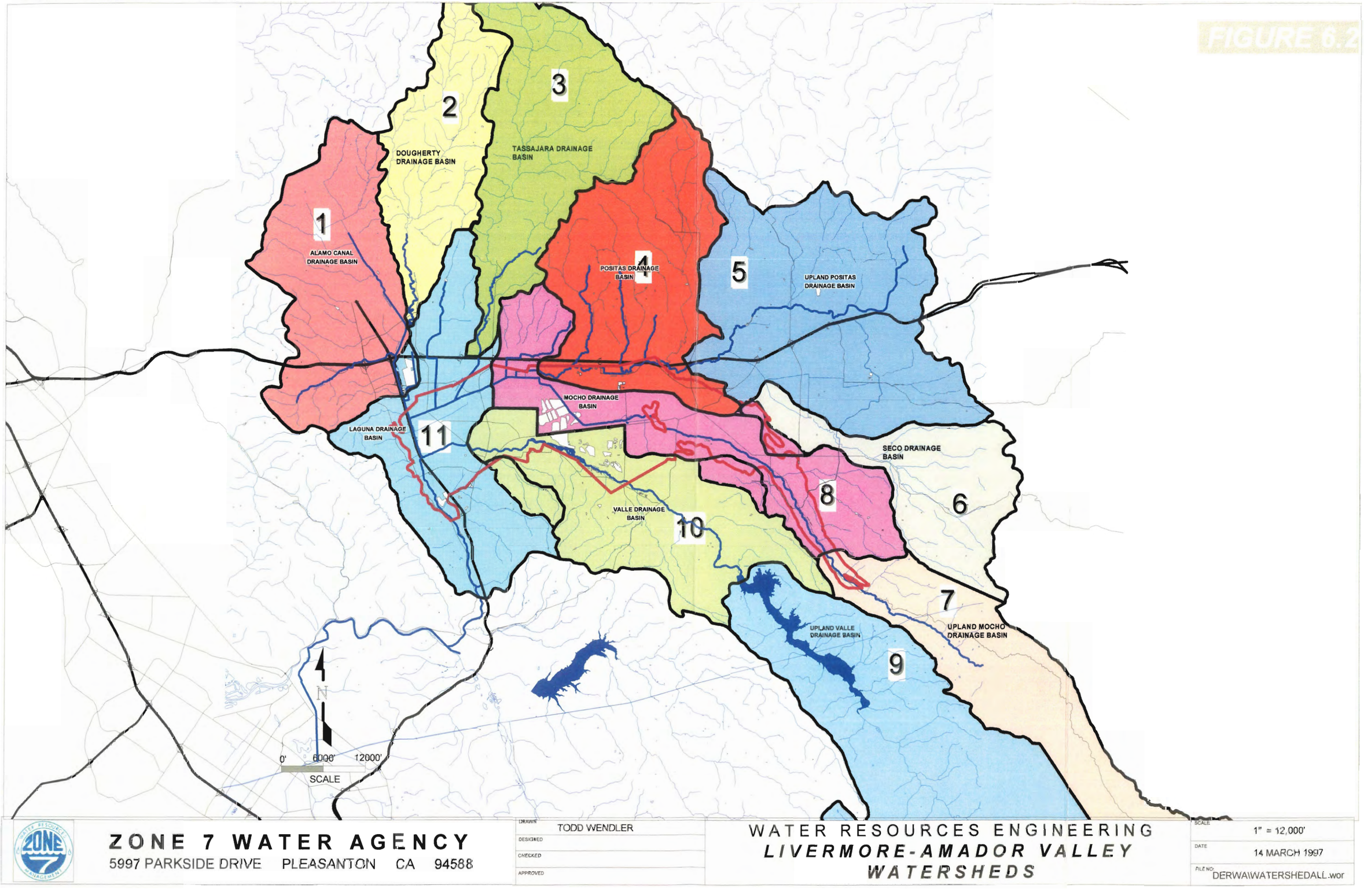
6.3 Watershed Approach to Characterize Existing and Expected New Salt Loading

As previously stated, the existing monitoring programs focus on water quality and quantity in the main groundwater basin of the watershed. The purpose of the SMMP is to augment those programs so that the total mass of salt moving in and out the watershed may be accounted for. For the purpose of salt management, salt sources in the watershed are considered to be either existing or future. Many future salt sources in the watershed are linked to irrigation associated with new urban and agricultural development, much of which will be located outside of the Main Basin. Accordingly, the SMMP focuses on enhancing the understanding of the hydrogeology of the fringe/main basin transition areas and recharge areas where the salt sources directly impact the Main Basin and/or flow out of the valley to Alameda Creek.

In developing this SMMP, the watershed was divided into eleven drainage basins (Figure 6.2). Each of those drainage basins was further subdivided into sub-drainage basins that represent unique characteristics with respect to ground and surface water. In Reference G, each of the drainage basins and sub-drainage basins are described and mapped. Key issues within each drainage basin are addressed with respect to future salt loading and future development. Reference G also contains examples of data reporting forms and a summary of background TDS, hardness, nitrate, and chloride water quality data for existing surface and groundwater stations in the SMMP network.

Reference G contains an evaluation of the wells and stations that might be associated with the SMMP at theoretical "full build-out" conditions to accurately track salt loading impacts from the associated development. This conceptual "ultimate" monitoring network was developed primarily to provide an estimate of the upper limit scope of the program if and when "full build-out" were to occur and all proposed monitoring sites turned out to be required to accurately track salt loading impacts. A more abbreviated program, perhaps operating only for a limited period of time, is believed to be adequate to characterize salt loading from the various sub-watersheds. As discussed below, the timing and intensity of future monitoring efforts will be linked to the relative magnitude of each sub-watershed's contribution to the overall Main Basin salt loading.

FIGURE 6.2



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LIVERMORE-AMADOR VALLEY
WATERSHEDS

SCALE	1" = 12,000'
DATE	14 MARCH 1997
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6.4 Recommended Near-Term Salt Management Monitoring Program

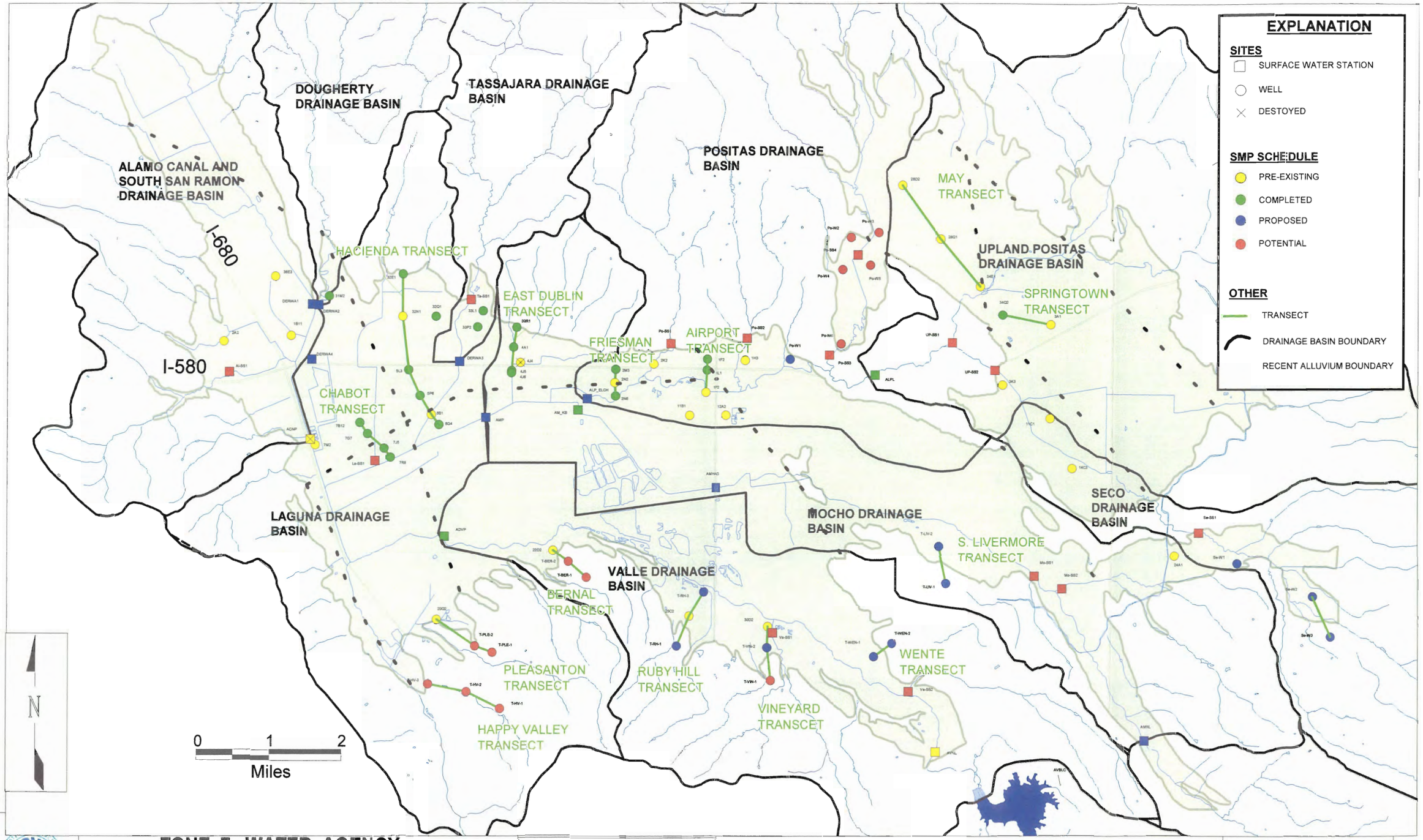
The emphasis of the near-term SMMP is to quantify salt loading in the watershed with particular attention paid to new sources of salt and to areas of geologic uncertainty. Accurately quantifying the salt loading in the watershed involves characterizing the groundwater basin with respect to mineral concentration gradients throughout the basin, evaluating the effects of future recycled water projects on local groundwater, evaluating overall trends in groundwater quality throughout the basin, and enhancing the understanding of hydrogeology of the basin.

In general, the strategy behind the near-term monitoring program is to immediately collect sufficient data to document baseline conditions, and to add additional groundwater monitoring sites as necessary to document the impacts of new sources of salt to the watershed. To realize this strategy, existing wells are taken advantage of immediately and existing surface water monitoring stations will be upgraded to collect continuous flow and conductance data. As development occurs and/or irrigation projects come on-line, new wells will be added as appropriate to the monitoring network.

This SMP program was implemented in 2000 and much of the previously proposed work has already been completed since then. Therefore, the components of the SMP are describe herein as:

- **Pre-existing** – Items that already existed prior to the implementation of the SMP Program.
- **Completed** – Items that were proposed in the original Draft SMP and are already completed.
- **Proposed** – Items proposed in the original Draft SMP that still are to be completed, and
- **Potential** – Possible items to be completed in the future, depending on effectiveness of Pre-existing, completed, and proposed items.

A summary of the monitoring sites along with a brief rationale for including each in the monitoring program is given in Table 6.1. The network of SMP wells corresponds to areas of hydrogeologic uncertainty and areas in which near-term future development could alter current salt loading characteristics in the watershed. The primary purpose of the proposed surface and groundwater monitoring is to establish baseline conditions throughout the watershed so that the impacts of future development and irrigation may be accurately assessed. Figure 6.3 and Table 6.1 show that, in general, the recommended new wells have been placed in "transects" incorporating existing wells where available. The primary purpose of the transects is to help quantify both current and future salt migration with respect to subsurface flow in areas of new salt loading and/or hydrogeologic uncertainty (see basin connectivity discussion in Section 3.3). When complete, the SMP monitoring network will include at least 56 monitoring wells and 11 surface water stations (15 including the proposed DERWA stations).



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SALT MANAGEMENT PLAN

SURFACE WATER AND GROUNDWATER MONITORING SITES

DATE	Mar 3, 2004
FIGURE	**6.3**

TABLE 6.1
Summary of Salt Management Monitoring Program

	Drainage Basin	Type	#	Map ID	SMP ID	Database ID	Scope/Notes	Rationale	Status
Pre-existing	01-Alamo	W	1	1B11	1B11	3S/1W 1B 11	Pre-Existing Well	GWQ, geology, & rising water	Pre-existing
	01-Alamo	W	1	2A2	2A2	3S/1W 2A 2	Pre-Existing Well	GWQ, geology, & rising water	Pre-existing
	01-Alamo	W	1	36E3	36E3	2S/1W 36E 3	Pre-Existing Well	GWQ, geology, & rising water	Pre-existing
	01-Alamo	W	1	7M2	7M2	3S/1E 7M 2	Pre-Existing Well	GWQ, geology, & rising water	Pre-existing
	04-Positas	W	1	11B1	11B1	3S/1E 11B 1	Pre-Existing Well	GWQ entering main basin, geology	Pre-existing
	04-Positas	W	1	12A2	12A2	3S/1E 12A 2	Pre-Existing Well	GWQ entering main basin, geology	Pre-existing
	04-Positas	W	1	1H3	1H3	3S/1E 1H 3	Pre-Existing Well	GWQ, geology	Pre-existing
	04-Positas	W	1	2K2	2K2	3S/1E 2K 2	Pre-Existing Well	Subsurface flow	Pre-existing
	04-Positas	W	1	1P2	T-AIR-3	3S/1E 1P 2	Pre-Existing Well	Airport Transect (T-AIR), GWQ	Pre-existing
	04-Positas	W	1	2N2	T-FRI-2	3S/1E 2N 2	Pre-Existing Well	Friesman Transect (T-FRI), GWQ	Pre-existing
	05-Upland positas	W	1	3K3	3K3	3S/2E 3K3	Pre-Existing Well	GWQ, geology, & rising water	Pre-existing
	05-Upland positas	W	1	28D2	T-MAY-1	2S/2E 28D 2	Pre-Existing Well	May Transect (T-MAY)	Pre-existing
	05-Upland positas	W	1	28Q1	T-MAY-2	2S/2E 28Q 1	Pre-Existing Well	May Transect (T-MAY)	Pre-existing
	05-Upland positas	W	1	34E1	T-MAY-3	2S/2E 34E1	Pre-Existing Well	May Transect (T-MAY)	Pre-existing
	05-Upland positas	W	1	3A1	T-SPR-1	3S/2E 3A 1	Pre-Existing Well	Springtown Transect (T-SPR)	Pre-existing
	06-Seco	W	1	11C1	11C1	3S/2E 11C 1	Pre-Existing Well	GWQ, geology	Pre-existing
	06-Seco	W	1	14C3	14C3	3S/2E 14C3	Pre-Existing Well	GWQ, geology	Pre-existing
	08-Mocho	W	1	4J4	4J4	3S/1E 4J 4	Pre-Existing Well	GWQ. Well to be destroyed	Destroyed 2004
	08-Mocho	W	1	24A1	24A1	3S/2E 24A 1	Pre-Existing Well	GWQ & geology of eastern WS	Pre-existing
	10-Valle	W	1	22D2	T-BER-3	3S/1E 22D 2	Pre-Existing Well	Bernal Transect (T-BER), GWQ	Pre-existing
	10-Valle	W	1	25C2	T-RH-2	3S/1E 25C2	Pre-Existing Well	Ruby Hill Transect (T-RH)	Pre-existing
	10-Valle	W	1	30D2	T-VIN-3	3S/2E 30D 2	Pre-Existing Well	Vineyard Transect (T-VIN), GWQ	Pre-existing
	11-Laguna	W	1	32N1	T-HAC-2	2S/1E 32N 1	Pre-Existing Well	Hacienda Transect (T-HAC)	Pre-existing
	11-Laguna	W	1	8B1	T-HAC-5	3S/1E 8B 1	Pre-Existing Well	Hacienda Transect (T-HAC)	Pre-existing
	11-Laguna	W	1	20Q2	T-PLE-3	3S/1E 20Q 2	Pre-Existing Well	Pleasanton Transect (T-PLE), flow	Pre-existing
	01-Alamo	SS	1	ACNP	ACNP	ACNP	AC Near Pleasanton	Flow into ADLL from AC	Abandoned
	09-Upland Valle	SS	1	AVBLC	AVBLC	AVBLC	AV Below Lang Canyon	SW flow below Lang Canyon	Pre-existing
	10-Valle	SS	1	AVNL	AVNL	AVNL	AV near Livermore	SW flow from lake Del Valle	Pre-existing
	11-Laguna	SS	1	ADLLP	ADLLP	ADLLP	ADLL near Pleasanton	SWQ leaving Basin	Pre-existing
Completed for SMP	02-Dougherty	W	1	31M2	31M2	2S/1E 31M 2	Well for SMP	GWQ and GW flow	Drilled 2000
	03-Tassajara	W	1	33L1	33L1	2S/1E 33L 1	Well for SMP	GWQ	Drilled 2000
	03-Tassajara	W	1	33P2	33P2	2S/1E 33P 2	Well for SMP	GWQ	Drilled 2000
	04-Positas	W	1	1F2	T-AIR-1	3S/1E 1F 2	Well for SMP	Airport Transect (T-AIR), GWQ	Drilled 2000
	04-Positas	W	1	1L1	T-AIR-2	3S/1E 1L 1	Well for SMP	Airport Transect (T-AIR), GWQ	Drilled 2000
	04-Positas	W	1	2M3	T-FRI-1	3S/1E 2M 3	Well for SMP	Friesman Transect (T-FRI),	Drilled 2000
	04-Positas	W	1	2N6	T-FRI-3	3S/1E 2N 6	Well for SMP	Friesman Transect (T-FRI), GWQ	Drilled 2000
	05-Upland positas	W	1	34Q2	T-SPR-2	2S/2E 34Q 2	Well for SMP	Springtown Transect (T-SPR)	Drilled 2001
	08-Mocho	W	1	33R1	T-DUB-1	2S/1E 33R 1	Well for SMP	East Dublin Transect (T-DUB)	Drilled 2001
	08-Mocho	W	1	4A1	T-DUB-2	3S/1E 4A 1	Well for SMP	East Dublin Transect (T-DUB)	Drilled 2001
	08-Mocho	W	1	4J5	T-DUB-3	3S/1E 4J 5	Well for SMP	East Dublin Transect (T-DUB)	Drilled 2001
	08-Mocho	W	1	4J6	T-DUB-4	3S/1E 4J 6	Well for SMP	East Dublin Transect (T-DUB)	Drilled 2001
	11-Laguna	W	1	7B12	T-CHA-1	3S/1E 7B12	Well for SMP	Chabot Transect (T-CHA)	Drilled 2002
	11-Laguna	W	1	7G7	T-CHA-2	3S/1E 7G 7	Well for SMP	Chabot Transect (T-CHA)	Drilled 2002
	11-Laguna	W	1	7J5	T-CHA-3	3S/1E 7J 5	Well for SMP	Chabot Transect (T-CHA)	Drilled 2002
	11-Laguna	W	1	7R8	T-CHA-4	3S/1E 7R 8	Well for SMP	Chabot Transect (T-CHA)	Drilled 2003
	11-Laguna	W	1	32Q1	32Q1	2S/1E 32Q 1	Well for SMP	GWQ	Drilled 2000
	11-Laguna	W	1	32E1	T-HAC-1	2S/1E 32E 1	Well for SMP	Hacienda Transect (T-HAC)	Drilled 2000
	11-Laguna	W	1	5L3	T-HAC-3	3S/1E 5L 3	Well for SMP	Hacienda Transect (T-HAC)	Drilled 2001
	11-Laguna	W	1	5P6	T-HAC-4	3S/1E 5P 6	Well for SMP	Hacienda Transect (T-HAC)	Drilled 2000
	11-Laguna	W	1	8G4	T-HAC-6	3S/1E 8G 4	Well for SMP	Hacienda Transect (T-HAC)	Drilled 2001
	05-Upland positas	SS	1	ALPL	ALPL	ALPL	Upgrade-ALP at Livermore	SWQ in ALP entering main basin	Upgraded 2000
	08-Mocho	SS	1	AM_KB	AM_KB	AM_KB	Upgrade-AM at Kaiser Bridge	SWQ recharging West Amador	Upgraded 2001
	10-Valle	SS	1	ADVP	ADVP	ADVP	Upgrade-AV at Pleasanton	SWQ leaving AV, entering ADLL	Upgraded 2000
Proposed	04-Positas	W	1	Po-W1			Proposed Well for SMP	GWQ edge of DB	Proposed
	06-Seco	W	3	Se-W1 to 3			3 Proposed new wells	If development occurs	Proposed
	08-Mocho	W	1	T-LIV-1			Proposed Well for SMP	South Livermore Transect	Proposed
	08-Mocho	W	1	T-LIV-2			Proposed Well for SMP	South Livermore Transect	Proposed
	10-Valle	W	1	T-RH-1			Proposed Well for SMP	Ruby Hill Transect (T-RH)	Proposed
	10-Valle	W	1	T-RH-3			Proposed Well for SMP	Ruby Hill Transect (T-RH)	Proposed
	10-Valle	W	1	T-VIN-2			Proposed Well for SMP	Vineyard Transect (T-VIN)	Proposed
	10-Valle	W	1	T-WEN-1			Proposed Well for SMP	Wente Transect (T-WEN)	Proposed
	10-Valle	W	1	T-WEN-2			Proposed Well for SMP	Wente Transect (T-WEN)	Proposed
	01-Alamo	SS	1	DERWA1			Proposed - SSRC	Flow from SSRC	Proposed
	02-Dougherty	SS	1	DERWA2			Proposed - AC N. of 680	Flow from Dougherty DB into ADLL	Proposed
	03-Tassajara	SS	1	DERWA3			Proposed - Tassajara Creek	SWQ from Tassajara DB	Proposed
	04-Positas	SS	1	ALP_ELCH	ALP_ELCH	ALP_ELCH	Upgrade-ALP at El Charro Rd	SWQ from ALP to AM and ADLL	To be upgraded
	07-Upland Mocho	SS	1	AMNL	AMNL	AMNL	Upgrade-AM Near Livermore	SWQ, AM Near Livermore	To be upgraded
	08-Mocho	SS	1	AMHAG	AMHAG	AMHAG	Upgrade-AM at Livermore	SWQ in AM over main basin	To be upgraded
	08-Mocho	SS	1	AMP	AMP	AMP	Upgrade-AM near Pleasanton	SWQ in AM entering ADLL	To be upgraded
	11-Laguna	SS	1	DERWA4			Proposed - Dublin Sports Park	Inflow into Trench Line G-1-1	Proposed
Potential	04-Positas	W	5	Po-W2 to 6			5 Proposed wells		Potential
	10-Valle	W	1	T-BER-1			Proposed Well for Transect	Bernal Transect (T-BER)	Potential
	10-Valle	W	1	T-BER-2			Proposed Well for Transect	Bernal Transect (T-BER)	Potential
	10-Valle	W	1	T-VIN-1			Proposed Well for Transect	Vineyard Transect (T-VIN)	Potential
	11-Laguna	W	1	T-HV-1			Proposed Well for Transect	Happy Valley Transect (T-HV)	Potential
	11-Laguna	W	1	T-HV-2			Proposed Well for Transect	Happy Valley Transect (T-HV)	Potential
	11-Laguna	W	1	T-HV-3			Proposed Well for Transect	Happy Valley Transect (T-HV)	Potential
	11-Laguna	W	1	T-PLE-1			Proposed Well for Transect	Pleasanton Transect (T-PLE), flow	Potential
	11-Laguna	W	1	T-PLE-2			Proposed Well for Transect	Pleasanton Transect (T-PLE), flow	Potential
	01-Alamo	SS	1	Al-SS1			1 Proposed surface station		Potential
	03-Tassajara	SS	1	Ta-SS1			1 Proposed surface station		Potential
	04-Positas	SS	4	Po-SS1 to 4			4 Proposed surface stations		Potential
	05-Upland positas	SS	2	UP-SS1 to 2			2 Proposed surface stations		Potential
	06-Seco	SS	1	Se-SS1			1 Proposed surface station		Potential
	08-Mocho	SS	2	Mo-SS1 to 2			2 Proposed surface stations		Potential
	10-Valle	SS	2	Va-SS 1 to 2			2 Proposed surface stations		Potential
	11-Laguna	SS	1	La-SS1			1 Proposed surface station		Potential

AC	Alamo Canal
ADLL	Arroyo de La Laguna
ALP	Arroyo Las Positas
AM	Arroyo Mocho
AV	Arroyo Valle
DB	Drainage Basin
DERWA	DSRSD, EBMUD Recycle Water Agency
SS	Surface Station
GW	Groundwater
GWQ	Groundwater quality
SMP	Salt Management Plan
SSRC	South San Ramon Creek
SW	Surface Water
SWQ	Surface Water Quality
WS	Watershed

Pre-Existing Monitoring Network

Following is a description of the pre-existing monitoring wells and surface water monitoring stations that were monitored for salt management purposes.

1) Twenty-five pre-existing monitoring wells were included in the SMMP to track groundwater levels and quality. Well 3S/1E 4J 4, initially included in the SMP, was destroyed in February of 2004. The 24 remaining wells are in the following drainage basins:

   - **Alamo Canal-South San Ramon Creek** – To monitor salt loading;
   - **Positas** – To investigate geologic uncertainty and groundwater quality at the edge of the Main Basin;
   - **Upland Positas** – To investigate geologic uncertainty and high TDS groundwater. The May Transect will consist of three of these pre-existing wells;
   - **Seco** – To investigate fringe basin geologic uncertainty and groundwater quality;
   - **Mocho** – To investigate fringe basin geologic uncertainty and groundwater quality;
   - **Valle** – To characterize groundwater quality entering the Main Basin; and
   - **Laguna** – To characterize groundwater quality entering and leaving the Main Basin.

2) Four pre-existing surface water recorder stations (AVBLC, south of Del Valle Reservoir, is not shown on Figure 6.3) were included in the SMMP to track stream water flow and quality in two major waterways in the watershed (Arroyo Valle and Arroyo de La Laguna). One of these stations (ACNP – Alamo Canal near Pleasanton) has since been abandoned. Data from the ADLLP (Arroyo de la Laguna below Pleasanton) stream gage station is collected by the USGS.

Already Completed for SMMP

The following items were proposed in previous versions of the SMP and have already been completed as part of the SMMP:

1) Twenty-one new wells were drilled from 2000 to 2003 in the Dougherty, Tassajara, Positas, Upland Positas, Mocho, and Laguna Drainage Basins. Their purpose is to better quantify the baseline subsurface flow into the Main Basin from the Camp sub-basin, and the salt impacts from new development in East Dublin, Dougherty Valley, Tassajara Valley and the Triad area in Livermore. These wells will be used to identify the fringe basin aquifers, and, along with other wells along the aquifer flow path, to track subsurface flows and quality into the main basin.

- **Dougherty** - One well will be used to monitor groundwater quality and flow from the Dougherty Basin into the Laguna Basin.

- **Tassajara** - Two wells will be used to monitor the impacts of recycled water use at Emerald Glen Park in East Dublin.

- **Positas** - Four wells will be used to monitor groundwater flow and quality from the northern boundary of the watershed. These wells will complete the Friesman and Airport Transects.

- **Upland Positas** - One new well will be used to quantify subsurface salt migration due to development in the Springtown area. This well will complete the Springtown Transect.

- **Mocho** - Four wells will be used to monitor groundwater flow and quality from the northern boundary of the watershed. These wells will complete the East Dublin Transect.

- **Laguna** - Nine wells were drilled to quantify salt migration from the Dublin and Camp sub-basins to the Bernal and West Amador sub-basins. Four of these wells will complete the Hacienda Transect. Four will complete the Chabot Transect. One well (3S/1E 32Q 1) will monitor groundwater quality entering the northern portion of the main basin.

2) Three existing surface water monitoring stations were upgraded with the installation of automatic water quality monitoring equipment to monitor electrical conductivity, temperature, pH, and stream stage (water height).

   - **Upland Positas** - Arroyo Las Positas at Livermore (ALPL),

   - **Mocho** - Arroyo Mocho at Livermore (AMHAG), and

   - **Valle** - Arroyo Valle at Pleasanton (ADVP).

Proposed Monitoring Network

1) There are eleven new monitoring wells planned for the future. The majority of these wells are along the southern and eastern portions of the groundwater basin.

   - **Positas** - One new well is planned to quantify salt migration into the Main Basin from outlying areas and the fringe basins due to proposed development in North Livermore. It will be located where four sub-drainage basins come together.

   - **Seco** - Three new wells are planned to investigate groundwater flow and quality from the eastern portion of the groundwater basin.

- **Mocho** - Two new wells are proposed for the southern portion of the drainage basin. These wells will complete the South Livermore Transect.

- **Valle** - Five new wells are proposed. Four of these wells will complete the Wente and Ruby Hill Transects. One of these wells will be part of the Vineyard Transect. All are intended to help quantify groundwater flow and salt loading from the Livermore Uplands to the Main Basin, and in particular, the effects of irrigation projects, such as The Wente Vineyards golf course, Veterans Administration Hospital and Ruby Hills vineyards, on Main Basin recharge.

2) Four existing stations will be upgraded.

- **Positas** - Arroyo Las Positas at El Charro (ALP_ELCH), recently relocated because of the realignment of a portion of the Arroyo Las Positas, will be upgraded with the installation of automatic water quality monitoring equipment for electrical conductivity, temperature, and pH.

- **Upper Mocho** - Arroyo Mocho near Livermore (AMNL) will be upgraded with water quality monitoring and recording equipment.

- **Mocho** - Arroyo Mocho at Kaiser Bridge (AM_KB, recently reinstalled because of the realignment of the Arroyo Mocho) will be upgraded with water quality monitoring and recording equipment. Arroyo Mocho near Pleasanton (AMNP) will also be upgraded with water quality monitoring and recording equipment.

3) Four new stream gaging stations will be constructed by DERWA and incorporated into the monitoring program following their completion. These are to be located at:

- South San Ramon Creek,
- Alamo Creek north of I-680,
- The Dublin Sports Park, and
- Lower Tassajara Creek.

Potential Monitoring Network

1) Potentially, there may be 13 additional wells. Five of these wells would complete the Pleasanton and Happy Valley Transects in the southern portion of the Laguna Drainage Basin. Another three would complete the Bernal and Vineyard Transects in the southern portion of the Valle Drainage Basin. Five wells would be located in the eastern portion of the Positas Drainage Basin.

2) Fourteen additional stream gages potentially may be installed. These would be installed if needed based on review of collected data to fill in "data gaps" and/or to provide baseline data relative to new development related salt loading sources.

Constituents to be Monitored

All wells and surface waters in the near-term monitoring program will be sampled and analyzed annually for "major ions" (i.e., Ca, Mg, Na, K, HCO3, SO4, Cl, NO3, SiO2), boron, manganese, selenium, chromium, arsenic, electrical conductivity, pH, TDS, alkalinity and hardness. As surface water monitoring stations are upgraded with automated water quality measuring instruments, electrical conductivity, temperature and pH will be recorded on a nearly continuous basis. Historic groundwater and surface water quality data from existing stations are summarized in Reference I.

6.5 Costs Associated with SMP Monitoring Program

Based on the monitoring program described above, a summary of the additional costs to implement the program is shown in Table 6.2. To develop that summary it was assumed that the capital cost for each additional well would be $5,000, new surface water stations would be $80,000 each, and recorder station upgrades would be $13,000 each. The laboratory costs are estimated at $300 per sample, and the estimated O&M labor to collect samples, maintain the stations, and produce the continuous record from the on-line instruments would be approximately 0.4 full-time equivalent (FTE) of an employee at $75,000/FTE/yr. The four proposed DERWA stations will be paid for by DERWA and their costs are not included in this table.

Table 6.2
Estimated Annual Costs
Salt Management Monitoring Program

	Monitoring Wells				Surface Water Stations					O&M	
Year	Existing	New	Capital Cost	Lab Cost	Existing	New	Upgrade	Capital Cost	Lab Costs	FTE	O&M Cost
Completed	24	21	$105,000	$13,500	3	0	3	$39,000	$900	0.4	$30,000
Proposed	45	11	$55,000	$16,800	7	4	4	$372,000	$3,300	0.4	$30,000
Potential	56	13	$65,000	$20,700	15	14	0	$1,120,000	$8,700	0.4	$30,000
Subtotal	24	45	$225,000	$51,000	3	18	7	$1,531,000	$12,900	1.2	$90,000

A summary of the total costs associated with the Salt Management monitoring program is shown in Table 6.3.

Table 6.3
Salt Management Monitoring Program
Estimated Total Costs

Year	Total Capital Cost	O&M Costs	Total Lab Cost	Total Cost
Completed	$144,000	$30,000	$14,400	$188,400
Proposed	$427,000	$30,000	$20,100	$477,100
Potential	$1,185,000	$30,000	$29,400	$1,244,400
Subtotal	$1,756,000	$90,000	$63,900	$1,909,900

6.6 Future Recycled and Untreated Water Use Related Monitoring

Future Demands

Zone 7 has compiled information from local municipalities on potential future untreated water demands as part of its water supply planning efforts (September 1999 Draft Integrated Water System Study Report, Water Transfer Associates). Figure 6.4 shows existing and future agricultural and non-agricultural demand areas (by code number) that could be served by various sources of untreated water including recycled water. Table 6.4 lists the individually coded demand areas by retailer service area. The largest potential future demand areas include development in Dougherty Valley, East Dublin, North Livermore (under comprehensive re-evaluation), plus increased South Livermore irrigated agriculture. Table 6.4 shows that the valley-wide untreated demand could increase from the existing 15,700 af/yr to as high as 37,300 af/yr.

The magnitude of gross salt loading from this level of development will depend on the TDS level in the sources of untreated water ultimately supplied. The source water projections shown in Table 6.4 represent one set of assumptions and are subject to change as projects evolve. Related work found that there was 34,000 af/yr of recycled water potentially available valley-wide, 18,000 af/yr of potential use currently identified by retailers, and potentially 16,000 af/yr available for other uses. More recycled water could conceivably be used than shown in Table 6.4 depending on institutional arrangements, quality requirements, cost, and other factors. The actual salt loading impacting the Main Basin from future untreated water irrigation will depend on project location relative to the Main Basin (see Section 11.2 map and description of relative percent impact zones) in addition to the untreated water supply TDS.

The near-term SMMP and potential future surface and groundwater monitoring stations described above and shown in Figure 6.3 are intended to track changes in salt loading at key junctures from best estimates of likely new development and new irrigation. It is not anticipated that most irrigation projects would require extensive additional individual groundwater monitoring. In new development there could very likely be a mixture of treated, untreated, and recycled water irrigation making it difficult, if not impossible, to track "recycled water" salt. The SMMP includes groundwater monitoring at a few

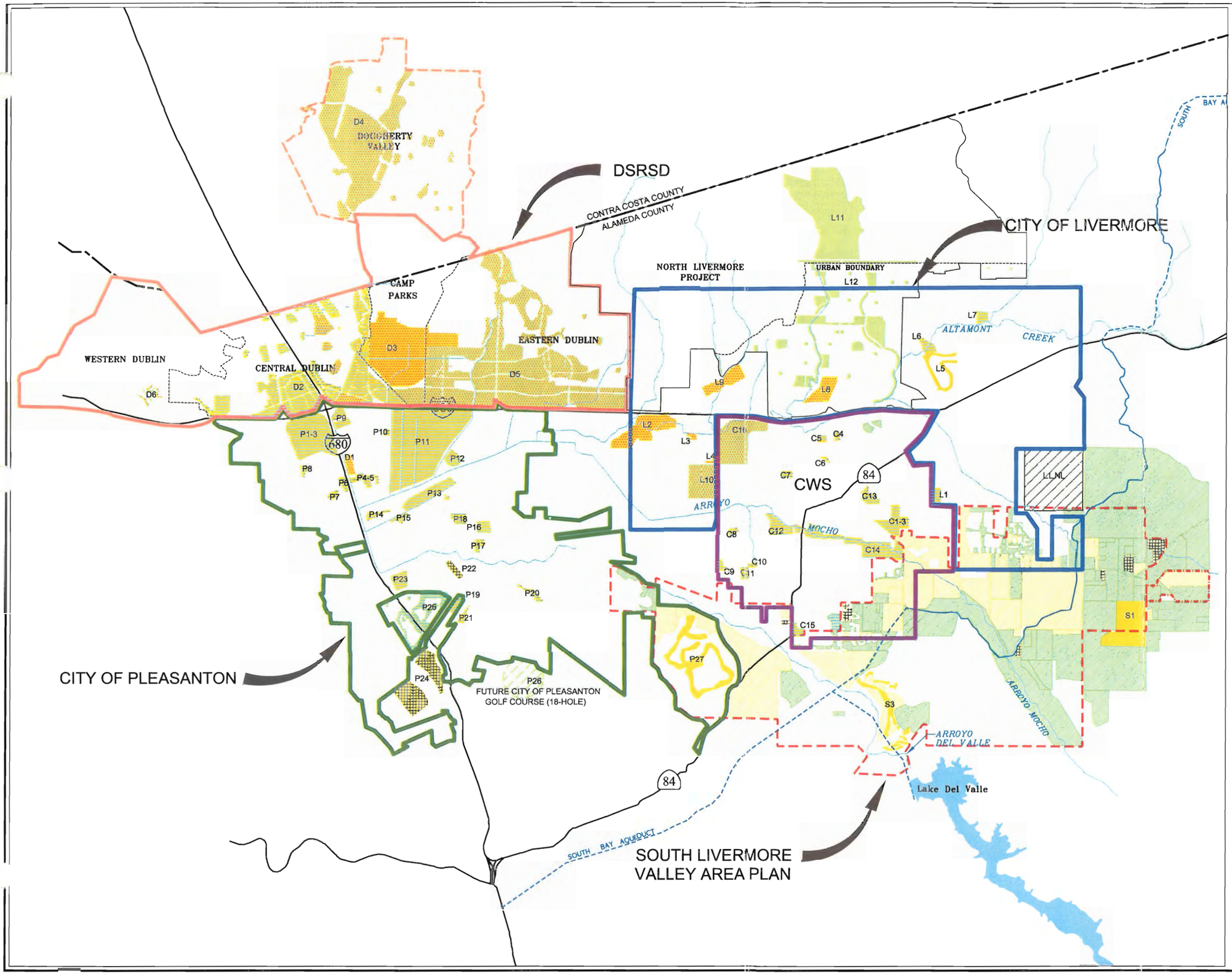


FIGURE 6.4

Zone 7 Water Agency Integrated Water System March 2000

PROPOSED WATER SUPPLIES TO SERVE EXISTING AND FUTURE UNTREATED WATER DEMANDS

N

0 4000 8000

SCALE IN FEET

NOTES:

1. SOURCES OF DATA:
   - CITY OF PLEASANTON RECYCLED WATER FEASIBILITY STUDY, ADMIN DRAFT REPORT, HYA & HYDROSCIENCE, INC., NOV 1998.
   - DSRSD DRAFT WATER MASTER PLAN, WYA, OCT 1999.
   - NORTH LIVERMORE PROJECT TECHNICAL MEMORANDA NO. 5-1,6,8,9, WYA, 1998.
   - ZONE 7 WATER SUPPLY PLANNING STUDY UPDATE, WTr, JAN 1999.
   - ZONE 7 MEMO VALLEY LAND USE, 1998 WY," OCT 1998.
   - PERSONAL COMMUNICATIONS WITH CITY OF LIVERMORE, CITY OF PLEASANTON, DSRSD, CWS AND MIKE GATZMAN, JUN-SEP 1999.

LEGEND:

- EXISTING UNTREATED WATER DEMAND AREA (NON-AGRICULTURAL)
- FUTURE UNTREATED WATER DEMAND AREA (NON-AGRICULTURAL)
- EXISTING UNTREATED WATER DEMAND AREA (AGRICULTURAL)
- FUTURE UNTREATED WATER DEMAND AREA (AGRICULTURAL)
- RECYCLED WATER
- PRIVATE GROUNDWATER
- ZONE 7 – TREATED WATER
- NO HATCH PATTERN — ZONE 7 – UNTREATED WATER

Water Transfer Associates

TABLE 6.4 Proposed Water Supply to Meet Existing and Future Untreated Water Demands

(Unless otherwise noted, data for this Table has been developed based on the sources of information listed at the bottom of the Table)

Retailer Service/Planning Area	Code (See Figure 1-2)	Untreated Water Demand Area (a)	Existing Water Demand (afa)	Future Water Demand (afa)	Source of Water (b) (as currently planned)	Comment
DSRSD	D1	DSRSD Wastewater Treatment Plant	6	6	Recycled	
	D2A	Central Dublin	790	790	Zone 7 - Treated	
	D2B	Central Dublin	260	260	Recycled	Demand currently on potable system; will be transitioned to recycled water system
	D3	Camp Parks	440	440	Recycled	Demand currently on potable system; will be transitioned to recycled water system
	D4	Dougherty Valley	0	1,520	Recycled	
	D5	East Dublin	0	2,385	Recycled	
	D6	Western Dublin	0	70	Recycled	
		Subtotal	1,500	5,400		
City of Pleasanton (includes adjacent areas)	P1	Stoneridge Mall	47	47	Zone 7 - Treated	
	P2	Stoneridge Drive	31	31	Zone 7 - Treated	
	P3	Stoneridge Corps Plaza	27	27	Zone 7 - Treated	
	P4	Val Vista Park	15	15	Zone 7 - Treated	
	P5	Donlon School	36	36	Zone 7 - Treated	
	P6	Muirwood Community Park	35	35	Zone 7 - Treated	
	P7	Lyoiksen School	20	20	Zone 7 - Treated	
	P8	Moller Park	11	11	Zone 7 - Treated	
	P9	Commerce Circle	32	32	Zone 7 - Treated	
	P10	Signature Center	12	12	Zone 7 - Treated	
	P11	Hacienda Business Park	183	183	Zone 7 - Treated	
	P12	Southern Pacific Development	21	21	Zone 7 - Treated	
	P13	Pleasanton Sports Park	230	230	Zone 7 - Treated	
	P14	Valley Trails Park	26	26	Zone 7 - Treated	
	P15	Pleasanton Tennis & Community Park	22	22	Zone 7 - Treated	
	P16	Amador Valley Community Park	21	21	Zone 7 - Treated	
	P17	Amador Valley High School	66	66	Zone 7 - Treated	
	P18	Harvest School	44	44	Zone 7 - Treated	
	P19	Pleasanton Middle High School	51	51	Zone 7 - Treated	
	P20	Kottinger Community Park	27	27	Zone 7 - Treated	
	P21	Centennial Park & Senior Center	25	28	Zone 7 - Treated	
	P22	County Fairgrounds/Golf Course	640	640	Private Groundwater	
	P23	Koll Business Center	171	171	Zone 7 - Treated	
	P24	Castlewood County Club	688	688	Private Groundwater	
	P25	SFWD Project	0	395	Zone 7 - Treated	
	P26	Future Pleasanton Golf Course	0	350	Zone 7 - Treated	
	P27	Ruby Hills Golf Course	--	--	Zone 7 - Untreated	See South Livermore Valley
		Subtotal	2,480	3,230		
CWS	C1	Livermore Civic Center & Park	17	17	Zone 7 - Treated	
	C2	St. Michaels Cemetery	48	48	Zone 7 - Treated	
	C3	Sunken Garden Park	19	19	Zone 7 - Treated	
	C4	Vista Meadows Park	10	10	Zone 7 - Treated	
	C5	Masonic Cemetery	15	15	Zone 7 - Treated	
	C6	Junction Avenue Park	6	6	Zone 7 - Treated	
	C7	May Poo Nissen Park	37	37	Zone 7 - Treated	
	C8	Pleasure Island Park	26	26	Zone 7 - Treated	
	C9	Holm-Well Park	14	14	Zone 7 - Treated	
	C10	El Padro Park	14	14	Zone 7 - Treated	
	C11	Max Baer Park	24	24	Zone 7 - Treated	Based on actual 1994-1998 CWS deliveries
	C12	Granada High School	39	39	Zone 7 - Treated	Based on actual 1994-1998 CWS deliveries
	C13	Livermore High School	40	40	Zone 7 - Treated	Based on actual 1994-1998 CWS deliveries
	C14	Robertson Park	148	148	Zone 7 - Treated	Based on actual 1994-1998 CWS deliveries
	C15	Independence Park	38	38	Zone 7 - Treated	Based on actual 1994-1998 CWS deliveries
	C16	Industrial Park Site	0	60	Recycled	Assumes future use of recycled water
		Subtotal	500	560		
City of Livermore	L1	Robert Livermore Park	90	90	Zone 7 - Treated	
	L2	Las Positas Golf Course	500	500	Recycled	
	L3	Livermore Municipal Airport	10	10	Recycled	
	L4	Livermore Wastewater Plant	5	5	Recycled	
	L5	Springtown Golf Course	185	185	Zone 7 - Untreated	Maximum Zone 7 Entitlement
	L6	North Livermore Park	38	38	Zone 7 - Treated	
	L7	Christiensen Park	40	40	Zone 7 - Treated	
	L8	Triad Development	90	171	Recycled	Assumes future use of recycled water
	L9	Las Positas College	16	67	Recycled	Assumes future use of recycled water
	L10	Industrial Park Site	0	60	Recycled	Assumes future use of recycled water
	L11	North Livermore Project - Zone A	0	1,867	Zone 7 - Untreated	(c)
	L12	North Livermore Project - Zone B	0	1,775	Zone 7 - Untreated	(c)
	L13	Isabelle Avenue	0	100	Recycled	
		Subtotal	970	4,910		
South Livermore Valley	S1	Poppy Ridge Golf Course	815	815	Zone 7 - Untreated	1999 Zone 7 Request
Valley (includes lands east of Greenville Road)	P27	Ruby Hills Golf Course	790	790	Zone 7 - Untreated	Maximum Zone 7 Entitlement
	S3	Wente Golf Course	350	350	Zone 7 - Untreated	Estimated based on water use for other golf courses in the region
		Agriculture	7,747	20,647	Zone 7 - Untreated	Estimated based on acreages
		Agriculture	245	245	Private Groundwater	Estimated based on acreages
		Subtotal	9,950	22,850		
Other		Altamont Landfill	328	328	Zone 7 - Untreated	Maximum Zone 7 Entitlement
TOTAL RECYCLED WATER DEMAND			1,330	5,580		
TOTAL PRIVATE GROUNDWATER DEMAND			1,570	1,570		
TOTAL ZONE 7 TREATED WATER DEMAND			2,610	3,360		
TOTAL ZONE 7 UNTREATED WATER DEMAND			10,200	26,800		
TOTAL VALLEY-WIDE UNTREATED DEMAND			**15,700**	**37,300**		

Notes:

(a) Untreated water demand areas identified based on current planning efforts by the Zone's retailers, discussions with local agricultural community representatives, and review of recent aerial photography. Minor untreated water demand areas may not be included.

(b) Water supply source identified is based on existing water supplies and discussion with Zone 7's retailers. Water supply sources are subject to change based on retailer planning efforts and further development of the Zone's Integrated Water System Master Plan.

(c) Although the City of Livermore is also planning on serving recycled water to these areas, the City is still requesting untreated water from Zone 7 for this area.

Sources of Information:

1. City of Pleasanton Recycled Water Feasibility Study, Administrative Draft Report, HYA & HydroScience Engineers, Inc., November 1998.
2. DSRSD Draft Water Master Plan, WYA, October 1999.
3. North Livermore Project Technical Memoranda No. 5-1, 6, 8, 9, WYA, 1998.
4. Zone 7 Water Supply Planning Study Update, WTr, January 1999.
5. Zone 7 Memorandum "Livermore Valley Land Use, 1998 Water Year," October 23, 1998.
6. Personal communications with City of Livermore, DSRSD, CWS, City of Pleasanton and Mike Gatzman (Wente Vineyards), June-September 1999.

indicator recycled water irrigation sites to track changes in local ambient groundwater quality and verify assumptions about travel times, percolate quality, and related issues.

Several new projects proposing to use recycled water for groundwater recharge or irrigation are currently underway or in various stages of review and approval. In general, it is expected that individual recycled water projects will have some level of site specific monitoring, but not necessarily groundwater monitoring, required as part of the Master Permit approval process. Once such projects and associated monitoring programs are approved, the monitoring would be incorporated into the overall SMMP. Following is a brief description of existing and selected proposed recycled water irrigation and injection projects and a summary of the proposed or recommended monitoring programs.

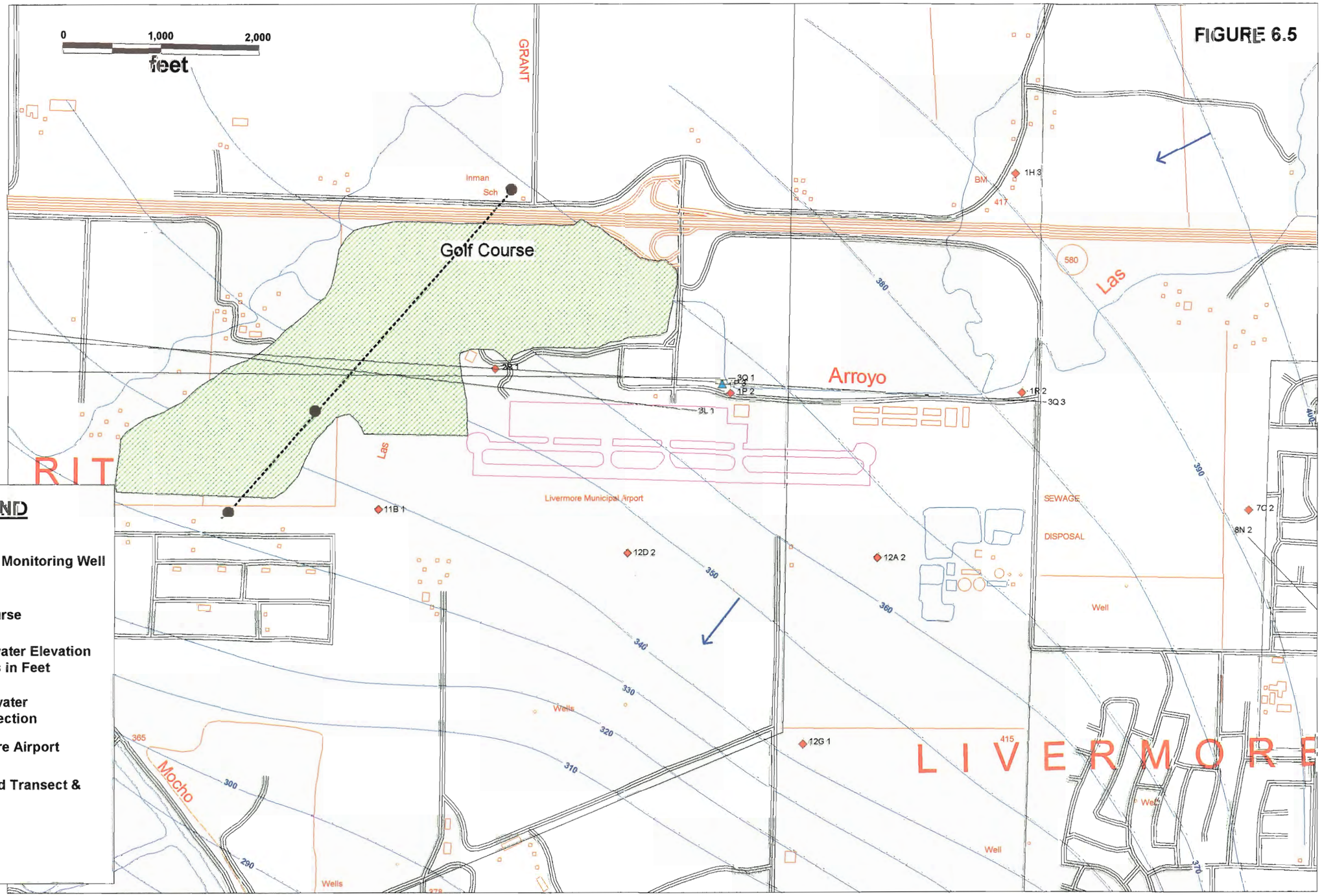
Recycled Water Irrigation Projects

As shown in Figure 6.4 and Table 6.4, several large untreated water irrigation projects are currently proposed that could use recycled water or blends of recycled and other untreated water(s). Overall it is anticipated that use of recycled water for irrigation purposes will increase in the future. **For Zone 7 to be able to calculate the salt loading due to recycled water irrigation, any agency irrigating with recycled water shall submit a report to Zone 7 containing the monthly amount of water applied in each of the salt loading impact zone areas shown in Figure 11.2, the monthly average TDS of applied recycled water, the monthly complete mineral analysis, and an annual a map showing irrigated areas.** In the near-term, new or revised monitoring at three sites is recommended to expand baseline information and better evaluate potential future impacts of irrigation with recycled water use on the groundwater basin.

Livermore Golf Course—The Livermore Airport and Golf Course use about 400 AF of recycled water annually for irrigation. The current monitoring program consists of 10 wells installed jointly by Zone 7 and the USGS in the late 1970's. The collection and analysis of groundwater data was initially done by USGS and Zone 7, but the collection was taken over by Livermore in 1985. The RWQCB established monthly monitoring and reporting requirements in Water Reclamation Permit No. 90-102 issued to the Livermore Water Reclamation Plant. Zone 7 reviews the groundwater quality data submitted by Livermore to the RWQCB and makes additional water level and groundwater quality measurements. Zone 7 maintains records on monthly recycled water use, recycled water quality and the application areas and rates.

The 10 existing monitoring wells were established prior to expansion of both the Livermore Airport and the golf course. Figure 6.5 shows the current monitoring well locations and the area of applied recycled water. Eight of the 10 monitoring wells are effectively outside of the area of interest and cannot be classified as either up gradient or down gradient wells. It appears, therefore, that the historic network of wells should be modified as follows to account for the relocation and expansion of the golf course. It would provide more useful information if two lines of wells "or transects" were

FIGURE 6.5



LEGEND

- Existing Monitoring Well
- Golf Course
- Groundwater Elevation Contours in Feet
- Groundwater Flow Direction
- Livermore Airport
- Proposed Transect & Wells

N
W E
S

ZONE 7 WATER AGENCY

5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	C MAHONEY
DESIGNED	G GATES
CHECKED	M KATEN
APPROVED	

WATER RESOURCES ENGINEERING

LIVERMORE WATER RECLAIMATION PLANT GROUNDWATER MONITORING SITES

SCALE	1" = 1000'
DATE	November 30, 2000
FILE NO.	h:\smp\fig6.5

established, each containing three shallow monitoring wells. These lines of wells would be oriented to coincide with groundwater movement (see Figure 6.5). The first well would be up gradient to monitor background conditions. The second well would be located in the irrigation area and would monitor the effects of the applied recycled water. The third well would be down gradient and would monitor the groundwater as it leaves the irrigation area.

Revised reporting methods to display both level and quality data in terms of these lines, tracking changes to either level and/or quality, would be beneficial. The monthly monitoring of applied water quality, volume and area of application should be continued. The daily rainfall and pan evaporation data collected by LWRP should be continued to provide a record of local rainfall and evapotranspiration. The monitoring of local stream water quality and recharge rates calculated by Zone 7 should also be continued and reviewed in conjunction with the shallow well data. Groundwater quality in the down gradient wells is believed to be a combination of upgradient groundwater flow, stream recharge, applied water recharge from recycled water and rainfall recharge. Data should be collected and quantified in a manner suitable for use in future groundwater flow and transport modeling.

Given the long history of non-RO recycled water irrigation at this site, it is a valuable demonstration site for tracking and evaluating the impacts on groundwater nitrate, chloride and TDS levels associated with recycled water irrigation. Data collected from this site would be useful for helping to characterize the likely groundwater impacts of similar proposed irrigation projects within the Main Basin.

It does not appear that similarly intensive monitoring programs will be needed or justified at typical recycled water irrigation sites based on Zone 7 staff review of historic data, groundwater model results, and the incremental loadings relative to overall basin salt loadings. Results from Livermore and one new or retrofit irrigation site (below) should provide adequate representative documentation of irrigation impacts. However, it is recommended that the Zone 7 groundwater model be reviewed approximately every five years and the data collected from these recycled water projects and other SMMP monitoring wells, and applied water data be added to the historic model data sets. Predicted water quality from the model and actual monitored data should be reviewed, any significant discrepancies between the modeled results and actual results should be evaluated, and appropriate modifications should be made to the monitoring program and/or the model to improve the accuracy and utility of future SMMP results.

Public Parks—It is recommended that two shallow wells be constructed at a large park such as the Pleasanton Sports Park, Dublin Sports Grounds, or Emerald Glen Park that is irrigated with recycled water. One upgradient well would monitor background conditions and the other downgradient well would monitor the effects of irrigation with recycled water. The wells would be monitored quarterly for approximately one year and then annually once baseline conditions were established.

VA Hospital—The Veterans Administration (VA) Hospital wastewater treatment system and percolation ponds are located at the southern edge of the Main Basin. This system is also regulated by RWQCB Waste Discharge Requirements that include groundwater monitoring and reporting requirements. For consistency and completeness, it is recommended that the existing requirements be reviewed to evaluate the usefulness of the information being collected. As appropriate, recommendations could then be made for monitoring changes to best document the current and future impacts of the percolate on groundwater quality.

Potential RO Recycled Water Groundwater Recharge Projects

Both the City of Livermore and Dublin San Ramon Services District (DSRSD) have designed and built (in 1997 and 1998 respectively) advanced treatment facilities capable of producing RO recycled water in conformance with current Department of Health Services (DHS) and RWQCB Master Permit requirements for groundwater injection. Zone 7 staff, the TAG, and GMAC actively participated in review of and comment on product water and groundwater monitoring requirements in associated CEQA documents, DHS Engineering Reports, and groundwater modeling efforts. Proposed monitoring programs for all Title 22 regulated constituents and various recommended currently unregulated constituents were developed for the DSRSD Clean Water Revival project. Zone 7 staff provided recommendations on monitoring well locations and designs based in part on groundwater modeling work. Further work on finalizing monitoring plans was put on hold following the Zone 7 Board decision in Fall of 1998 to withhold support for these projects pending demonstration of increased public acceptability.

Presented below is an overview of the two proposed projects, preliminary recommended monitoring well locations, and general monitoring program elements based on TAG and GMAC recommendations as of the end of 1998.

Project Descriptions—In August 1997, the City of Livermore completed the construction of its Advanced Water Reclamation Facility. The facility provides microfiltration and reverse osmosis treatment of tertiary filtered recycled water. The facility can produce 0.75 mgd of RO recycled water that, as originally proposed, at some point in the future, following demonstration of increased public acceptability, could potentially be used to replenish the groundwater supply through direct injection into the main groundwater basin.

An existing well near the Livermore airport was selected for conversion to an injection well based on regulatory requirements, hydrogeologic characteristics of the region and basin, property ownership and access, existing potable well locations, and relative distance to the treatment facility. To meet capacity needs as well as to provide redundancy, a second well has been proposed that would accommodate 100 percent of the water production from the treatment facility. Recharge of recycled water would be achieved by injecting the water through the recharge well(s) to the target confined aquifer that is

approximately 350 feet below the ground surface. This project was never fully completed and there are no plans to complete this project.

The DSRSD Clean Water Revival (CWR) Groundwater Replenishment Project is a 2.5 mgd advanced treatment project that uses microfiltration and reverse osmosis to produce RO product water (similar to the Livermore project) for potential injection into the Main Basin. Injection was proposed at two new wells, each capable of injecting 2.5 mgd. Each well would be 700 feet deep and capable of injecting at four different depths (see additional description in sections 8.8 and 10.3). This project was never fully completed and there are no plans to complete this project.

Potential Monitoring Wells—Proposed DHS regulations for groundwater recharge projects require monitoring wells located at a minimum of one-quarter and one-half the distance to the nearest potable extraction wells. To conservatively meet these requirements, three monitoring wells were proposed down-gradient from the recharge well, located 1/2, 1/4, and 1/8 of the way to the Stoneridge production well, plus one additional well mid-way south towards the nearest Cal Water well. The 1/8 location well would provide earlier information on the rate of movement of any injected water. The southerly well would provide information in the event that movement was to proceed upgradient from the Livermore injection locations toward the CWS well unexpectedly. One of the three monitoring wells could potentially be shared with one of Clean Water Revival's monitoring wells. Proposed injection and monitoring well sites are shown in Figure 6.3 (and in more detail in Figure 10.15). Each of the injection monitoring wells were proposed to be nested wells, screened at four different depths. Three nested wells were completed prior to the cancellation of the project. These three wells are now owned and monitored by Zone 7.

Monitoring wells for the CWR injection sites were proposed to be composed of seven additional wells located along transects extending from the injection sites towards the nearest potable production well (Stoneridge) and also towards Pleasanton production wells. Potential injection and monitoring sites are shown in Figure 6.3. This network would include wells installed at the required 1/2, 1/4, and 1/8 of the distance between each injection well and the nearest production well. Each of the monitoring wells would be nested wells to monitor groundwater quality at four different depths.

Potential Monitoring Programs—Based on communications through late 1998, groundwater samples were proposed to be taken at a minimum on a monthly basis, from four levels in the aquifer at each monitoring well, and analyzed for general minerals, metals, organic chemicals including TOC, and total nitrogen. This would exceed the minimum requirements of the proposed groundwater recharge regulations. Twenty-four hour composite samples would be collected daily from the feed pipe to the injection wells and tested for coliform bacteria. Grab samples of the RO reclaimed water would be collected weekly and analyzed for total nitrogen. On a quarterly basis grab samples would be analyzed for general minerals, metals, chlorinated hydrocarbons, chlorophenoxys, synthetics, and general physical characteristics.

Each treatment system incorporates real-time monitoring of several water quality parameters (e.g., TDS, TOC), which would allow for immediate correction, diversion for retreatment or storage, or shutdown if a problem is detected.

Proposed CWR monitoring was to include: quarterly sampling of RO product water for physical and aggregate parameters, a wide range of inorganic salts and metals, alpha and beta radioactivity, twenty-six volatile organic chemicals, and thirty-three non-volatile synthetic organic chemicals. In addition, the RO product water would be monitored daily for total coliform bacteria and total organic carbon, and weekly for total nitrogen.

On-going monitoring was initially proposed at monitoring wells DSRSD MON1, DSRSD MON2, DSRSD MON4, and DSRSD MON5. When RO recycled water was detected at wells DSRSD MON2 and DSRSD MON5, on-going monitoring would be initiated at wells DSRSD MON3, DSRSD MON6, and DSRSD MON7.

As the projects evolve, it was expected that these preliminary monitoring program elements would be reviewed and refined with input from Zone 7 and RWQCB staff. Draft implementation plans proposed initial injection of potable water, allowing time to confirm the rate and direction of water movement. If results met all criteria yet to be specified, increasing amounts of RO product water would then presumably be phased in.

6.7 Reporting and Refinement of the SMMP

The data collected as part of the SMMP will be used to identify changes in groundwater quality throughout the watershed, to refine salt loading estimates, and to provide input to the water resource allocation (WRMI) and groundwater models. Given that the SMMP was established in part to identify and fill existing data gaps and to provide a venue to evaluate the long-term effectiveness of the Salt Management Plan, an annual critique and refinement of the monitoring and data collection effort will be conducted.

Data collected as part of this SMMP will be used to critically evaluate the usefulness of the data collected relative to making salt management control measure decisions. The groundwater model and this monitoring program will be used in a complementary fashion, where monitoring program results are used as input to the model and the monitoring program subsequently uses the output from the model to help determine additional (or reduced) data needs. This SMMP approach will help to achieve long-term Salt Management Plan goals without consuming excessive resources that could otherwise be used to directly implement salt management measures.

Installation of future surface water monitoring stations and wells (beyond those described for years 1-3 above) will be delayed until a "trigger point" is reached. Triggers would vary by sub-watershed but could include percent of total salt loading represented by the upstream watershed, the approval of specific development projects, and/or the final approval of recycled water projects. Development and project approval status will need to

be closely tracked to ensure that monitoring is initiated early enough to adequately establish baseline conditions. There would also be "sunset" triggers, where, for example, once a baseline were established, monitoring could be reduced or terminated until another trigger event occurred, thereby minimizing future SMMP costs.

Reports summarizing results obtained as part of the SMMP are proposed to initially be generated on a quarterly and annual basis. The development of the final format for the reports and the determination of their frequencies are tasks that will be completed by Zone 7 during the first year following submittal of the SMP to the RWQCB. In addition to data collected by Zone 7 for the SMMP, there are a number of other sources of data that may be useful for the SMP. Some of those sources include the City of Livermore, DSRSD, ACWD, mining companies, data collected as part of other NPDES permit self-monitoring programs, and Zone 7 stream flow data collected at non-SMP monitoring program sites. Relevant additional data will be incorporated as appropriate into applicable Zone 7 and SMP databases.

Chapter 7

Salt Management Plan Policy Issues and Options

Chapter 7

Salt Management Plan Policy Issues and Options

7.1 Introduction

From the earliest phases of the Salt Management Plan it was evident that there were multiple, oftentimes competing variables involved in developing workable salt management strategies. The primary variables were groundwater quality, overall delivered water quality, localized (east-west) delivered water quality, and costs. For example, relatively low-cost strategies could be designed that would offset all current salt loading and thereby maintain groundwater quality, but that would result in degraded (higher TDS) delivered water quality. Other strategies could be developed that would maintain both groundwater and delivered water quality, but that would increase costs. Finally, strategies could be developed that would improve both groundwater and delivered water quality, but that would be considerably more expensive to implement.

As discussed in Section 2.2 (and the 1987 Zone 7 Groundwater Management Policy), Zone 7 historic operational rules did not explicitly address salt loading, groundwater quality, delivered water quality, or the equivalency of water quality delivered to customers. With an eye towards the future in developing this SMP, Zone 7 staff sought to identify strategies that could concurrently provide a sustainable water supply, sustainable delivered water quality, and sustainable groundwater quality, at reasonable costs.

To help narrow the range of potential strategies to investigate, and ultimately to recommend to the Zone 7 Board for adoption, additional policy alternatives were developed within the Zone 7 Groundwater Management Advisory Committee (GMAC) and the retailer based Technical Advisory Group (TAG). This chapter summarizes the policy options and recommendations developed through multiple meetings with the TAG and GMAC regarding:

- The extent and timeframe over which net salt loading should be reduced
- Balancing delivered water quality and salt management goals
- East-west delivered water quality equivalency goals
- Control and ownership of injected RO recycled water

Net salt loading reduction is a fundamental, long-term policy issue. The delivered water quality policy issues presented here are in the more limited context of what could be accomplished with potential near-term facilities. Longer term and system-wide water quality issues are being addressed through Zone 7's Water Quality Master Plan. RO

recycled water policy issues are also longer term issues given the Zone 7 Board decision to defer support of such injection projects until such time as there is a greater level of public acceptability.

Consensus recommendations were reached on the first three bulleted topics above and are summarized in this chapter. Considerable information was presented and discussions held regarding use and management of RO recycled water. While from a technical standpoint the TAG and GMAC endorsed the proposed use, the groups concluded that further work, beyond the scope of this SMP, was required to determine the best approach(es) acceptable to involved agencies and the public for any RO recycled water that might be injected into the groundwater basin in the future. The basic issues discussed and some potential options regarding blending and ownership are presented at the end of this chapter.

Salt management cost allocation policy issues and options were also developed in coordination with the TAG and GMAC. Results are presented in Chapter 11.

7.2 Four Fundamental Salt Management Options

The most fundamental salt management policy issue involves determining the extent to which the on-going accumulation of salts in the groundwater basin should be reduced. This can also be expressed as whether groundwater mineral quality (TDS) should be allowed to continue to degrade, be maintained at current levels, be improved, or some combination of these options depending on other constraints. This fundamental policy issue is essential to provide a foundation for subsequent more technical decisions regarding selection of the type, size, timing, and location of salt management strategies to implement.

Of relevance to selection of one of the four fundamental salt management options presented below is the Basin Plan guidance (p. 4-23) that the SMP define "a project or set of projects" that will:

- Minimize the current trend toward increasing main basin groundwater salinity due to subsurface groundwater inflow or natural recharge.
- Fully mitigate the effects of salt loading due to water recycling on the main basin groundwater resource.
- Ensure that water imports and water recycling will not contribute to the degradation of groundwater quality.
- Protect groundwater beneficial uses.

Also of relevance to this policy issue is the RWQCB Basin Plan 500 mg/L TDS groundwater quality objective (WQO) for the main basin, based on the USEPA and California DHS drinking water secondary Maximum Contaminant Level (SMCL) value for potable supplies.

Four potential policy options and their resultant impacts on groundwater quality relative to the 500 mg/L standard are shown schematically in Figure 7.1 and are defined below:

1. Maintain status quo
2. Maintain status quo until a trigger or regulatory limit is reached
3. Stabilize groundwater quality at current quality
4. Improve groundwater quality

Option 1: Maintain Status Quo—This option (as illustrated in the upper left hand quadrant of Figure 7.1), shows the resultant calculated impacts on groundwater quality if the policy choice is to maintain historic basin management practices. Maintaining this practice is predicted to result in an on-going average basin-wide TDS increase of 8-10 mg/L per year at the current steady-state average salt loading of 2200 tons per year. The lower line in this graph illustrates how average groundwater TDS concentrations, under these annual salt loadings, could thus increase from 450 to 500 mg/L in as soon as five years. As described later in this chapter and in more detail in Chapter 9, annual salt loading is projected to increase substantially and non-linearly, as mining exports decrease around 2003 and urban and agricultural development and associated irrigation increase. The upper dashed line in this graph schematically illustrates the more rapid projected increase in groundwater TDS if salt loading were to increase linearly to the predicted 5400 tons per year by the year 2010.

Option 2: Maintain Status Quo until Trigger or Regulatory Limit Reached--This option (upper right hand quadrant) illustrates the conceptual impacts of delaying implementation of any salt management measures. The assumption here is that it would be acceptable to allow overall average groundwater TDS to increase from 450 to potentially 500 mg/L, at which time measures would then be taken to offset all additional future salt loading and thereby maintain groundwater quality at the secondary MCL of 500 mg/L TDS. The upper solid line illustrates that under average rainfall conditions and at current long-term average salt loading levels (2200 tons/year or 8-10 mg/L/year) calculated groundwater quality could reach the 500 mg/L TDS Basin Plan and DHS SMCL level in as soon as five years. The lower dashed line shows that it would take 10 years to reach 500 mg/L if due to lag time and/or attenuation, accumulated salt were to move at a rate of 5 mg/L/yr instead of the mass balance calculated 10 mg/L/year from the upper to lower aquifers. This lower rate is close to the long-term rate measured in the Bernal subbasin.

Option 3: Stabilize Groundwater at Current Quality—This option (lower left hand quadrant) assumes that measures would be implemented immediately to offset all the existing (2200 tons/year) salt loading plus all new salt loading that occurred each year due to new urban and agricultural development, increased recycled water use, or other sources. As a practical matter, it would likely take at least a few years to initiate significant salt management strategies. TDS would therefore continue to increase until the strategies were fully operational and equilibrium established. Rather than a straight line, this option might actually look more like Option 2 unless the salt removal capacity of the initial strategies

FIGURE 7.1

Fundamental Salt Management Policy Options and Resultant Main Basin Groundwater Quality

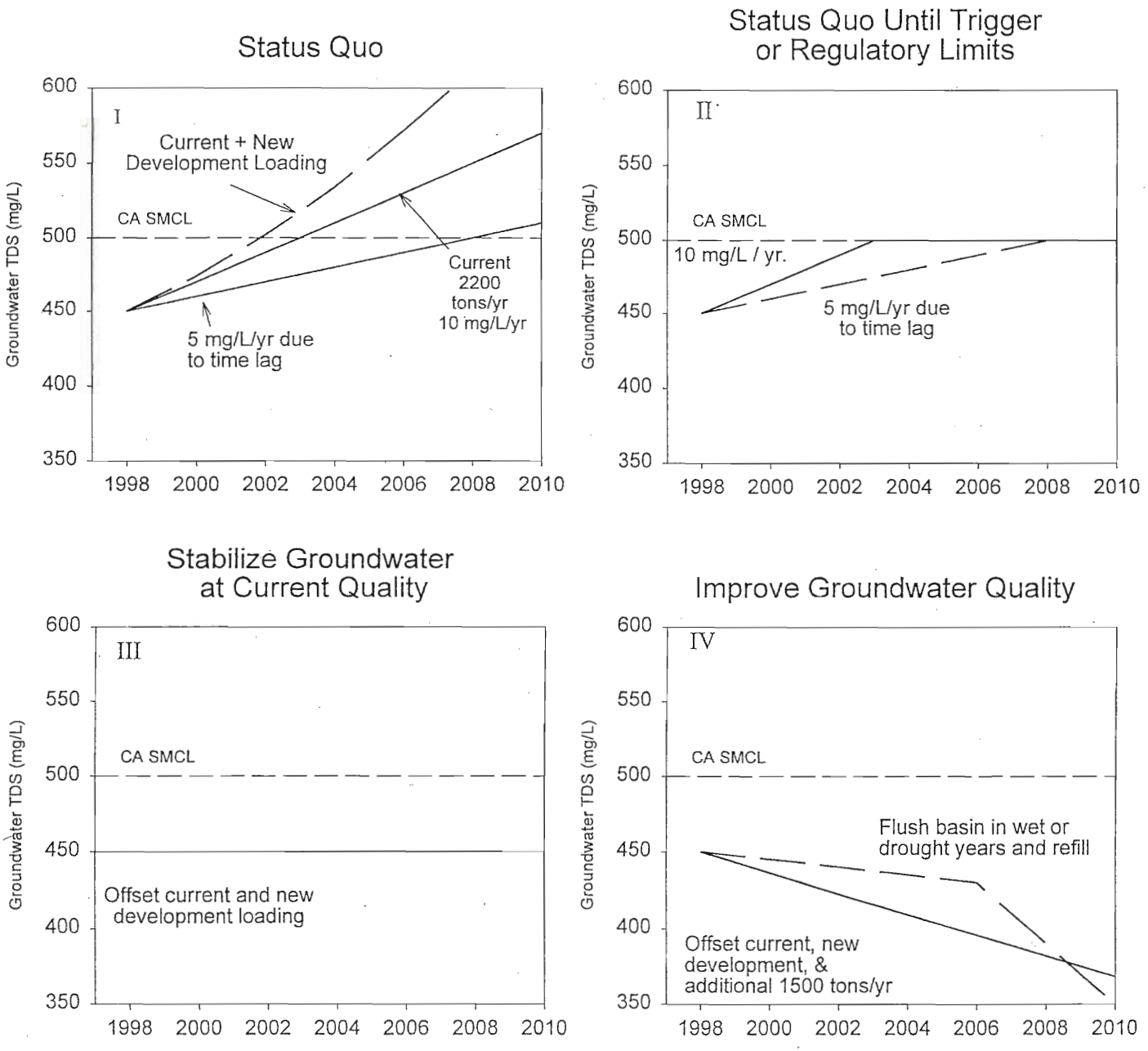


FIGURE 7.1

were significantly increased, or additional strategies were implemented, to offset the accumulated net salt loading from the years between decision and operation.

Option 4: Improve Groundwater Quality—This Option (lower right hand quadrant) assumes that a policy decision is made to improve groundwater from the current long-term average 450 mg/L level. The upper dashed line illustrates what might occur if it were decided to offset all current and future salt loading plus a small amount more each year. The steep drop in the line illustrates what might occur if, for example, several very wet years in a row occurred and large volumes of low TDS water were recharged and high TDS water pumped from the basin. Alternatively, the same effect could occur if a drought occurred, when existing high TDS water had to be pumped from the basin to meet demands, and then the basin was refilled with low TDS surface water.

GMAC and TAG Recommendations—The GMAC and TAG reviewed the four fundamental salt management strategies and each arrived at similar conclusions. Option 1 was rejected as non-responsive to the goals of the SMP and allowing unacceptable degradation of the groundwater supply and ultimately of delivered water quality. Similar concerns were expressed about Option 2. Option 3 was recommended as a minimum, with a goal of moving towards Option 4 when conditions permitted. As an example, when excess (surplus) high-quality surface water is available, it would be desirable to recharge ("flush") the basin with more than the minimum amount required to offset calculated salt loading and thereby more rapidly improve groundwater quality. Option 3 was supported with the presumption, based on the planning level cost information provided, that it could be achieved at a reasonable cost.

It was also recommended that salt loading reduction targets be set on a long-term basis, e.g., measured over a five-year period, to provide maximum flexibility and cost effectiveness. For example, less salt might be removed during a drought year when there may not be any available low-cost (or potentially any) water to artificially recharge to meet salt management conjunctive use goals. Similarly, it was recommended not to degrade delivered water quality (see below) solely to meet an annual salt removal goal.

7.3 Options in Balancing Salt Management and Delivered Water Quality Goals

Once a fundamental salt management option from Section 7.1 is selected there are multiple individual salt management measures that can be implemented (see Chapter 8), singly or in combination, to achieve the desired salt loading reduction. The individual strategies selected and how they are implemented will have differing impacts on delivered water quality. Therefore, overall delivered water quality policy goals also need to be established to help guide selection and use of the most appropriate salt management strategies. This section presents four basic policy options and narrative goals regarding how Zone 7 could manage its overall system operation to balance salt loading and the resultant delivered water quality impacts:

1. Maintain Status Quo
2. Improve Delivered Water Quality Through Future ASR Well Use
3. Operate to Achieve Salt Loading Goal Independent of Delivered Water Quality
4. Maintain/Improve Delivered Water Quality within Salt Loading Goals

Option 1: Maintain Status Quo—Option 1 represents the historic basin management strategy where the goals are for Zone 7 to deliver the maximum volume of surface water whenever possible and to use the groundwater basin only for peaking or when SBA supply is otherwise not available. This option results in a long-term annual average delivered water blend of approximately 85% imported surface water and 15% groundwater. Delivered water quality will therefore primarily remain a function of available surface water quality. With currently available facilities, this option provides the highest overall quality (lowest TDS) water delivered at Zone 7 turnouts. However, without offsetting salt loading, groundwater TDS levels and thus delivered water TDS levels will continue to proportionately increase.

Option 2: Improve Delivered Water Quality Through Future ASR Well Use—Option 2 represents the case where Zone 7 would redirect more SBA water from stream recharge to the treatment plants and then after treatment inject it via ASR wells during low demand periods. The injected water would be extracted during summer months to meet peak demand. As available, excess treated water could also be injected and stored to create "bubbles" available to meet future peak and drought demand. The option could provide the best possible and least variable Zone 7 delivered water quality. However, groundwater quality outside of areas used by Zone 7 for ASR injection would degrade at a faster rate than in Option I. Groundwater pumped by Cal Water and Pleasanton would increase in TDS over time to the extent that artificial stream recharge previously directing lower TDS SBA water towards their wells was reduced. In addition, Zone 7's recent experience with ASR injection at its Hopyard wellfield suggests that ASR may not be a viable long-term option.

Option 3: Achieve Salt Loading Goal Independent of Delivered Water Quality—Under Option 3, achieving the target salt loading goal would be a higher priority operating rule than maximizing delivered water quality. If, for example, a "No net salt loading to the main basin" goal were adopted, available facilities would be operated so that no net salt loading would be consistently attained and the water quality resulting from those operating conditions would be delivered to the turnouts. With currently available facilities, Option 3 would require increased groundwater pumping and recharge and reduced surface water deliveries (i.e., the mirror image of Option 1). Delivered water TDS levels would immediately increase, particularly in the western portion of the service area where the majority of wells are currently located. Over time, groundwater TDS levels would decrease.

Option 4: Maintain/Improve Delivered Water Quality within Salt Loading Goals—Option 4 places a higher priority on delivered water quality goals than on salt loading

goals. It is similar to Option 3 except that a "trigger" level would be placed on delivered water quality, at which point salt management measures such as groundwater pumping that increase delivered water TDS would be reduced or terminated until TDS levels dropped below the trigger level. For example, during dry and drought periods imported surface water TDS levels may increase to a point where it was no longer possible to "blend down" pumped groundwater TDS and stay below the delivered water quality trigger.

Under Option 4, Zone 7 delivered water TDS levels could be maintained or improved while achieving salt loading goals a greater proportion of the time (although at increased costs) if adequately sized and appropriately located wellhead demineralization facilities were available for operation (see chapters 8-10).

GMAC and TAG Recommendation—The GMAC and TAG recommended Option 4, with the understanding that salt loading goals would be set to be achieved long-term, perhaps over a five-year time period. In dry years, for example, when it was not possible to achieve the goal without compromising delivered water quality, a salt "debt" would be accrued. When conditions permitted, as during a wet year, additional salt reduction measures would be implemented to offset the accrued salt debt.

7.4 East-West Delivered Water Quality Equivalency Options

A somewhat more narrow policy issue regards the extent to which measures should be implemented by Zone 7 and/or others to provide equivalent delivered water quality to customers. This policy issue impacts decisions on the siting, sizing, and manner of operating existing and proposed wells and demineralization facilities. Three options include:

1. Continue historic practices
2. Provide equivalent water quality at Zone 7 turnouts
3. Provide equivalent water quality at end-use points

Option 1: Continue Historic Practices—Historic operational practices result in a relatively low TDS in delivered water at Zone 7 turnouts, being a blend of approximately 85% imported surface water and 15% groundwater in average and wet water years (see Chapter 4). Customers in the east, closer to the water treatment plants, typically receive a higher percentage of treated surface water and, therefore, lower TDS water than customers in the western part of service areas. Zone 7 wells are used to meet peaking demand and when inadequate SBA water is available. This strategy generally results in minimum distribution system and well pumping costs for Zone 7. Delivered water quality varies seasonally and annually, primarily as a function of SBA water quality, and secondarily for well pumping and water routing decisions. Changes in relative blends can cause consumer complaints.

Pleasanton and Cal Water control operation of their wells. Customers near the Cal Water and Pleasanton wellfields receive higher percentage blends of groundwater (see Figure 4.14). During summer months, some customers may receive almost all groundwater.

Option 2: Provide Equivalent Quality Water at Zone 7 Turnouts—Under this option, Zone 7 would alter operation of its existing facilities and construct new facilities as needed so that all turnouts would receive equivalent and less variable water quality. Equivalent could be defined on a seasonal (best available) basis or on an annual average basis depending on the water quality goals selected.

This approach could be achievable long-term depending on results of the Well Master Plan and decisions regarding siting, timing, and operation of new Zone 7 wells. If ASR well operation had proven reliable, 100% ASR well operation might achieve the objective without a significant increase in delivered water TDS. In the near-term, the only way to achieve this goal would be for Zone 7 to significantly reduce surface water deliveries; increase groundwater pumping; and construct additional distribution system pumping, blending, and intertie facilities to route more groundwater from wellfields in the west to customers in the east.

Delivered water quality could degrade for many consumers due to the increased percentage groundwater pumping unless wellhead demineralization and/or a large amount of ASR well operation were implemented (by Zone 7 or the retailers). There would be potentially significant costs for additional distribution system pumping and blending. This could be done as a first step towards the more extreme equivalent end use delivered water quality goal (Option 3).

Option 3: Provide Equivalent Quality Water at End Use Points—This option would include the same features as Option 2, plus Zone 7 would need to coordinate valley-wide pumping and distribution system operations with Cal Water and Pleasanton so that all end use points would receive equivalent (and less variable) water quality. This option could entail significant costs beyond those for Option 2 for additional blending and/or wellhead demineralization facilities. There would also be significant institutional coordination issues to address.

GMAC and TAG Recommendation—The GMAC and TAG recommended that Zone 7 pursue an approach between Option 1 and 2. There was no support for spending public funds to "pump water in circles" and not improving water quality, versus spending funds for water quality improvement projects such as wellhead demineralization. It was recommended that Zone 7 consider Option 2 as a long-term goal and attempt were feasible to site new wells and facilities where they would contribute towards the goal of more equivalent delivered water quality.

7.5 TDS Concentration Effects on Consumer Acceptability and Costs

To provide background information regarding setting TDS (mineral) goals or guidelines for delivered water quality, a literature search was conducted and a technical memorandum prepared summarizing available information on consumer acceptability of, and indirect or "penalty" costs associated with, varying levels of TDS and hardness in delivered water. That memorandum and an AWWA1990 TDS standards review paper are included at the end of this report in Reference L. Key issues are presented in this section.

California Mineral Taste Survey—In the late 1960's and early 1970's the California Mineral Taste survey (CMTS) was conducted to formulate a rationale for evaluating and recommending standards governing mineral content in drinking water. The research had three specific aims: 1) To relate the TDS in domestic water to consumer evaluation of taste quality by a taste scale rating (TSR) procedure; 2) To relate TDS in domestic water to the out-of-pocket monthly penalty cost aggregate incurred because of minerals in water; and 3) To relate TDS in domestic water to the amount consumers would be willing to pay more per month for improved quality.

This major research effort was composed of thirteen separate studies. Three of the thirteen studies were performed to establish the relationship between taste evaluation and mineral content. One of these three studies was performed in a controlled laboratory environment using a taste panel to obtain ratings of taste quality. The second study surveyed 29 communities and 1700 respondents. The final study investigated 15 urban water service areas and the relationship between mineral content, taste quality, income level, and bottled water consumption of 1500 consumers. Results from the third study are based on data from Oakland, San Francisco, San Jose, Sacramento, Los Angeles, and San Diego ("Consumer Evaluation of the Cost and Quality of Domestic Water", 1976, UC Davis Water Resources Center).

Customer Satisfaction—From the various surveys, regression equations were developed relating consumer taste scale rating results to mineral content in drinking water. A pooled regression equation using 4,940 data points from the surveys demonstrated that there was a linear relationship between increasing TDS and decreasing taste quality (palatability) of water. This relationship was then used to develop five qualitative TDS potability (acceptability) grades based on specified percentages of respondents rating their water below neutral on the CMTS Taste Quality Rating Scale. A neutral rating on the Taste Quality Rating Scale meant that the consumer perceived the water to have neither good nor bad taste ("This water has a neutral taste").

The "excellent" category corresponded to 0-15 percent of consumers rating their water below neutral; the "good" category corresponded to 16-25 percent of consumers rating their water below neutral; the "fair" category corresponded to 26-35 percent of consumers rating their water below neutral; the "poor" category corresponded to 36-45 percent of consumers rating their water below neutral; and the "unacceptable" category corresponded to greater than 45 percent of consumers rating their water below neutral. The TDS

concentrations associated with those percentages are shown in Table 7.1. It should be noted that these discrete grades are superimposed on a continuous (linear) relationship. Additionally, it should be realized that the subdivisions between grades were to some degree arbitrary. Therefore, TDS values corresponding to or near boundary percentages should not be considered significantly different than each other simply because they correspond to different grades (i.e., 80 vs 81 mg/L, 450 vs 451 mg/L, etc.).

Table 7.1
Recommended TDS Standards Based on Pooled CMTS Data

Potability	Excellent	Good	Fair	Poor	Unacceptable
Grade	A	B	C	D	F
Percent below Neutral[1]	0-15	16-25	26-35	36-45	46-100
TDS mg/L	<=80	81-450	451-760	761-1020	>1021

[1]Percent below neutral on the Taste Quality Rating Scale

Customer satisfaction with the taste and palatability of drinking water, is less straightforward than the research summarized above indicates. Practical palatability is also related to habit, "training" of the palate, and individual preferences, in addition to those factors noted above.

Results from another CMTS study indicated that anions rather than cations exert the major differential effect on taste of drinking water. That study reported that among anions, taste quality was least degraded by bicarbonate (HCO_3), next least by sulfate (SO_4), then by chloride (Cl), and most by carbonate (CO_3). Temperature was found to have a small and mixed effect on the taste of mineralized water samples.

Care needs taken in extrapolating the above results to the Zone 7 service area where delivered water quality can vary by season, location, and on the relative amount of surface versus groundwater delivered. Variability in source water blends has been reported to be a more significant determinant of consumer acceptability (or lack thereof) than the actual TDS or hardness level.

The CMTS equations were used to present the percentage of customers rating the water below "neutral" by 50 and 100 mg/L increments of TDS from 50 to 900 mg/L. Table 7.2 shows that between 200 and 500 mg/L TDS, the percentage of consumers who would rate their water below neutral increases by approximately 1.5 percent for each increase of 50 mg/L TDS. These ratings assume that all consumers would be supplied with the same water supply.

Table 7.2
Summary of TDS and the Percentage of Customers Rating Their Water Below Neutral on the Taste Quality Rating Scale[1]

TDS mg/L	Potability Grade[2]	Percent Rating Below Neutral [3]
50	A	14.5
100		15.6
200		18.0
250		19.3
300	B	20.7
350		22.0
400		23.5
450		25.0
500		26.5
600		29.8
700	C	33.1
800		36.7
900		40.3

[1] Based on CMTS Methodology
[2] Based on Reference [5]
[3] Percentage of Consumers Likely to Rate Their Water Below Neutral on the Taste Quality Rating Scale

For comparative purposes the annual average TDS of Zone 7 deliveries between 1972 and 1996 ranged from 250 mg/L to 440 mg/L. If Zone 7 customers respond as did those in the CMTS, the percentage of consumers likely to rate their water as having below neutral taste would have ranged from approximately 17 to 25 percent, respectively. Actual water quality will vary more than indicated by the annual averages given the variability discussed above.

Costs Associated with Changing TDS—There are a number of indirect consumer costs (penalty costs) which may be associated with increased TDS or hardness levels in drinking water. Increased costs include, but are not limited to, the costs of bottled water for drinking and non-drinking purposes, monthly costs of operating a water softener, water softener additives, shortened life-span of water heaters and other appliances using water due to corrosion, additional soap and cleaning supplies, and additional plumbing repairs. The 1982 Zone 7 Wastewater Management Plan indicated that a reasonable penalty cost for increased salinity could be estimated as $30/AF per 100 mg/L TDS increase per year. This can be interpreted as a $15 penalty per household per year for each increase of 100 mg/L in delivered water (assuming 0.5 AF/household/year).

Limited literature is available on consumer costs associated with TDS and hardness levels. A salinity management study conducted for the Metropolitan Water District of Southern California estimated about $750 million in overall service area annual economic damages at current salinity levels to users of Colorado River Water. The estimates varied with the

blend of Colorado River supply with other supplies, ranging from $50-$110 per household per year. Residential damages due to salinity included in the estimate were the reduced life spans of plumbing facilities and appliances using water, increased cleaning costs, home water treatment systems, and the purchase of bottled water. The report also documented damages to water and wastewater utilities and industrial users due to increased salinity.

The CMTS research found that the "fair" taste of tap water associated with a TDS of 500 mg/L would cause an estimated 25% of consumers to purchase bottled water for consumption. The research found that TDS and taste scale ratings correlated with bottled water use, but average per capita yearly income did not.

GMAC Taste Test Results—The GMAC conducted a one-time informal taste test of groundwater (from Hopyard 1 well) blended with distilled water to provide a six sample TDS range from 0 to 360 mg/L. Results varied by participant and showed no significant pattern of preference over this TDS range.

7.6 RO Recycled Water Blending and Ownership

Preliminary discussions were held regarding Livermore and DSRSD members of the TAG during development of this SMP regarding RO recycled water injection and impacts on basin management. Discussions focused on identifying alternative approaches for complying with Title 22 blending water requirements; potential joint use of injection facilities; and ownership options for injected water, recycled water, and associated salt credits. The discussions were put on hold in late 1998 prior to reaching agreement on specific recommendations. The intent of this section is to capture the range of options and associated rationale discussed for use if at some point in the future it is deemed acceptable for some form of RO recycled water injection project to proceed.

Treated Water Injection Options—To meet its long-term operational goals of maintaining sustainable delivered water quality and groundwater quality, Zone 7 needs additional groundwater recharge and related facilities. Zone 7 has suspended future construction of aquifer storage and recovery (ASR) wells. ASR wells would help maintain or improve delivered water quality but would not beneficially affect groundwater quality or the basin salt balance during normal operation, nor was recent testing of the process at the Hopyard wellfield considered successful.

Injection of treated surface water into the main groundwater basin and withdrawal downgradient by Zone 7 production wells (i.e., conjunctive use) can improve groundwater quality and the basin salt balance. Depending on the proximity of the injection and extraction wells, the zone of higher quality (lower TDS) groundwater created would over some period of time reach the extraction well(s) and improve extracted groundwater quality and, thereby, delivered water quality.

One near-term salt management strategy (see Chapter 8) is for Zone 7 to begin to shift its water resources management strategy towards more conjunctive use and reduced delivery of surface water. More SBA water could be redirected to stream recharge or more treated water redirected to injection well recharge. Alternatively, treated water could be injected in cooperation with Livermore and/or DSRSD via unused well capacity. Further study would be required before these alternatives might be implemented.

Blending Water Source and Injection Options—The Livermore Advanced Water Reclamation Facility (AWRF) and DSRSD Clean Water Revival Project (CWR) were both designed with the future goal of injecting RO recycled water into the main groundwater basin to increase the local water supply, improve groundwater quality, and increase wastewater disposal capacity.

For such recycled water groundwater injection projects, the proposed Title 22 groundwater recharge criteria states that 1) extracted groundwater never contain more than 50% recycled water, 2) potable wells be prohibited within 2,000 feet of any recycled water injection well, and 3) recycled water remain a minimum of one year underground before extraction. The 2,000 foot and one-year retention time restriction zones could be complied with by the two projects as proposed. The 2,000-foot radius is the more restrictive of the two requirements given that it was estimated to take up to several years for recycled water to move that far from either the AWRF or CWR proposed injection sites.

To comply with the Title 22 50% maximum extracted recycled water requirement, Zone 7 would need to track the movement of any injected recycled water to ensure that no groundwater with greater than 50% recycled water was extracted from new or existing wells and used for potable purposes. While this is feasible with appropriately placed monitoring wells and with the proposed noble gas tracer addition, it adds considerable complexity to the modeling, monitoring program and well restriction program requirements. If such injection projects were to proceed in the future, Zone 7 proposed to work cooperatively with the cities and water purveyors to monitor and ensure compliance with this requirement in part through negotiation and implementation of an injection/blending water agreement.

The CWR and AWRF groundwater injection facilities have excess injection capacity for redundancy and/or to allow for seasonal operation at higher capacities. In the proposed CWR implementation plan, CWR, during the initial five years of operation, would only inject a maximum of 1,000 afa versus the design capacity of 2,500 afa. If suitable institutional arrangements could be negotiated, Zone 7 could potentially meet some of its needs for additional recharge capacity and salt loading reduction by using the excess capacity of these facilities, when available, to inject treated surface water into the groundwater basin.

As an example, under an injection/blending agreement, Zone 7 could provide treated surface water and be allowed to inject it using the CWR facilities up to the maximum excess capacity of these facilities. If RO recycled water injection were to proceed in the future, Zone 7 could also potentially commit to injecting, for example, on a five-year average basis, an amount equal to that injected by the recycled water injection projects to meet the Title 22 50% blending requirements. This could be accomplished via in-well mixing or potentially by injection into a relatively nearby downgradient well.

The mode of operation could provide some operational flexibility to Zone 7 and by meeting the intent of the Title 22 50% blending requirement in the vicinity of the recycled water injection wells, it could potentially reduce the extent and cost of groundwater monitoring and modeling required to track the injected recycled water. The well restriction program would also be greatly simplified, only having to address the 2,000-foot radius area around the recycled water injection wells (i.e., there would be no zones of greater than 50% injected recycled water present). Local groundwater mineral quality would also improve more, and a larger salt removal credit generated by recharging/blending with low TDS surface water versus proposed CWR blending and recharging with high TDS groundwater.

Blending Water Cost and Ownership Options—There are several potential blending water cost and ownership options. One of the simplest, from a water inventory standpoint, would be for Zone 7 to continue to "own" the treated surface water used as blending water. Zone 7 could commit to providing excess (surplus) treated surface water for injection and blending in the vicinity of the recycled water recharge projects. In this scenario, Zone 7 would view the blending water as just one more part of its many other groundwater recharge operations conducted for sustainable basin management.

Zone 7 marginal treated water costs are about $20/AF. Zone 7 could provide 100% blending for what it would cost to pump groundwater (at $60/AF) for a 33% blend. One Zone 7 option would be to provide blending water at no cost to Livermore and/or DSRSD and simply meld the $20/AF cost into its overall basin management costs. A related decision in this case would involve whether Zone 7 would in return for the free or marginal cost blending water be eligible for some of the salt loading credits resulting from the project. Alternatively, DSRSD or Livermore could purchase blending water from Zone 7 (at a rate to be determined) and be allowed to pump an equivalent amount of groundwater (perhaps minus agreed upon basin losses) elsewhere via an increased Independent Quota.

Injected RO Recycled Water Ownership Options—Cost (value) and ownership options for injected RO recycled water were addressed independently of blending water issues given the additional complexities involved. Two preliminary options would be for DSRSD and Livermore to retain ownership or for them to transfer ownership, under yet to be determined conditions, to Zone 7.

From a basin management standpoint an argument can be made that it would be simpler to have one entity controlling what is recharged and where and to also be responsible for tracking and managing the basin inventory and salt balance.

Ownership of the salt credits generated by such projects could be linked to ownership of the recycled water or not (see Section 11.7). Conceivably the water could be sold (for a lower price) and the salt credits retained by the original owner. Many pricing strategies are possible. Zone 7 executed an agreement with Livermore to purchase RO recycled water produced over a five-year period at $500/AF up to a maximum of $2 million.

Zone 7 will be reviewing overall basin management relative to the use of the Chain of Lakes. The Chain of Lakes could provide additional options for capturing, storing, and recharging waters from various sources, including recycled water. Given these uncertainties, it might be prudent and expedient to consider negotiating short-term rather than long-term contracts.

As discussed further in chapters 11 and 12, additional discussions beyond the scope of this near-term SMP will need to be held to select mutually acceptable strategies for accommodating increased RO and non-RO recycled water use in the valley.

Chapter 8

Individual Salt Management Strategies

Chapter 8

Individual Salt Management Strategies

8.1 Introduction

This chapter describes potential salt management strategies available to Zone 7 to offset the calculated long-term average salt (TDS) loading to the main groundwater basin of approximately 2,200 tons per year. The available alternatives are defined as those capital facilities and/or operational strategies already included in Zone 7's capital improvement program or under evaluation in the Facilities Master Plan, and the Well Master Plan that is currently in preparation by Zone 7.

As discussed in Chapter 2, Zone 7 is planning on constructing approximately 15 new wells by the year 2020 to improve reliability and be able to continue to meet peak summer demands. As demand increases over time, an increased percentage of peak demand will have to be met by pumping groundwater due to limitations in treatment plant capacity and South Bay Aqueduct capacity. To maintain delivered water quality during future periods of increased groundwater pumping, Zone 7 has plans for constructing a nominal 3 MGD wellhead demineralization facility.

A primary objective of the Salt Management Plan is to identify how these existing and planned facilities and the groundwater basin can be best managed to reduce net salt loading to the basin and to maintain or improve groundwater quality and delivered water quality. This chapter describes individual salt management strategies, their unit operating costs, and unit salt removal capabilities. The focus is on strategies that are under the control of Zone 7 and that could be implemented near-term. Potential impacts of any future Livermore and DSRSD RO recycled water injection projects are discussed. Future Chain of Lakes operation and possible Delta improvements that may come out of the on-going CalFed process are also described briefly. Combinations of individual strategies or composite strategies at year 2010 land use conditions are described in Chapter 9.

The primary salt loading inputs to and exports from the main basin are shown schematically in Figure 8.1 and by relative percent contribution in Table 8.1. Reducing net salt loading requires reducing the import of salts and/or increasing the export of salts. The individual salt management strategies are organized into three general categories: increased conjunctive use (increased groundwater recharge and pumping), wellhead demineralization, and seasonal groundwater export. There are variations within each strategy depending on where water is recharged or pumped.

8.2 Water Conservation Impacts on Salt Loading

Sources of salt loading to the main basin for the 1998 water year are shown in Table 8.1. It can be seen that urban irrigation represents a significant portion of the potentially "controllable" portion of the total salt loading to the basin. There is a limited amount to which the other sources can be controlled, with the possible exception of shallow groundwater pumping that might reduce high TDS subsurface inflow and recharge on Las Positas.

Figure 8.1
Main Basin Salt Balance Schematic

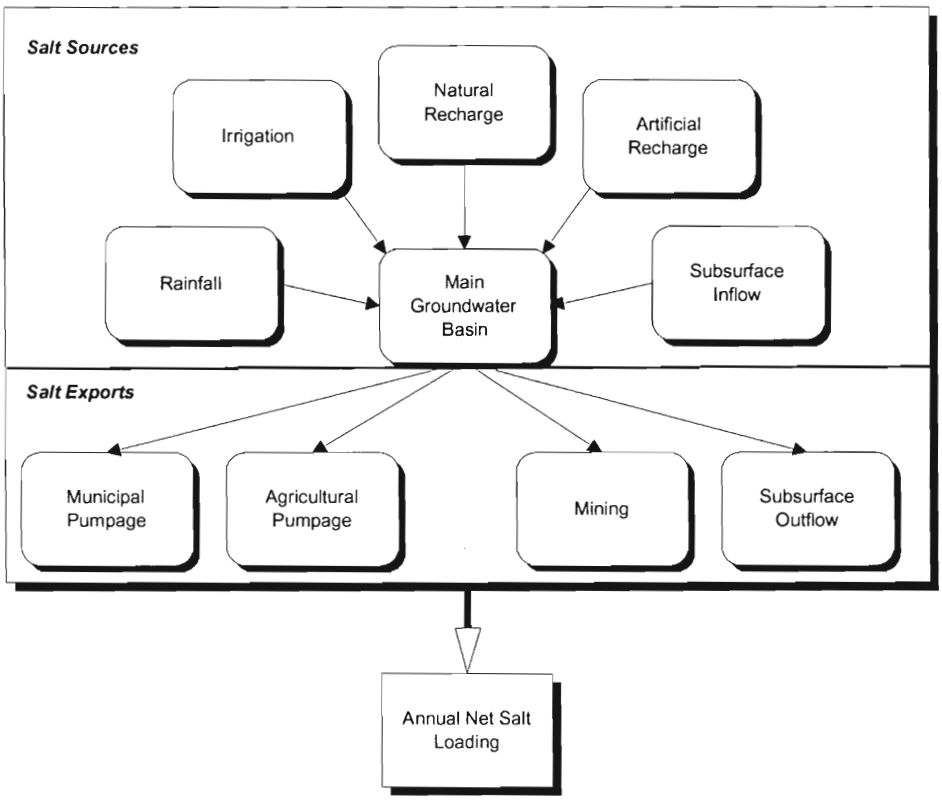


Table 8.1
Main Basin Relative Salt Loading Sources
1998 Water Year

Urban Irrigation	33%
Natural Recharge on Arroyo Mocho	18%
Subsurface Inflow	13%
Natural Recharge on Arroyo Las Positas	14%
Natural Recharge on Arroyo Valle	13%
Agricultural Irrigation	3%
Artificial Recharge	6%

Any decrease in the amount of water applied as urban irrigation over the main basin will result in a direct decrease in salt loading. Interior water use does not affect the salt loading directly since the water is discharged to either the Livermore or DSRSD wastewater treatment plant and exported to San Francisco Bay via the LAVWMA Pipeline. Interior use produces wastewater that typically results in a 200-300 mg/L TDS increase over the potable concentration (the "use increment"). Therefore, interior use can have an indirect impact on salt loading to the extent that non-demineralized recycled water is used for irrigation above the main basin.

Zone 7 and the water retailers already have in place various water conservation programs. Given the direct correlation between urban irrigation over the main basin and salt loading, water conservation should continue to be considered an important component in existing and future urban water management plans. Following is a summary of some of the on-going conservation efforts within the valley.

As a wholesale water supplier, Zone 7 employs an agency-appropriate low profile program to promote water efficiency. The Board of Directors passed Resolution No.1506 in January 1992 committing Zone 7 to "implement and support those conservation measures identified as Best Management Practices (BMPs) that are uniquely suitable for and beneficial to the Zone 7 area". This was in response to the development of the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU) that contained a list of recommended BMPs. Since that time, these BMPs have been identified as: a) Providing financial and technical support, along with program management, for retailers' water conservation efforts; b) Designating a Water Conservation Coordinator to oversee Zone 7's water conservation program; c) Maintaining a public education and information program; and d) Implementing a program for the replacement of existing high-water-use toilets with ultra-low-flush toilets (ULFTs) and washer rebates.

The Zone 7 retail water agencies—Dublin San Ramon Services District (DSRSD), California Water Services Company (CWS), and the cities of Livermore and Pleasanton—each have their own program for promoting the efficient use of water. DSRSD and CWS are signatories of the MOU. Both of those agencies have well established water conservation programs, particularly in the way of school education and public information, in place. CWS and the City of Pleasanton also distribute low-flow showerheads free of charge to its customers. Some of the agencies have tiered rate structures for water rates.

Zone 7's operating policy has been to recognize that the retail agencies are best equipped to deal with water conservation programs in their respective service areas. Zone 7 acts to coordinate efforts in programs that affect the entire service area. When appropriate, financial and technical support is provided. To facilitate the free flow of information, Zone 7 formed a committee of its retailers and Lawrence Livermore National Laboratory (LLNL). The Tri-Valley Water Awareness Committee meets monthly or more often if needed and discusses water conservation issues.

Zone 7 coordinates the valley-wide program to replace high-water-using toilets with ULFTs in single family and multi-family residences. A financial incentive in the form of a $75 rebate is offered to customers to encourage them to replace their old toilets with a ULFT. Zone 7 provides the financial backing for the rebates, technical support for questions that may arise, and overall program management. Zone 7 has distributed over 6,000 rebates and aggressive promotion should increase this number in the future. The valley's retailers feel strongly that this program should continue.

Zone 7 has also taken the lead in coordinating valley-wide public information programs. Recent activities include school education programs, distribution of low-flow showerheads, and distribution of water conservation information. Zone 7 and its retail agencies, as well as LLNL and Alameda County Water District (ACWD), maintain and staff a water education booth at the Alameda County Fair. Zone 7 coordinates efforts involved in constructing, designing, and staffing the booth. Other large-scale events, such as the 1997 Zone 7 Fun Run to promote Water Awareness Month, were also coordinated by Zone 7 and included multi-agency involvement. During 1998 the California Water Awareness Campaign's Education Subcommittee produced a School Education Kit, which was designed for distribution to students in kindergarten through sixth grade. Zone 7 purchased 50 kits, which were delivered by retailers to their contacts at local schools.

In May of 1994, Zone 7 completed a drought tolerant garden at its administrative headquarters. This garden demonstrates low-water-using landscaping techniques that can be employed by individual homeowners. Zone 7 is considering increasing its water awareness activities related to outdoor water use efficiency including the installation of a California Irrigation Management Information System (CIMIS) station that can provide daily irrigation information to all classes of water users.

The MOU process described above also created the California Urban Water Conservation Council (CUWCC). Membership is open to all signatories of the MOU. It offers member organizations assistance in implementing existing BMPs. The CUWCC is also responsible for reviewing and revising the BMPs as necessary. The MOU recognized that water management is a dynamic process and the BMPs need to reflect this. A natural evolution of the 16 original BMPs was expected. The original BMPs were evaluated and some were consolidated or deleted. Two new BMPs were added, one which dealt with high-efficiency washing machine rebates and a second which attempts to codify basic levels of assistance that wholesale water suppliers should provide to their retailers.

Also, in April 1998, the CUWCC voted unanimously to accept CalFed's proposal that it act as the water conservation program certification authority for water agencies requesting water transfers. Certification would be given to an agency's water conservation program if it shows implementation of BMPs appropriate to the local area, size and type (wholesale/retail) of the agency. Water conservation is very important, but it is important to recognize that salt loading can only be reduced by reducing the TDS of irrigation water or by reducing the volume of evaporation. Excess irrigation water that percolates into the ground causes no net salt loading.

8.3 Historic Groundwater Basin Management

Early each calendar year Zone 7 evaluates likely water supply conditions and makes projections for how the available supply will be used and how the groundwater basin will be managed. The use and supply priorities and proposed general "operational rules" are described in the annual "Water Supply Forecast" memoranda and graphics and are summarized in section 2.2 (see January 12, 1999 memorandum, Reference C).

Zone 7 has established water use and source priorities that result in general operational rules for the management of available water supplies and the groundwater basin. Generally speaking, the historic basin management strategy has been to maximize the amount of treated surface water deliveries to maintain groundwater storage near the top of managed storage levels (~224,000 AF per mining company agreements) and to minimize Zone 7 groundwater pumping. This translates in average and wet years to an annual average delivered water blend of approximately 85% surface water and 15% groundwater. In dry and drought years the percentage of surface water in the delivered water may be significantly lower.

Historic operational rules did not explicitly address delivered water quality, groundwater quality, or salt loading, but rather focused on capturing and using the lowest cost of the various seasonally available supplies. The rules have generally been effective in producing lower short-term costs and higher delivered water quality, particularly when the in-lieu program has been in effect (i.e., replacing retailer groundwater pumping with reduced cost treated surface water when water supply and groundwater basin storage conditions permit). Under these rules, annual salt loading varied in large part due to the amount of rainfall and low TDS recharge. In very wet years, such as 1996/97, there can be a calculated net reduction (negative) in salt loading. In dry years with minimal rainfall and stream recharge, salt loading can reach several thousand tons (see Chapter 5).

Based on 1998 land use characteristics and the historic basin management strategy of maximizing surface water deliveries, there is an estimated long-term average net salt loading of 2,200 tons per year to the main basin. The resultant effect on the groundwater TDS varies by location but can result in a calculated increase of up to 10 mg/L per year (see Chapter 5). This TDS estimate is based on the simplifying assumption that the groundwater basin is one contiguous, well mixed, and homogenous basin (i.e., the bucket model). Under current practices, each 1,000 AF of 250 mg/L TDS irrigation water applied above the main basin represents a theoretical salt loading of approximately 350 tons. Put another way, for each 10 mg/L TDS increase or decrease in imported water quality, salt loading will change by about 13 tons per 1,000 AF of applied water.

A summary of typical Zone 7 delivered water quality, as impacted by seasonal SBA water quality, under the historic basin management strategy is shown below in Table 8.2.

Table 8.2
Typical Delivered Water TDS
Under Historic Basin Management Strategy

Climatic	Delivered Water %SBA		Zone 7delivered (mg/L)	
Conditions	Winter	Summer	Winter	Summer
Dry	30%	30%	470	470
Average	100%	90%	270	240
Wet	100%	90%	170	180

Climatic	SBA TDS (mg/L)		GW
Conditions	Winter	Summer	TDS
Dry	500	500	450
Average	270	220	450
Wet	170	150	450

The principal advantages of continuing forward with the historic basin management strategy would be that it maximizes delivered water quality in non-drought years, minimizes salt management expenditures, and requires no changes to historic water supply and basin management policies. Disadvantages of the historic basin management strategy are that groundwater TDS levels will continue to increase, that delivered water TDS will also increase, that the delivered water TDS will vary significantly with climatic conditions, and that unless other salt management measures are implemented, this strategy may not be considered responsible stewardship of the groundwater basin resource (i.e., may not comply with state and federal non-degradation requirements). If basin water quality is allowed to continue to degrade at, for example, 10 mg/L/year, consumers could be experiencing 500-600 mg/L TDS delivered water quality during extended droughts when essentially the only source of supply is groundwater.

8.4 Maximum Stream Recharge Conjunctive Use Strategy

An alternative and essentially opposite basin management strategy to the historic management strategy described above would be to maximize the volume of groundwater, versus treated surface water, delivered to Zone 7 customers. Use and source priorities could be modified so that to the extent practicable more local and imported surface water would be allocated for stream recharge (or in the future Chain of Lakes recharge) rather than being run through the treatment plants. Additional wells (possibly designed as ASR wells) would be needed in proportion to recharge capacity to accommodate seasonal demand. The overall goal of this strategy would be to increase the "flushing" of the basin. Low TDS (~250 mg/L) surface water would be recharged via streams and higher TDS (~450 mg/L) groundwater extracted by the Zone 7 production wells. The two most direct effects of implementing this strategy

would be lowering the net salt loading to the basin while concurrently increasing the TDS of the delivered water.

Currently, the maximum amount of groundwater that could be delivered without significant infrastructure changes is approximately 70% of the Zone 7 demand of ~35 TAF. Potential delivered water quality under a basin management strategy of 70% groundwater pumpage assuming that groundwater salinity stabilizes at 450 mg/L is shown in Table 8.3. A related operational alternative would be to maximize groundwater (i.e., high TDS) deliveries during winter low irrigation months when the majority of delivered water would be used indoors and exported from the valley via the LAVWMA wastewater pipeline.

Table 8.3
Potential Zone 7 Delivered Water TDS
Under Basin Management Strategy of
70% Annual Groundwater Pumpage

Climatic	Delivered Water %SBA		Zone 7delivered (mg/L)	
Conditions	Winter	Summer	Winter	Summer
Dry	30%	30%	470	470
Average	30%	30%	400	380
Wet	30%	30%	370	360

Advantages of implementing this increased stream recharge conjunctive use basin management strategy are that it would beneficially effect the salt balance, it could be implemented incrementally and begin immediately, it is a relatively inexpensive solution for salt mitigation, and it would provide less variable delivered water quality on both a seasonal and long-term basis. Increased recharge and extraction may delay or avoid the need for expanding treatment plant capacity. More detailed (i.e., WRMI) cost estimates will be needed to evaluate the potential additional marginal capital cost savings of maximizing use of existing treatment facilities and providing more wells and recharge capacity versus more treatment plant capacity.

There are other potential cost and water quality benefits from increased investment in conjunctive use versus new treatment plant capacity and/or new treatment systems. These include reduced chemical costs (versus increased energy costs for groundwater pumping), reduced TDS increase due to treatment chemical additions, and potential avoidance of capital and O&M costs for new treatment plant taste and odor control (e.g., ozone) and disinfection facilities.

Increased conjunctive use strategies become more attractive to the extent recycled water and/or other non-potable supplies become available to meet peak demands, thereby further offsetting the need for new Zone 7 wells and related distribution system peaking infrastructure. During wet years there would be also be increased opportunities for

offsetting annual and/or historic salt loading given the increased availability of low TDS (and potentially low cost) imported water for recharge and/or blending.

The major disadvantages associated with this maximum stream recharge conjunctive use strategy are associated with the increased level of TDS in the delivered water. Since a higher percentage of the water delivered to Zone 7 customers would be groundwater instead of imported surface water, the TDS of the delivered water would be closer to that of the groundwater (~390 mg/L). There are a number of issues related to consumer acceptance of increased levels of TDS in drinking water and indirect costs to consumers associated with those increased levels of TDS. Those issues are summarized in Chapter 7 and discussed in more detail in Reference L.

Figure 8.2 compares estimated delivered water TDS levels for three conjunctive use strategies: 1) The current strategy of maximizing surface water deliveries (85:15 surface to groundwater blend), 2) An intermediate 50:50 blend of surface water and groundwater, and 3) The strategy of maximizing the volume of groundwater delivered (30:70 surface water to groundwater blend).

Figure 8.2 illustrates the previously presented advantages and disadvantages for these basin use strategies. The historic basin management strategy of maximizing surface water deliveries also minimizes the concentration of TDS in the delivered water. The differences between strategies are negligible in dry years when only 30% SBA deliveries are available and are most apparent during wet and average winter periods. It is also noteworthy that the strategy of maximizing groundwater deliveries minimizes delivered water quality variability, albeit at the price of a higher average TDS value.

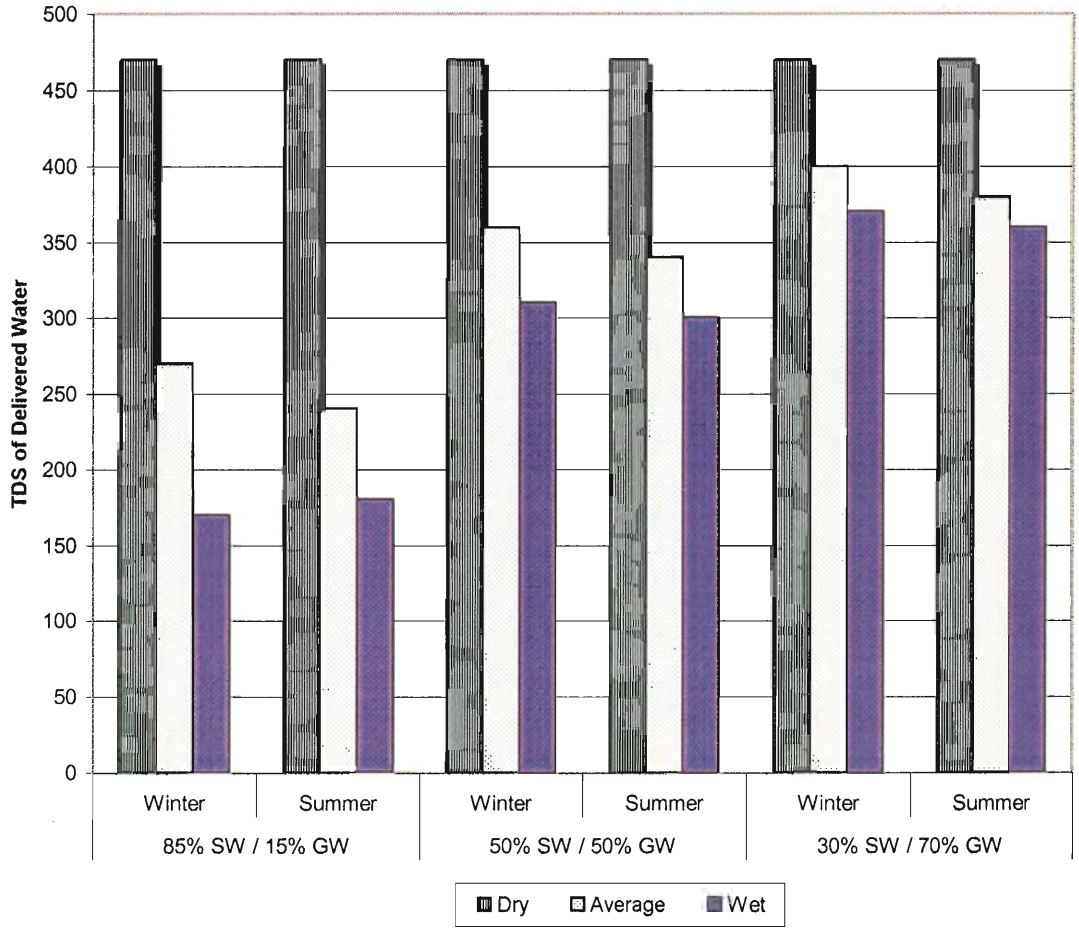
An alternative way to implement increased conjunctive use would be to set a water quality goal and pump variable, rather than fixed, amount of groundwater as needed to maintain the target delivered water TDS. Under this strategy, the ratio of surface to groundwater in the delivered water would vary and the volume of conjunctive use conducted annually would be a function of the imported surface water quality (i.e., more pumping conducted when SBA quality is better). Depending on the water quality goals, there may be some months or years that the TDS of imported surface water would exceed those goals.

8.5 Paired Injection/Extraction Well Conjunctive Use

A limitation of stream recharge conjunctive use is that it can take many years, if not decades, for recharge via the Arroyo Mocho and Arroyo Valle in the central and easterly portions of the basin to beneficially impact production wells in the western portion of the basin. An alternative that would provide both basin "flushing" benefits and a more rapid improvement to delivered water quality would be to construct injection wells in the vicinity (upgradient) of the Zone 7 well fields for injection of treated surface water. This would result in bubbles of low TDS surface water that would mix with the higher TDS groundwater and over time be drawn to and extracted from the production wells. These

wells could be ASR wells that are operated in injection-only mode, but could be switched if needed to meet peaking or drought condition demands.

Figure 8.2
Projected Delivered Water Quality
Under Various Basin Use Strategies



8.6 Zone 7 ASR Well Operation Strategy

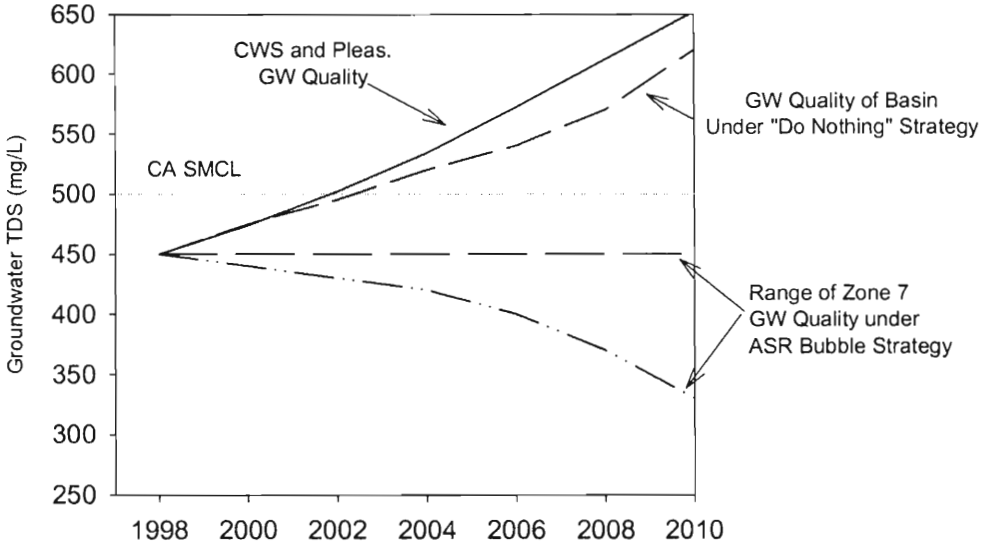
As noted in Chapter 5, aquifer storage and recovery (ASR) wells are capable of pumping groundwater from and injecting surface water into the groundwater basin. If the ASR well clogging problem could be fixed, ASR wells could be used to inject low TDS treated surface water for about six months during the winter and to extract an equivalent volume for six months (50:50) during the summer. This could serve to maintain and, in average to wet years, improve delivered water quality. During summer months a larger fraction of the peak demand that is typically met with groundwater would actually be met with stored

treated surface water (~250 mg/L versus ambient ~450 mg/L TDS groundwater from a typical production).

A maximum ASR strategy would be where Zone 7 maximizes treatment and injection and minimizes stream recharge. This would create bubbles of low TDS water around all of Zone 7's wells and result in the best Zone 7 delivered water quality at the lowest cost. To the extent Zone 7 was able to inject more than it needed to extract, the bubbles would serve as reservoirs of low TDS water that could be withdrawn to mitigate reduced surface water supplies and increased TDS levels during dry periods. However, under this maximum ASR strategy, groundwater TDS concentrations would increase around other wells in the basin that were no longer being beneficially impacted by the curtailed stream recharge (Figure 8.3).

Zone 7 has indicated that its policy as basin manager is to operate the basin to protect the entire basin, not just the areas around Zone 7 wells, and we will continue to utilize stream recharge and possibly ASR wells in the future.

Figure 8.3
Resultant Groundwater Quality:
Use of ASR Wells to Create "Bubbles"
of High Quality Zone 7 Groundwater



CA SMCL = California Secondary Maximum Contaminant Level

From a salt management perspective, while ASR wells operated in a 50:50 mode, improving delivered water quality, they do not improve groundwater quality nor directly impact the salt balance. However, salt loading would be indirectly reduced to the extent that lower TDS surface water injected into the basin and then delivered during the summer replaces higher TDS groundwater, which would otherwise be extracted for irrigation.

8.7 Wellhead Demineralization

Wellhead demineralization in this section refers to the demineralization of groundwater at the point of extraction. For purposes of this SMP report, demineralization is assumed to include a reverse osmosis membrane-based treatment system producing as product water with TDS in the range of 100 mg/L. If LLNL's capacitive deionization becomes commercially available it may be a desirable alternative. The demineralized water would be blended with other groundwater (non-demineralized) and/or surface water prior to delivery to achieve a target delivered water TDS or hardness and to reduce aggressiveness to distribution lines.

The most significant salt removal benefits from wellhead demineralization are achieved if high TDS upper aquifer water is pumped and demineralized versus typical 450 mg/L TDS lower aquifer water. Pumping upper aquifer water also removes the high TDS water that otherwise can migrate vertically over time and degrade the lower aquifer. The Camp Parks well site would be an ideal location for a wellhead demineralization project given the high levels (~1000 mg/L) of TDS in the upper aquifer, proximity to Zone 7 transmission mains, and proximity to the LAVWMA export pipeline for potential brine disposal.

Zone 7 has approximately $20 million budgeted (2004-2005) in its capital improvement fund (water rate) for Phase-I of a wellhead demineralization system and associated brine disposal project. The proposed facility would be operated during peak groundwater pumping periods to maintain delivered water quality. The facility could be operated for additional periods of time as needed to meet salt management goals.

The primary advantages of wellhead demineralization are that significant salt loading benefits may be realized while concurrently lowering delivered water TDS and hardness. Depending on the capacity installed, wellhead demineralization allows one to "dial-in" desired delivered water quality and to reduce seasonal and drought related variability. The primary disadvantages of wellhead demineralization are the moderately high, though decreasing, O&M costs for pumping energy and the costs for brine disposal.

Groundwater demineralization is less costly than recycled water demineralization since it requires less pretreatment (e.g., no microfiltration). There is, potentially, a wider variety of lower operating pressure membranes available since there is not the concern about pathogen and trace organics removal that there is with recycled water. Desalting also provides immediate delivered water quality benefits, whereas demineralized recycled water injection has been proposed for easterly and central areas of the basin where it would have the longest transit time to the nearest production wells. Depending on the location of the wellhead demineralization unit, its output could be directed into the distribution system to areas with high percentages of local groundwater pumping to help equalize delivered water quality throughout the system. As delivered water TDS is reduced from distribution of desalted groundwater, recycled water TDS will also be reduced; and both actions will reduce salt loading from irrigation.

8.8 RO Recycled Water Injection

The Master Water Reclamation Permit identifies the requirements for groundwater recharge of recycled water. The City of Livermore and DSRSD have both been pursuing projects to inject demineralized recycled water into the groundwater basin. Each project uses microfiltration followed by reverse osmosis to create demineralized product water with a TDS <100 mg/L and that meets all drinking water requirements prior to injection. These projects would provide a net salt loading benefit (salt credit) depending on the actual TDS of the water injected. This can vary depending on the extent of blending conducted prior to injection and the TDS of the blending water. One example of where a 350 mg/L salt credit could be accrued would be where 100 mg/L TDS water is injected to recharge the basin, and 450 mg/L groundwater is extracted elsewhere from the basin (see Section 11.7).

City of Livermore Advanced Water Reclamation Facility—In August 1997, the City of Livermore completed construction of its 0.75 MGD Advanced Water Reclamation Facility (AWRF). The AWRF was designed as a demonstration project to document the viability, reliability, and cost of demineralization and groundwater injection as a method of water recycling. The project is intended to augment the local water supply, develop additional wastewater disposal capacity, and improve groundwater quality.

Clean Water Revival—DSRSD's 2.5 mgd Clean Water Revival (CWR) project completed construction near the end of 1998. In September 1998, the Zone 7 Board of Directors adopted Resolution No. 98-1982 recommending to the RWQCB that any use of reverse osmosis water be limited to non-potable uses, irrigation or agriculture, and that no direct injection take place until such time as there is sufficient community support to warrant it. A 16-week testing period of the CWR treatment facilities was completed by DSRSD in July 1999. Test results demonstrated that the product water quality met or exceeded every regulatory requirement. An independent panel of scientists and engineers from the University of California reviewed and verified the results and conclusions of the testing program. In February 2000, the RWQCB acting Executive Officer, acting on an affirmative recommendation from DOHS, issued conditional approval for the project including a phased implementation of potable then recycled water.

As stated in the CWR EIR, DSRSD's objectives for the Clean Water Revival include the following:

- Increase wastewater disposal capacity so that DSRSD may provide service for approved development.
- Replenish the local groundwater supply.
- Demonstrate a safe, feasible, and cost-effective approach for groundwater injection of recycled water within the valley that meets water quality and public health regulations.

- Improve groundwater quality—Contribute to the protection and management of the valley's groundwater by developing water management practices that reduce salt loads to the groundwater basin and enhance existing water quality.
- Increase local water resources—Expand DSRSD's water recycling program to minimize water waste and the export of water resources from the valley and to maximize reuse within the valley to meet water demands.

Additional information on the groundwater modeling conducted by Zone 7 for impact analysis of these projects, a map showing the proposed locations of the CWR and Livermore AWRF injection and monitoring wells, and projected flow pathlines are presented in Chapter 10 (figures 10.15 and 10.16).

8.9 RO Recycled Water Stream Recharge and Phased Injection

Between May and August 1998 public concerns over the injection of RO recycled water for indirect potable reuse became a serious issue and in September 1998 the Zone 7 Board passed a resolution requiring demonstrated public acceptance prior to supporting any injection projects. Following that action, staff from Zone 7, DSRSD and Livermore started investigating alternative strategies to make use of the demineralized recycled water. One of the several alternatives investigated was augmenting the artificial stream recharge on the Arroyo Mocho with demineralized recycled water produced by the Livermore and/or DSRSD RO plants.

Under this strategy, the demineralized recycled water from either plant could be piped and released into the Arroyo Mocho for recharge into the main basin. Currently, Zone 7 releases water from the SBA into Arroyo Mocho beginning in April when the water supply yield for the year is mostly known. The duration and amount of releases depends upon the water supply yield. Since SBA utilization during summer is approaching near capacity, Zone 7's releases during summer may be limited also by SBA capacity. Demineralized recycled water releases especially during the summer periods would increase total stream recharge of low TDS water into the basin. Increased groundwater pumpage (at 450 mg/l TDS) from the basin to offset the increased stream recharge due to demineralized recycled water (100 mg/l) would have about the same salt removal benefits as injection of demineralized recycled water. Stream recharge may be perceived as more acceptable to the public than direct injection into the basin given the additional treatment "barrier" of streambed percolation.

The project could also provide environmental benefits through improving riparian and aquatic habitat and extending the length of time that the otherwise ephemeral Arroyo Mocho could support aquatic life beneficial uses. Figure 8.4 shows a conceptual pipeline alignment for conveying RO recycled water south along Isabel Avenue to Arroyo Mocho. Releases could be coordinated with SBA releases so that all water released continues to be recharged within the valley (i.e., no impacts to ACWD).

Another option available to Livermore and DSRSD, while awaiting increased public acceptance of RO injection, would be to pursue a demonstration phased injection project. An example is also illustrated in Figure 8.4, whereby Zone 7 treated potable water would be injected into the existing unused Livermore injection well. A new Zone 7 production well could be constructed near the future Chain of Lakes at Lake E and connected through a new pipeline eastward to the existing Zone 7 distribution system main or perhaps to supply agriculture. This Lake E well would be operated to alter and maintain the groundwater gradient to flow southerly, as shown in Figure 8.4. Noble gas tracers could be added to verify the predicted injected potable water travel times and direction. If monitoring showed the water moved as predicted and if the Lake E well water was directed to non-potable uses, perhaps that would increase public acceptance to a point where increasing amounts of RO recycled water could over time be allowed to be injected into and contained within the northwest corner of the Amador subbasin, near the Livermore treatment plant (as shown in Figure 8.4).

8.10 Seasonal Groundwater Export

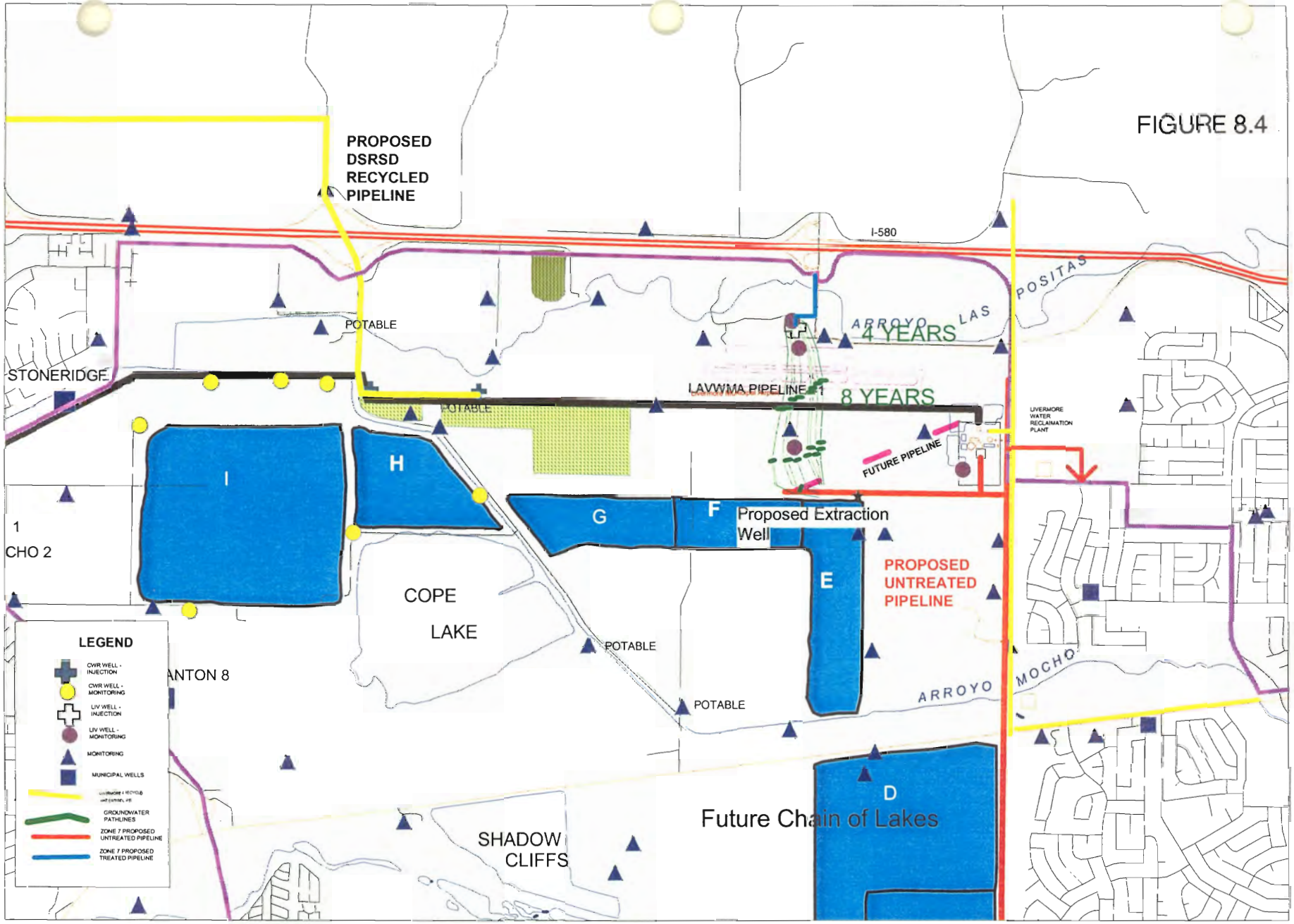
Seasonal groundwater export is defined as the pumping of high TDS shallow groundwater to the creeks during wet season periods when it would not adversely impact in-stream and downstream user beneficial uses. A major advantage to this salt management strategy is that it has the potential to be a relatively inexpensive solution, depending on yet-to-be-determined costs for replacement water and potential impacts on ACWD. It is also a flexible strategy in that it could be scheduled only for implementation when excess water was available and/or the basin was above a specified level.

The most significant disadvantages are that it would require various agency approvals, would need to be closely coordinated with ACWD operations, could potentially only be conducted during periods of high or peak stream flows, would generally require procurement of additional water supply to replace the water lost, and it may be perceived as an inappropriate use of a valuable resource.

Potential disposal options for the high TDS water pumped include the following: 1) To the creeks, 2) To a distribution pipeline, and 3) To a demineralization facility. It should be realized that the siting and disposal issues would need to be considered together to obtain a workable solution. Zone 7 will be investigating potential shallow water well sites for groundwater export as part of the Well Master Plan. Results from ACWD's salt transport study and LAVWMA's wet weather overflow study will also be providing information useful in further evaluation of the institutional feasibility and cost of seasonal groundwater export as a salt management strategy.

Camp Parks Groundwater Export—Export of ~1,000 mg/L TDS shallow groundwater from the Camp Parks well site to Arroyo de la Laguna during periods of high flow would provide a 100 percent salt reduction benefit to the main basin. If a wellhead demineralization facility were constructed at this site, pumpage could potentially be

FIGURE 8.4



ZONE 7 WATER AGENCY 5997 PARKSIDE DRIVE PLEASANTON CA 94588	DRAWN GERALD GATES DESIGNED GERALD GATES CHECKED DAVID LUNN APPROVED	WATER RESOURCES ENGINEERING ***LIVERMORE TREATED WATER INJECTION DEMONSTRATION PROJECT***	SCALE NOT TO SCALE DATE 29 JUN 1999 FILE NO H:\CWR\LIVDEMO.WOR

FIGURE 8.4

diverted to the Arroyo during peak wet weather flows as a lower cost alternative than pumping and demineralization. Another potential option for high TDS water from this site is disposal via the LAVMMA pipeline when dry weather excess capacity is available. The water could also potentially be blended with treated surface water and distributed for irrigation.

Bernal Subbasin Groundwater Export—Export of ~800mg/L shallow groundwater from the Bernal Subbasin to the Arroyo de la Laguna during periods of high flow would provide a 100 percent salt reduction benefit to the Bernal portion of the main basin. Similar to the Army well site, if a wellhead demineralization facility were constructed at this site, pumpage could potentially be diverted to the Arroyo during peak wet weather flows as a lower cost alternative than pumping and demineralization.

Dublin Basin Groundwater Export—Export of ~1,000 mg/L TDS shallow groundwater from the Dublin sub-basin would not impact salt loading to the main basin but it could be managed to reduce salt loading impacts on ACWD. Shallow groundwater in the Dublin sub-basin rises and most ultimately exits the valley via the Arroyo de la Laguna, since there is minimal main basin recharge in that area of the valley. Shallow wells in the Dublin area could be used to draw down groundwater levels during winter so that high TDS net recharge during summer months would be stored rather than rising and increasing the baseflow in the Laguna. Since much of this summer baseflow is captured and recharged by ACWD, this strategy would further reduce current and future irrigation related salt loading to ACWD. This strategy could be a potential way for DERWA to help mitigate recycled water irrigation impacts to ACWD. The issue of whether replacement water would need to be provided would need to be addressed.

Positas Groundwater Export—Arroyo Las Positas in the vicinity of the southern Positas drainage basin recharges the main basin at a rate of approximately 2 cfs with high (~1000 mg/L) TDS with the remainder of flow exiting the valley without recharging. High TDS soils in the Positas basin generate high TDS shallow groundwater that rises into the tributary streams and flows in the Arroyo Las Positas. Shallow wells could be used to draw down groundwater levels during winter so that high TDS would be stored during summer rather than rising and increasing the baseflow and/or TDS concentration in the recharging Positas. High TDS groundwater would be pumped to Arroyo Las Positas during high flow conditions when it would not adversely affect ACWD and when it would not significantly increase the TDS of Positas flow recharging the main basin.

Increased Mining Export—An indirect method of implementing seasonal groundwater export would be to increase artificial recharge on Arroyo Mocho. This would raise the groundwater level in the mining areas and would require mining companies to increase their pumpage of ~600 mg/L TDS water to the streams and eventually to San Francisco Bay through the Niles Cone. The result would be increased basin flushing and increased removal of salts. To initiate this procedure extra imported surface water would need to be procured or the strategy only conducted during seasons with excess surface water supply.

The issue of whether the mining companies would have to be compensated for excess pumping costs would need to be addressed.

Basin Outflow—Zone 7 could alter its pumping and recharge practices to allow the elevation of water in the Bernal Subbasin to increase to the level where it begins outflow of approximately 700 mg/L TDS water to the Arroyo de La Laguna.

8.11 Chain of Lakes

The Chain of Lakes will provide salt management benefits through their additional storage and recharge capacity. During wet weather, potentially low cost, low TDS surface water and/or runoff could be purchased/captured and stored/recharged for future treated/untreated supply. Demineralized recycled water could also be stored and/or recharged in the Chain of Lakes. Lake-H and Lake-I became available in May 2003. The complete Chain of Lakes (all nine lakes) will not be available until about 2030.

As Hanson's mining operations came to a close the watershed lost its most significant source of salt export. It was shown in Chapter 5 that on average, mining water exports (mainly from Hanson) accounted for over 40% of the total salt removed from the main basin because of its dewatering activities (Refer to Table 5.2 and Figure 5.2). To maintain groundwater quality, that 40% plus some additional salt removal due to increased population and irrigation will have to be made up from other sources.

8.12 Delta Fix

The "Delta Fix" refers to the state and federally sponsored CalFed Bay-Delta Program's proposed projects to solve multiple Bay-Delta water quality, quantity, resource, and environmental problems. Of interest to Zone 7 are options that, if implemented, would result in higher quality (lower TDS) Delta water being conveyed to the State Water Project and thus to Zone 7 and other municipalities throughout California. On March 16, 1998, CalFed released a Programmatic Draft EIR/EIS that identified three potential Bay-Delta solutions. Each contains a set of "Common Programs" and provides for up to six million acre-feet of new storage capacity.

Alternative 1 is the Existing System Conveyance in which minimal improvements to existing channel configurations of the Delta are proposed. Alternative 2 is the Modified Through-Delta Conveyance in which significant improvements are made to the flow channels in the Delta. Alternative 3 is the Dual Conveyance System, which is similar to Alternative 2 with the addition of an isolated conveyance facility on the east side of the Delta with a 5 to 15 cfs flow capacity. The estimated cost of these alternatives ranges from $9 billion for Alternatives 1 and 2 to $10 billion for Alternative 3.

The current projection is that if a project like Alternative 3 were to occur, imported surface water with average TDS in the range of 100-150 mg/L could be delivered to Zone 7. This change by itself would eliminate the current salt imbalance. Potential costs to Zone 7 are uncertain, but may be in proportion to its percent entitlements of the State Water Project.

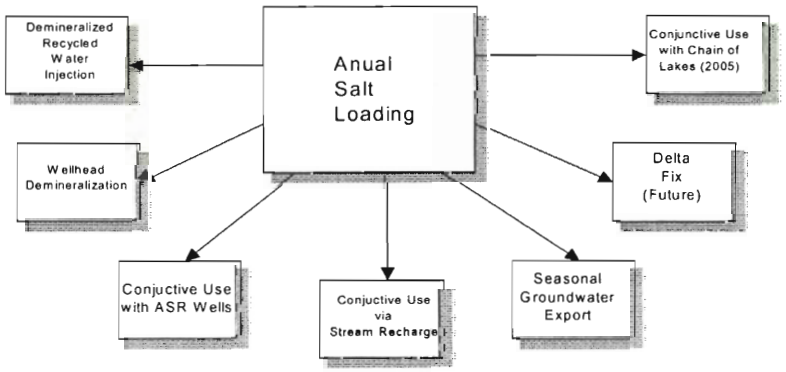
The fundamental disadvantages to the Delta Fix as a salt management strategy are that it is unknown what, if any, project will actually be implemented and when. The certainty and timing of the Delta Fix are such that it currently should not be relied on as the sole salt management tool to mitigate the current salt loading to the main basin.

8.13 Composite Projects

A schematic diagram showing the key individual salt management strategies is presented in Figure 8.5. Some of the individual strategies when used alone have maximum salt removal capacity limits. Some strategies when used alone would have technical, timing or other limitations. For example, seasonal groundwater export alone may not be enough to fix the salt in balance, increased conjunctive use alone increases delivered water TDS, and wellhead demineralization alone may be too expensive. A composite strategy that includes more than one individual strategy appears to offer a more flexible and potentially cost-effective approach.

Composite basin management strategies refer combinations of the individual strategies described above and shown in Figure 8.5. For example, a composite strategy could be composed of seasonal groundwater export, conjunctive use, and demineralized recycled water recharge. Quantitative evaluation of several individual and composite strategies, based on projected 2010 land and water use conditions, are conducted in Chapter 9.

Figure 8.5
Individual salt management Strategies



8.14 Preliminary Unit O&M Cost Estimates for Salt Management Strategies

This preliminary unit cost analysis presents the relative effectiveness of the various strategies for salt removal and provides planning level operational cost estimates in 1998-1999 dollars. Preliminary planning level operations and maintenance (O&M) unit cost estimates for individual salt management strategies are summarized in Table 8.4. Following is an explanation of the terms used in Table 8.4.

O&M Cost is the incremental cost to implement 1,000 acre-feet of the respective strategy. **Unit O&M Cost Components** explain the basis for the O&M cost calculation. The numbers (1-6) in the unit O&M cost column correspond to the numbers in the sub-table "**Unit O&M Costs**". The unit operational costs shown are based on Zone 7 Water Resources Engineering planning level costs for operations and maintenance. Groundwater pumping (1) for treated water delivery costs approximately $60/AF for electrical and pumping costs. Surface water treatment marginal chemical and power (2) costs average approximately $20 AF. Reverse Osmosis (3) is estimated to cost $400/AF plus an additional $30/AF treated through the micro-filtration and demineralization units (20% brine production) for brine disposal (4) based on LAVWMA pumping costs. Potential "buy-in" or other costs are not included. The shallow groundwater pumping to waste (5) costs approximately $40/AF (due to lower pumping head requirements). Replacement water (6) is the O&M cost of $70/AF to purchase one acre-foot of SWP water. Estimate Annual Entitlement payment (7) is $200/AF for SWP water.

Gross Salt Removed is the total salt removed by a given salt management strategy. Since a part of the gross salt removed returns back to the main basin (for example 25-30% of groundwater pumpage is applied for irrigation over the main basin), the **Net Salt Removed** is the gross salt removed less any salts that return back to the main basin via irrigation.

Net Salt Removal Cost is the O&M cost to achieve one ton of net salt removal.

Table 8.4
INDIVIDUAL SALT MANAGEMENT STRATEGIES
UNIT O&M COSTS AND REMOVALS PER 1,000 AF

Salt Management Strategy	O&M Costs to Implement 1,000 AF	Unit O&M Cost Components (*)	Gross Salt Removed (tons/TAF)	Net Salt Removed (tons/TAF)	Net Salt Removal Cost ($/ton)
I. Conjunctive Use (450 mg/L pumpage)					
A. Stream recharge (250 mg/L untreated)	$40,000	(1-2)	270	200	$200
B. Well recharge (250 mg/L treated)	$60,000	(1)	270	200	$300
II. RO Recycled water (to 100 mg/L)					
A. RO Stream recharge or Injection	$60,000	(1)	480	410	$146
III. Wellhead Demineralization					
A. Shallow wells (1,000 to 100 mg/L)	$444,000	(3+4+6)	1220	1000	$444
B. Deep wells (450 to 100 mg/L)	$444,000	(3+4+6)	470	250	$1,776
IV. Seasonal Groundwater Export to Creeks					
A. Army wells (1,000 mg/L)	$110,000	(5+6)	1360	1020	$108
B. Bernal (800 mg/L)	$110,000	(5+6)	1090	750	$147
C. Dublin (1,000 mg/L)	$110,000	(5+6)	1360	1020	$108
D. Excess mining pumpage (600 mg/L)	$110,000	(5+6)	820	470	$234
E. Basin outflow (700 mg/L)	$70,000	(6)	950	610	$115
v. Continuous Groundwater export on arroyos by Zone 7					
A. Zone 7 export on AV (500 mg/L)***	$290,000	(1.5(1)+7))	680	340	$853
B. Zone 7 export on AM (500 mg/L)***	$260,000	(1+7)	680	340	$765

AF = Acre-feet
GW = Groundwater
SW = Surface water
TAF = Thousand AF
O&M = Operations & Maintenance
RO = Reverse Osmosis

(*)

Unit O&M Costs	
Description	$/AF
1. GW Pumping	$60
2. SW Treatment Plant	$20
3. Reverse Osmosis	$400
4. Brine Disposal Cost	$30 (**)
5. Shallow GW Pumping	$40
6. Replacement Water	$70
7.Estimated Annual Entitlement payment:	$200

Net removal reflects replacement water TDS and pumpage/ salts reapplied over main basin.

(**) $150/AF LAVWMA pumping cost & 0.2 AF brine production and 0.2 AF replacement water per 1 AF demin.

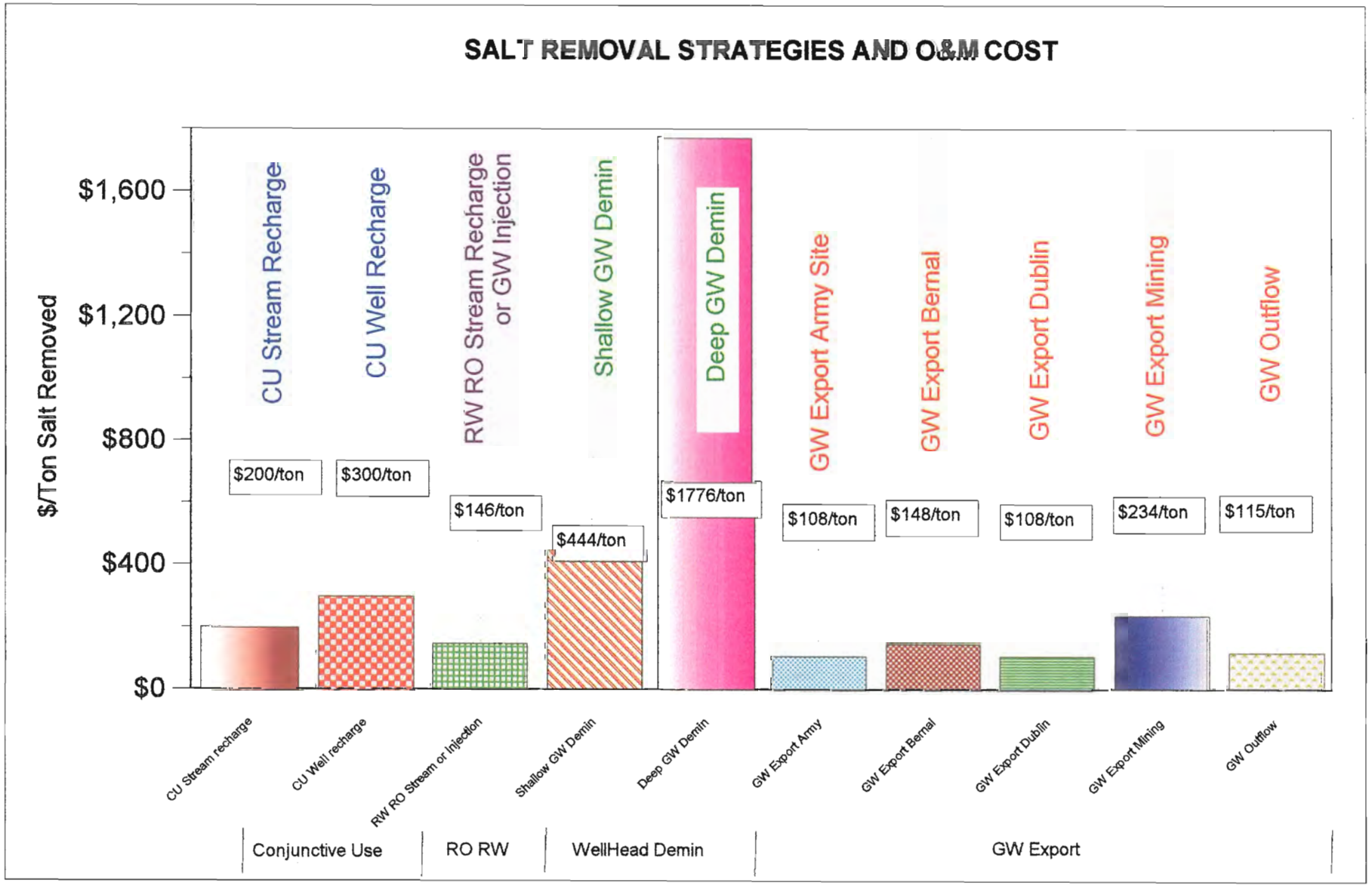
(***) The cost does not include the conveyance capacity cost and entitlement purchase cost.

In Table 8.4 and Figure 8.6 the salt management strategies have been divided into four main categories: 1) Conjunctive use, 2) Recycled water demineralization, 3) Wellhead demineralization, and 4) Seasonal groundwater export. Following is a brief description of each category and the rationale for the costs and salt removals shown.

(I) Conjunctive Use

Effective conjunctive use for salt balance require three things: 1) low TDS water put into the basin, 2) higher TDS water pumped out, and 3) higher TDS water exported from the basin. As listed in Table 8.4, Zone 7 has two ways to do conjunctive use for salt balance: 1) Stream recharge and 2) Well recharge. Conjunctive use is a relatively inexpensive tool for salt management. The main disadvantage is that it raises the delivered water TDS, which

FIGURE 8.6



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was deemed unacceptable (Chapter 7) from a policy standpoint by Zone 7 technical and public advisory groups.

Conjunctive use by stream recharge is defined here as the recharge of 250 mg/l SBA water (untreated) in the Arroyo Mocho or Arroyo Valle and Zone 7 pumpage of 450 mg/l groundwater for municipal deliveries. The incremental operational cost of this scenario includes the groundwater pumping cost and the savings of not treating that volume of surface water at a treatment plant. The power cost to pump 1,000 acre-feet (AF) of groundwater is about $60,000. The cost savings for not treating the SBA water at treatment plants is about $20,000 per 1000 AF. Therefore, the net cost for 1,000 AF of conjunctive use by stream recharge is about $40,000. The gross salt removed is 270 tons per TAF (tons/TAF). Since some (25-30%) of the salt removed is applied back over the main basin for irrigation use, the net salt removal is about 200 tons/TAF. The cost to remove one ton of salt would be about $200. The O&M costs of this and other Table 8.4 strategies are compared in Figure 8.6.

Conjunctive use by well recharge is defined as the recharge by injection of 250 mg/l SBA water (treated) through ASR wells and pumpage of 450 mg/l groundwater for municipal deliveries. The incremental operational cost of this operational scenario would be the groundwater pumping cost. Therefore, the net cost for 1,000 AF of conjunctive use by well recharge is about $60,000. The gross salt removed is 270 tons/TAF. The net salt removal is about 200 tons/TAF. The cost to remove one ton of salt would be about $300.

(II) RO Recycled Water

This strategy includes RO recycled water (to 100 mg/L TDS), recharging the RO recycled water into the groundwater basin by stream recharge in the Arroyo Mocho or through injection wells (pending public acceptance), and the pumping of 450 mg/l groundwater for municipal deliveries. The incremental operational cost of this operational scenario is just the groundwater pumping cost or about $60,000 per TAF. The cost of RO recycled water treatment plant operation or the cost to purchase 100 mg/L TDS water is not included in the calculation. Since this RO recycled water becomes a new supply for the valley, it is assumed that the cost for Zone 7 to purchase the RO recycled water would be covered from funds set aside for purchasing new water supplies. Alternatively, DSRSD or Livermore could choose to retain ownership of the demineralized recycled water recharged and coordinate the associated groundwater extraction with Zone 7. It has been assumed that RO facility O&M costs would be paid for by wastewater ratepayers. The gross salt removed is 480 tons/TAF. The net salt removal is about 410 tons/TAF. The cost to remove one ton of salt would be about $150.

(III) Wellhead Groundwater Demineralization

Wellhead demineralization is an effective but relatively expensive strategy for salt management. It also requires a feasible means of brine disposal, which for purposes of this SMP has been assumed to be a yet to be negotiated agreement for export via the LAVWMA pipeline. The basic concept is to pump groundwater, pass it through a demineralization plant, export the concentrated brine as wastewater, mix the low TDS (100 mg/l) water with other groundwater, and deliver an equivalent or lower TDS supply to the customer. This tool, combined with conjunctive use, makes both tools very effective. For significant conjunctive use to be employed, wellhead demineralization would be necessary to maintain the delivered water TDS. Wellhead demineralization could be used for shallow well pumpage or for deep well pumpage. Since the shallow groundwater at some locations has higher TDS (about 1000 mg/l), the brine concentration would be higher and, therefore, the process would be more cost effective for salt removal. Table 8.4 divides wellhead demineralization (III) into two categories: 1) Demineralization of shallow groundwater pumpage (1000 mg/L; and 2) Demineralization of deep groundwater pumpage.

Shallow well demineralization includes the demineralization of high TDS (1000 mg/l) shallow GW, export of concentrated brine, and delivery of low TDS water to customers. It was estimated that brine disposal volume would be about 20% of total groundwater demineralization volume. The incremental operational cost for demineralization plant operation is estimated to be about $400,000/TAF of production. Brine disposal cost would be $30,000/TAF of production and the cost to replace water lost as brine would be about $14,000/TAF of production (replacement water is $70,000/TAF and since brine volume is about 20% of production, the replacement water cost is 20% of $70,000). The total cost is therefore $444,000/TAF of production. The gross salt removed would be 1,220 tons/TAF. Since some of this salt would be exported by just doing conjunctive use without demineralization, the net salt removed due to demineralization would be 1,000 tons/TAF. The cost to remove one ton of salt would be about $444. One limitation of shallow groundwater pumpage is that in a prolonged drought the shallow groundwater wells may go dry. To avoid this, demineralization facilities could be designed so that if the shallow wells went dry, deep well pumpage could be rerouted for demineralization.

Deep well demineralization is the same as shallow well demineralization except that deep groundwater pumpage (450 mg/l TDS) is used. The total cost would also be about $444,000/TAF of production. However, the gross salt removed would be 470 tons/TAF and the net salt removed due to demineralization would be only 250 tons/TAF. Therefore, the cost to remove one ton of salt would be about $1,776, the highest of any tool considered and four times greater than shallow well high TDS demineralization.

(IV) Seasonal Groundwater Export

Seasonal groundwater export to creeks would be one of the least expensive strategies. However, one of the main limitations is that it most likely could only be done during periods of relatively high flows in the Arroyo de la Laguna to minimize salt loading impacts to ACWD water supplies. As an example, there are only about 30 days/year on the average when the Arroyo de la Laguna flow is over 100 cfs. If this background flow were the limiting constraint, it would only be possible to export about 250 AF/year and 250 tons/year. It would require exporting about 2,200 AF/year of 1,000 mg/L TDS shallow groundwater to offset the entire 2,200 tons/year salt imbalance. The cost of seasonal groundwater export would include the shallow groundwater pumping cost of $40,000/TAF (except in the case of basin outflow situations where outflow would be natural rising GW) and water replacement cost of $70,000 per TAF for a total cost of $110,000/TAF of export. The gross salt removed would vary from 820 tons to 1,360 tons per TAF depending upon the TDS of water exported. Since the replacement water (250 mg/l) would add some salt to the basin, the net salt removed would vary from 470 to 1,020 tons/TAF at a cost of $108 to $234/ton.

Some conclusions from Table 8.4 and Figure 8.6 include the following:

- Conjunctive use removes considerably less salt per volume implemented than either wellhead demineralization or groundwater export.
- The costs associated with wellhead demineralization are significantly greater than other strategies.
- The costs associated with conjunctive use and groundwater export strategies are roughly comparable.
- Groundwater export without replacement water cost is the least expensive alternative in terms of total cost per ton of salt removed and is also the most efficient in terms of total salt removed.
- The cost per ton of salt removed associated with wellhead demineralization of 1,000 mg/L TDS water is about 50% more than conjunctive use through well recharge.
- Wellhead demineralization is only competitive with the other strategies in terms of cost per ton removed if high TDS upper aquifer water is used as the source water for the demineralization process.

The salt management preliminary cost estimates and unit costs presented in Table 8.4 are meant as screening level tools. Annual costs associated with implementing the salt management strategies introduced in this chapter and composite strategies are further discussed and refined in chapters 9, 11, and 12.

Chapter 9

Year 2010 Salt Management Studies and Screening

Chapter 9

Year 2010 Salt Management Studies and Screening

9.1 Introduction

This chapter presents the results of screening-level salt balance studies based on individual and composite salt management strategies described in Chapter 8. Multiple studies were initially developed and evaluated but only those that would successfully meet projected supply and demand conditions (i.e., provide a sustainable water supply) are reported herein. The studies were additionally constrained by having to use only existing or already planned Zone 7 facilities. In many cases the size of study components was determined based on these latter constraints and/or as needed to achieve a zero (neutral) salt balance under projected year 2010 demand, operational, and land use conditions.

The salt balance studies presented in this chapter were conducted using projected 2010 demands (derived from the April 1997 Sustainable Water Supply Report) and land use characteristics, and hydrology from 1922 through 1996 (which includes normal, wet, dry, and drought years). For each study a 75-year simulation using 1922 through 1996 hydrology was conducted to ensure that the study was a viable operations plan that could provide a sustainable water supply. As discussed in Section 5.2, the calculations were based on steady state 1974 through 1998 hydrology since these provide a better indicator of potential long-term loading conditions than calculations based on any given annual hydrologic conditions.

Strategy specific facility and operational constraints were input into a version of the Zone 7 salt balance model (presented in Chapter 5) modified to reflect year 2010 conditions. The modified model was used to evaluate how alternative salt management studies would affect the year 2010 salt balance. These screening level studies focused on projects and basin management measures directly affecting year 2010 salt loading to the Main Basin. Measures other than these may be needed to reduce salt loading to the creeks, which flow out of the valley and do not impact the main basin, but can potentially impact water quality in the Niles Cone.

Calculations were performed for each study to determine the estimated net salt loading to the Main Basin, the estimated net annual increase in TDS of the groundwater, the projected TDS in the overall groundwater basin after 10 years of implementation, the TDS of Zone 7 treated water deliveries, and the incremental operational costs (based on Chapter 8 unit costs) of implementing each strategy.

Originally, approximately 15 basic salt management studies were evaluated, all of which included an assumed 6 TAF/year of RO recycled water injection and recharge via Chain of Lakes Lake I. Several iterations of some of the basic studies were subsequently developed and evaluated based on optimizing the initial results, recommendations from Zone 7 advisory groups, and public concerns about RO recycled water injection.

Long-term averages for each water inflow and outflow component were calculated along with the main basin water and salt balances. Results in this chapter for each study evaluated are presented in individual tables similar in format to the 2010 steady-state salt balance results included in Chapter 5 (Table 5.3). The salt source (water supply) and salt export (water demand) components of these tables were defined in Chapter 5. Most of the assumptions inherent in generating the salt balance results presented in Chapter 5 also apply to these studies. These assumptions are summarized in sections 9.2 and 9.3. For a more comprehensive presentation of the details behind these year 2010 screening level salt balance studies refer to Reference M.

The individual study results are briefly described (Section 9.4) and then compared (Section 9.5) relative to their impacts on salt loading, groundwater quality, delivered water quality, and on water rates (i.e., costs). The concept of and examples of composite studies is then presented. A feasibility screening is then performed (Section 9.6) to identify the most promising studies to carry forward for more detailed analysis and modeling (Chapter 10).

9.2 Definitions and Assumptions

The key results of the year 2010 screening level studies have been summarized in two tables. Table 9.1 presents a summary of the water quality and O&M cost results of the studies. Table 9.2 presents a preliminary cost estimate associated with each of the salt balance studies. The following is a brief explanation of the components found in tables 9.1 and 9.2.

Vadose zone salt attenuation credit assumes that a given percent of salt applied for irrigation purposes is permanently retained by the soil and does not migrate vertically to impact the groundwater. Studies 3, 4, and 12 assume vadose zone attenuation at rates of 15% and 30%, which are based on the available literature. Vadose zone attenuation is incorporated by reducing the salt load mass resulting from urban and agricultural irrigation by the corresponding percentage.

Demineralized municipal pumpage assumes that groundwater of 450 mg/L or 1,000 mg/L TDS will be pumped and demineralized at the wellhead to 100 mg/L TDS. There is assumed to be a 10% loss to brine, so the pumpage required was increased by 10%.

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TABLE 9.1

SUMMARY OF SALT BALANCE STUDIES AT 2010 CONDITIONS

STUDY NO.	NAME	LONG TERM AVERAGE: VADOSE ZONE ATTENUATION CREDIT	DEMINERALIZED MUNICIPAL PUMPAGE TAF	SALT MGT. CONJ. USE GW PUMPAGE TAF	TOTAL ZONE 7 GW PUMPAGE TAF	NET SALT LOADING TONS/YR	NET INCREASE IN TDS mg/l/year	PROJECTED GW TDS AFTER 10 YEARS	TDS OF ZONE 7 DELIVERIES mg/l	INCREMENTAL OPERATIONAL COST: PER YEAR	INCREMENTAL OPERATIONAL COST: PER ACRE-FOOT OF TW DELIVERY
								CURRENT 450			
1	Status Quo 6 TAF RO RW INJECTION (1)	NONE	NONE	NONE	12	**3100**	**10**	**550**	**300**	**$0**	**$0**
1A	Status Quo NO RO RW INJECTION	NONE	NONE	NONE	7.5	**5400**	**18**	**630**	**275**	**$0**	**$0**
1B	Status Quo 3640 AF RO RW INJECTED PLUS 20% MORE GW PUMPED FOR AG	NONE	NONE	NONE	10.4	**5000**	**17**	**620**	**270**	**$0**	**$0**
2	DELTA FIX 100mg/l SBA water quality	NONE	NONE	NONE	12	**0**	**0**	**450**	**180**	**$0**	**$0**
3	15% ATTENUATION	15%	NONE	NONE	12	**2000**	**7**	**520**	**300**	**$0**	**$0**
4	30% ATTENUATION	30%	NONE	NONE	12	**1000**	**3**	**480**	**300**	**$0**	**$0**
5	INCREASED GW PUMPING FOR CONJUNCTIVE USE	NONE	NONE	16	28	**800**	**3**	**480**	**360**	**$760,000**	**$10**
6		NONE	NONE	22	34	**0**	**0**	**450**	**390**	**$1,100,000**	**$20**
7	DEMINERALIZE ZONE 7 GW PUMPAGE	NONE	13	NONE	12	**1700**	**6**	**510**	**210**	**$5,473,000**	**$100**
8	DEMINERALIZE ZONE 7, CWS & PLEASANTON GW PUMPAGE	NONE	20	NONE	12	**900**	**3**	**480**	**210**	**$8,420,000**	**$160**
9	COMPOSITE OF CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE	NONE	19	7	19	**100**	**0**	**450**	**212**	**$8,333,000**	**$160**
10		NONE	10	16	28	**-100**	**0**	**450**	**250**	**$4,968,000**	**$90**
11		NONE	5 (Demin 1000 mg/l GW pumpage to 100 mg/l)	5	17	**-2200**	**-7**	**380**	**270**	**$2,351,000**	**$40**
11A		NONE	1.5 (Demin 1000 mg/l GW pumpage to 100 mg/l)	10	22	**0**	**0**	**450**	**320**	**$1,091,500**	**$20**
11B		NONE	3 (Demin 1000 mg/l GW pumpage to 100 mg/l)	3	15	**0**	**0**	**450**	**277**	**$1,383,000**	**$30**
12	COMPOSITE OF ATTENUATION, CONJUNCTIVE USE & GW DEMINERALIZATION	15%	1.5 (Demin 1000 mg/l GW pumpage to 100 mg/l)	10	22	**-1200**	**-4**	**410**	**320**	**$1,077,500**	**$20**
13	ZONE 7 GW (1000TDS) PUMPAGE TO ARROYO MOCHO (EXPORT) WHEN GW STORAGE IS ABOVE 200 TAF	NONE	NONE	AVERAGE 3.6 TAF SEASONAL GW EXPORT	15.6	**0**	**0**	**450**	**300**	**$404,000**	**$8**
13A	ZONE 7 GW (1000TDS) PUMPAGE TO ARROYO MOCHO (EXPORT) WHEN GW STORAGE IS ABOVE 200 TAF	NONE	NONE	AVERAGE 1.5 TAF SEASONAL GW EXPORT	13.5	**1730**	**6**	**510**	**300**	**$169,000**	**$0**
14	COMPOSITE OF RO RW, ASR CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE **ASR RO RW PUMPAGE FOR AG USE**	NONE	4.6 (Demin 1000 mg/l GW pumpage to 100 mg/l)	4	14.3	**0**	**0**	**450**	**250**	**$2,096,600**	**$40**
14A	COMPOSITE OF RO RW ASR CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE **ASR RO RW PUMPAGE FOR URBAN IRRI.**	NONE	3.8 (Demin 1000 mg/l GW pumpage to 100 mg/l)	4	14.3	**0**	**0**	**450**	**255**	**$1,759,800**	**$30**
15	COMPOSITE OF CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE **NO RECYCLED WATER INJECTION**	NONE	5 (Demin 1000 mg/l GW pumpage to 100 mg/l)	8.5	16	**0**	**0**	**450**	**270**	**$2,607,000**	**$50**

Assumptions:

1. *All studies iIncludes 6 TAF/YEAR of RO recycled water (RW) injection except Study 1a & 15 have no RO RW water injection and studies 14 & 14a have 3640 af of demineralized RW injection.*
2. *All studies do not include salt loading due to future development outside the main basin or new recycled water irrigation water use.*
3. *Incremental operational cost is based upon total treated water deliveries (45,100 AF Zone 7 plus 7,214 AF GPQ pumpage) .*

03-Jul-02

TABLE 9.2

PRELIMINARY COST ESTIMATE FOR SALT BALANCE STUDIES AT 2010 CONDITIONS

		ANNUAL INCREMENTAL OPERATIONAL COSTS							ANNUAL INCREMENTAL CAPITAL COSTS					ANNUAL CAPITAL AND OPERATIONAL		
STUDY NO.	NAME	GW PUMPING COST	SW TREATMENT PLANT COST	GW Demin cost	BRINE DISPOSAL COST	TOTAL PER YEAR	COST/ AF	COST/ TON OF SALT MITIGATION	GW WELLS	TREATMENT PLANT EXPANSION	GW Demin PLANT	ADDITIONAL SBA CAPACITY	TOTAL PER YEAR	TOTAL COST/YEAR	COST/ AF	COST/ TON OF SALT MITIGATION
1	Status Quo 6 TAF RO RW INJECTION (1)	$0	$0	$0	$0	**$0**	**$0**	**$0**	$0	$0	$0	$0	**$0**	**$0**	**$0**	**$0**
1A	Status Quo NO RO RW INJECTION	$0	$0	$0	$0	**$0**	**$0**	**$0**	$0	$0	$0	$0	**$0**	**$0**	**$0**	**$0**
1B	Status Quo 3640 AF RO RW INJECTED PLUS 20% MORE GW PUMPED FOR AG	$0	$0	$0	$0	**$0**	**$0**	**$0**	$0	$0	$0	$0	**$0**	**$0**	**$0**	**$0**
2	DELTA FIX 100mg/l SBA water quality	$0	$0	$0	$0	**$0**	**$0**	**$0**	$0	$0	$0	$0	**$0**	**$0**	**$0**	**$0**
3	15% ATTENUATION	$0	$0	$0	$0	**$0**	**$0**	**$0**	$0	$0	$0	$0	**$0**	**$0**	**$0**	**$0**
4	30% ATTENUATION	$0	$0	$0	$0	**$0**	**$0**	**$0**	$0	$0	$0	$0	**$0**	**$0**	**$0**	**$0**
5	INCREASED GW PUMPING FOR CONJUNCTIVE USE	$960,000	($200,000)	$0	$0	**$760,000**	**$10**	**$300**	$0	$0	$0	$0	**$0**	**$760,000**	**$10**	**$300**
6		$1,320,000	($220,000)	$0	$0	**$1,100,000**	**$20**	**$400**	$1,344,000	$0	$0	$0	**$1,344,000**	**$2,444,000**	**$50**	**$800**
7	DEMINERALIZE ZONE 7 GW PUMPAGE	$78,000	$0	$5,200,000	$195,000	**$5,473,000**	**$100**	**$3,900**	$0	$0	$1,495,000	$0	**$1,495,000**	**$6,968,000**	**$130**	**$5,000**
8	DEMINERALIZE ZONE 7, CWS & PLEASANTON GW PUMPAGE	$120,000	$0	$8,000,000	$300,000	**$8,420,000**	**$160**	**$3,800**	$0	$0	$2,300,000	$0	**$2,300,000**	**$10,720,000**	**$200**	**$4,900**
9	COMPOSITE OF CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE	$534,000	($86,000)	$7,600,000	$285,000	**$8,333,000**	**$160**	**$2,800**	$0	$0	$2,185,000	$0	**$2,185,000**	**$10,518,000**	**$200**	**$3,500**
10		$1,020,000	($202,000)	$4,000,000	$150,000	**$4,968,000**	**$90**	**$1,600**	$0	$0	$1,150,000	$0	**$1,150,000**	**$6,118,000**	**$120**	**$1,900**
11		$330,000	($54,000)	$2,000,000	$75,000	**$2,351,000**	**$40**	**$400**	$0	$0	$575,000	$0	**$575,000**	**$2,926,000**	**$60**	**$600**
11A		$609,000	($140,000)	$600,000	$22,500	**$1,091,500**	**$20**	**$400**	$0	$0	$172,500	$0	**$172,500**	**$1,264,000**	**$20**	**$400**
11B		$198,000	($60,000)	$1,200,000	$45,000	**$1,383,000**	**$30**	**$400**	$0	$0	$345,000	$0	**$345,000**	**$1,728,000**	**$30**	**$600**
12	COMPOSITE OF ATTENUATION, CONJUNCTIVE USE & GW DEMINERALIZATION	$609,000	($154,000)	$600,000	$22,500	**$1,077,500**	**$20**	**$300**	$0	$0	$172,500	$0	**$172,500**	**$1,250,000**	**$20**	**$300**
13	ZONE 7 GW (1000TDS) PUMPAGE TO ARROYO MOCHO (EXPORT) WHEN GW STORAGE IS ABOVE 200 TAF	$144,000	$8,000	SWP VARIABLE $252,000 CHARGE FOR WATER REPLACEMENT	$0	**$404,000**	**$8**	**$130**	$250,000	$40,000	$0	$0	**$290,000**	**$694,000**	**$10**	**$200**
13A	ZONE 7 GW (1000TDS) PUMPAGE TO ARROYO MOCHO (EXPORT) WHEN GW STORAGE IS ABOVE 200 TAF	$60,000	$4,000	$105,000	$0	**$169,000**	**$0**	**$123**	$100,000	$20,000	$0	$0	**$120,000**	**$289,000**	**$10**	**$200**
									STUDY 13A COST DOES NOT INCLUDE ANY FIXED COST TO BUY ANY ADDITIONAL ENTITLEMENT							
14	COMPOSITE OF RO RW, ASR CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE **ASR RO RW PUMPAGE FOR AG USE**	$267,600	($80,000)	$1,840,000	$69,000	**$2,096,600**	**$40**	**$700**	$0	$0	$529,000	$0	**$529,000**	**$2,625,600**	**$50**	**$800**
14A	COMPOSITE OF RO RW ASR CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE **ASR RO RW PUMPAGE FOR URBAN IRRI.**	$262,800	($80,000)	$1,520,000	$57,000	**$1,759,800**	**$30**	**$600**	$0	$0	$437,000	$0	**$437,000**	**$2,196,800**	**$40**	**$700**
15	COMPOSITE OF CONJUNCTIVE USE & DEMINERALIZATION OF GW PUMPAGE **NO RECYCLED WATER INJECTION**	$540,000	($8,000)	$2,000,000	$75,000	**$2,607,000**	**$50**	**$800**	$0	$0	$575,000	$0	**$575,000**	**$3,182,000**	**$60**	**$1,000**

OPERATIONAL COSTS / ACRE-FOOT						CAPITAL COSTS / ACRE-FOOT			
GW PUMPING COST TO SYSTEM $/AF	SW TREATMENT PLANT COST	GW Demin COST	BRINE DISPOSAL COST	GW PUMPING COST TO WASTE $/AF	SWP ENTITLEMENT VARIABLE CHARGES	GW WELLS	TREATMENT PLANT EXPANSION	GW Demin PLANT	ADDITIONAL SBA CAPACITY
60	20	400	150	40	70	**50**	**100**	**115**	**25**

Salt management conjunctive use is the combination of pumping additional groundwater for delivered water supply and the complementary recharge to replace the groundwater with lower TDS (250 mg/L) surface water. Values listed under conjunctive use are in addition to the average annual projected year 2010 baseline pumpage and recharge of 12,000 AF.

Total Zone 7 pumpage is the sum of Zone 7 municipal pumpage, pumpage for blending with injected recycled water, and conjunctive use pumpage.

Net salt loading values are the expected salt loading to the main basin under a given salt management study and are rounded to the nearest 100 tons/year. The negative salt loading values in studies 10 and 12 indicate that, on average, more salt will be removed from the basin each year than would be applied.

Net increase in TDS converts the net salt loading in the basin to a corresponding increase in TDS of the groundwater. Implicit in this conversion are the assumptions that all salts have been uniformly mixed with groundwater.

Projected groundwater TDS after 10 years assumes that the current groundwater contains 450 mg/L TDS and computes the expected TDS after 10 years based on the previously described calculations. Implicit in this calculation is the assumption that the upper and lower aquifers are mixed.

TDS of Zone 7 deliveries are calculated assuming constant surface water (250 mg/L) and groundwater (450 mg/L) TDS concentrations. It should be noted that actual SBA concentrations vary from 100 to over 700 mg/L and the actual extracted groundwater TDS values also can vary, as described in Chapter 5.

Preliminary planning level cost estimates for these salt balance studies at 2010 conditions are summarized in Table 9.2. Costs are broken down into operational costs and capital costs. The unit costs for each component are itemized in the sub-tables at the bottom of Table 9.2 and in Table 9.3 below. The unit O&M cost information is a summary of information and assumptions presented in more detail in Section 8.14.

Annual incremental operational costs shown in Table 9.2 are conceptual planning level costs for unit operations and maintenance only. These costs include $60/AF for municipal groundwater pumping, $20/AF marginal cost to treat the water at one of the treatment plants, $400/AF for wellhead demineralization, $150/AF of brine disposed from associated wellhead demineralization, $40/AF for groundwater pumping to waste, and $70AF SWP entitlement variable charges for replacement water.

Table 9.3
Summary of Assumed Costs for
2010 Salt Balance Studies

Operational Expenses	Cost
GW demineralization	$400/AF
Brine disposal via LAVWMA	$150/AF
Groundwater pumpage power	$60/AF
Surface Water Treatment	$20/AF
SMP conjunctive use	$40/AF
SWP entitlement variable charges	$70/AF
Capital Expenses	
ASR Wells	$50/af/yr
Treatment plant expansion	$100/af/yr
Groundwater Demineralization plant	$115/af/yr
Additional SBA capacity	$25/af/yr

Annual incremental capital costs assume amortization at 7% interest over 30 years. Negative numbers represent avoided costs due to another aspect of the project (e.g., stream recharge and extraction versus treatment and delivery). Annual incremental capital costs included in the studies are reported per year and include $50/AF for new wells, $100/AF for treatment plant expansion, $115/AF for a wellhead demineralization facility, and $25/AF for additional SBA capacity. In contrast to the unit O&M costs, these capital costs are normalized per acre-foot of treated water delivered by Zone 7 during 2010 (i.e., 45 TAF).

The sum of the **Annual Capital and Operational** costs is tabulated on the right side of Table 9.2 and is also included as the final two columns in Table 9.1. Those costs have been computed in two ways, including the **total cost per year** and the **cost per acre-foot of treated water delivery** (45 TAF Zone 7 delivery plus 7.2 TAF groundwater pumping quota (GPQ)).

9.3 Assumptions Common to Year 2010 Salt Balance Studies

The following is a list of the assumptions that were used to generate the results for Study 1, which is considered the baseline case and is based on Zone 7's historic operational basin management strategy. Note that although the studies include facilities in addition to those presently (1998) available, the majority of the studies involve use of the facilities scheduled for construction as part of the expansion program (i.e., no new costs are incurred solely for salt management). All of the noted assumptions are also valid for the other studies unless noted otherwise in the description of the individual studies.

Demand and Supply—Zone 7 demand is based on sustained water supply. The hydrologic study period used for local supply is 75 years (1922 through 1996). The demand for SWP is assumed to be 4.1 MAF. The existing Zone 7 SWP entitlement is 46 TAF. An additional 15 TAF is assumed to be available by 2010. The Zone 7 treated demand for 2010 is 45,100 AF and untreated demand is 8,700 AF/year.

Water Quality—SBA water TDS was assumed at 250 mg/L, ASR pumpage TDS at 250 mg/L, and groundwater TDS at 450 mg/L. Annual average delivered water quality is calculated using these consistent concentration values proportioned to the blend of surface and groundwater delivered each year.

RO Recycled Water—RO recycled water (or other low TDS water) injection or recharge is assumed to be 6 TAF per year. This is 2,300 AF more than the amount potentially available through the Livermore and DSRSD projects. The Livermore and DSRSD projects would produce 840 AF/Y and 2,800 AF/Y, respectively. It was assumed that these projects would be expanded and the remaining 2,300 AF/Y recharged in the future Chain-of-Lakes. This was a significant component of the original studies since the assumed injection of 100 mg/L TDS water and extraction of 450 mg/L groundwater elsewhere would represent 2,300 tons per year of salt removal from the basin in 2010.

All the fifteen studies except 1A, 1B, 14, 14A and 15 include 6TAF of RO recycled water injection. Studies 1B, 14 and 14a include only 3,640 AF of RO recycled water recharge. Studies 1A and 15 do not include any RO recycled water recharge.

Wells—These studies assume that there will be some groundwater pumpage required to meet peak demands. The required groundwater pumpage is the sum of pumpage for daily peaking and seasonal peaking. It was assumed that if ASR is successful, Zone 7 could use ASR wells to inject low TDS surface water into the basin and pump it out to meet peak demands. The studies assumed injection capacity of ASR wells to be approximately 8,300 AF/year by year 2010. If ASR wells were not to be used (due to well clogging problems), increased wellhead demineralization could be used to maintain delivered water TDS and the Chain of Lakes could be used for surface water recharge.

Storage—It was assumed that when groundwater storage at the beginning of the water year is over 240 TAF Zone 7 will pump groundwater for deliveries and surface water supplies will carry over for the following year. It was assumed that Zone 7 will be allowed to carry over 10 TAF of local storage from one year to the next. Lake Del Valle supplies include the local water used as direct inflow and local water used after short-term storage in the lake. It does not include the local water released from the lake for recharge to satisfy prior rights on the Arroyo Valle.

Recharge—The artificial stream capacity includes existing Arroyo Mocho recharge capacity, existing Arroyo Valle recharge capacity, and the recharge capacity of Lake I in the Chain of Lakes. The existing Arroyo Mocho recharge capacity is about 19 cfs from April through September and 14 cfs from October through March. The existing recharge capacity on the Arroyo Valle is approximately 3 cfs. It was assumed that the stream capacity from June through August will be unusable due to the SBA capacity limit. Therefore, stream capacity is used for only nine months of the year. Delivery into Lake I is assumed to be 30 cfs for six months of the year plus 2,300 AF/Y of RO recycled water. It is anticipated that Zone 7 would make recharge releases between October and June down the Arroyo Mocho at a rate at 50-60 cfs. Of this, 20-25 cfs would recharge in the Arroyo Mocho and 30-35 cfs would be diverted for storage and recharge in the Chain of Lakes.

9.4 Individual Salt Balance Study Results

The following is a brief description of the 15 screening level salt management studies. The resultant main basin water and salt balances for each study are summarized on one page each in tables 9.4 through 9.17. The complete 75-year tabular and graphical results for each study are presented in Reference M. Note that all of the assumptions described in section 9.2 and 9.3 above apply to all 15 individual studies. Assumptions unique to each study are cited therein.

Study 1 reflects the historic operational practice of Zone 7 and is considered the baseline case. Study 1 does not include any salt management measures other than the assumed 6 TAF of RO recycled water injection common to studies 1-13.

Available surface water is used to meet water demands with groundwater pumped primarily to meet peak demands and demands that exceed the surface water supply. The surface water supply is limited by the SWP yield for the year, Zone 7's water treatment plant capacity, the maximum instantaneous SBA flow rate, and the maximum monthly delivery from the SWP.

Study 1 (and all others except 3, 4, and 12) assumes that 100% of applied salts impact the groundwater. The main basin water and salt balance for 2010 steady state conditions is given in Table 9.4. Study 1 conditions result in a salt loading of 3,100 tons/year and delivered water quality of 300 mg/L (range 250 to 440 mg/L). Since this is the original

Table 9.4

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

WITH NO ATTENUATION OF SALTS IN APPLIED WATER AND NO CONJUNCTIVE USE PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER		RECHARGE WATER		SALT	SALT LOAD IN TONS PER
	ACRE-FEET	TDS IN mg/l	ACRE-FEET	TDS IN mg/l	LOAD IN TONS	1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	8,360	250	780	2,679	2,840	3,640
Groundwater, Extraction only wells	4,660	450	430	4,877	2,850	6,630
Groundwater, ASR wells	390	250	40	2,438	130	3,250
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,935		1,360		6,250	4,600
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	950	1,500	950	1,500	1,940	2,040
Total Natural Supply	23,765		13,840		13,820	1,000
ARTIFICIAL RECHARGE						
Stream recharge	2,750	250	2,750	250	930	340
Injection well recherge (ASR wells))	1,550	250	1,550	250	530	340
Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	34,065		24,140		16,100	

WATER DEMAND COMPONENTS	WATER REMOVED		SALT	SALT REMOVED IN TONS PER
	ACRE-FEET	TDS IN mg/l	LOAD IN TONS	1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	1,550	250	530	340
Zone 7 municipal pumpage, Extraction only wells	6,110	450	3,740	610
Conjunctive use pumpage, Extraction only wells	0	450	0	0
Pumpage for injected recycled water, Extraction only wells	4,160	450	2,550	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	20,120		11,900	590
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	620	900	760	1,230
Total Demand	24,140		13,050	
WATER/SALT BALANCE	0		3,050	

baseline case study and no additional facilities are required other than those already assumed to be in place in the year 2010, there are no incremental costs associated with this study.

Study 1A and Study 1B are slight variations of Study 1. These studies were performed after the Zone 7 Board made the decision in September 1998 not to support RO recycled water injection into the main basin pending further public acceptability.

The only difference in Study 1A from Study 1 is that it has no injection of RO recycled water into the main basin. The main basin water and salt balance for 2010 steady state conditions is given in Table 9.4A. Study 1A conditions result in a salt loading of 5,400 tons/year and delivered water quality of 275 mg/L. Delivered water quality improves versus Study 1 because more surface water has to be delivered and Zone 7 groundwater pumpage is less than in Study 1. Groundwater basin salt loading increases to 5,400 tons/year from 3,100 tons/year for Study 1. Since this is also the baseline case and no additional facilities are required other than those already assumed to be in place in the year 2010, there are no incremental costs associated with this study. Study 1A defines the baseline for the salt management Study 15.

The only difference in Study 1B from Study 1 is that it has 3,640 AF/year injection of RO recycled water into the main basin instead of 6,000 AF/year. Also, all of RO recycled water injected (presumably during the wet weather season to provide additional peak wet weather disposal capacity) is assumed to be recovered by pumping at the same location during the irrigation season. The 3,640 AF represents the maximum annual combined production of the existing DSRSD and the Livermore RO facilities. The main basin water and salt balance for 2010 steady state conditions is given in Table 9.4B. Study 1B conditions result in a salt loading of 5,000 tons/year and delivered water quality of 270 mg/L. Delivered water quality improves versus Study 1 because more surface water is delivered and Zone 7 groundwater pumpage is less than in Study 1. Groundwater basin salt loading increases to 5,000 tons from 3,100 tons for Study 1. Since this is also the baseline case and no additional facilities are required other than those already assumed to be in place in the year 2010, there are no incremental costs associated with this study. Study 1B defines the baseline for the salt management studies 14 and 14A.

Study 2 is referred to as the "Delta Fix." This study evaluates the effect on salt loading to the main basin if a higher quality surface water supply were made available, for example, as part of the CalFed Option 3 dual conveyance system. SBA water quality is assumed to improve to 100 mg/L from 250 mg/L TDS. The direct cost for this improvement is assumed to not affect Zone 7 water rates.

As shown in Table 9.5, the Study 2 net salt loading to the main basin would be negligible without any other institutional changes. Delivered water quality would improve to approximately 180 mg/L TDS and the projected groundwater quality would stabilize at current levels (Table 9.1).

STUDY 1A

TABLE 9.4A

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

WITH NO ATTENUATION OF SALTS IN APPLIED WATER AND NO CONJUNCTIVE USE PUMPAGE FOR SALT MANAGEMENT
NO RECYCLED WATER INJECTION

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	9,440	250	880	2,682	3,210	3,650
Groundwater, Extraction only wells	3,370	450	310	4,892	2,060	6,650
Groundwater, ASR wells	600	250	60	2,500	200	3,330
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,935		1,360		5,900	4,340
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	980	1,500	980	1,500	2,000	2,040
Total Natural Supply	23,795		13,870		13,530	980
ARTIFICIAL RECHARGE						
Stream recharge	3,540	250	3,540	250	1,200	340
Injection well recherge (ASR wells))	2,390	250	2,390	250	810	340
Recycled water injection	0	100	0		0	0
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	29,725		19,800		15,540	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,390	250	810	340
Zone 7 municipal pumpage, Extraction only wells	5,110	450	3,130	610
Conjunctive use pumpage, Extraction only wells	0	450	0	0
Pumpage for injected recycled water, Extraction only wells	0	450	0	0
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	15,800		9,020	570
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	590	900	720	1,220
Total Demand	19,790		10,130	
WATER/SALT BALANCE	10		5,410	

Table 9.4B

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

WITH NO SALT MITIGATION, 3640 AF RECYCLED WATER INJECTION AND CWR WELLS PUMPING FOR AGRICULTURE DEMAND (120% of Recycled water)

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	9,700	250	910	2,665	3,300	3,630
Groundwater, Zone 7 Extraction only wells (NO Demin)	950	450	90	4,750	580	6,440
Groundwater, Zone 7 Extraction only wells (Demin)	0	100	0		0	0
Groundwater, ASR wells	620	250	60	2,583	210	3,500
Groundwater, others (No Demin)	2,180	450	200	4,905	1,330	6,650
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,975		1,370		5,850	4,270
Agricultural Irrigation						
SBA water	870	250	220	989	300	1,360
CWR Project agricultural pumpage	870	160	220	633	190	860
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		610	1,240
Subsurface groundwater inflow	1,020	1,500	1,020	1,500	2,080	2,040
Total Natural Supply	23,875		13,920		13,460	970
ARTIFICIAL RECHARGE						
Stream recharge	4,780	250	4,780	250	1,620	340
Injection well recherge (ASR wells))	2,340	250	2,340	250	800	340
RO Recycled water injection	3,640	100	3,640	100	490	130
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	34,635		24,680		16,370	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,340	250	800	340
Zone 7 municipal pumpage, Extraction only wells	3,630	450	2,220	610
Zone 7 municipal pumpage to waste, brine	0	450	0	0
Zone 7 municipal pumpage to waste, Demin brine (from 1000 mg/l water)	0	1,000	0	0
Conjunctive use pumpage, Extraction only wells(Deep aquifer water)	0	450	0	0
Conjunctive use pumpage, Extraction only wells(1000 MG/L GW)	0	1,000	0	0
Pumpage for injected recycled water, Extraction only wells	0	450	0	0
Other municipal pumpage	8,300	450	5,080	610
Addtional DSRSD's pumpage for recycled injection	2,240	450	1,370	610
Total municipal pumpage	16,510		9,470	570
CWR Project agricultural pumpage	4,370	160	950	220
Agricultural pumpage (groundwater)	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	400	900	490	1,230
Total Demand	24,680		11,300	

WATER/SALT BALANCE	0	5,070

STUDY 2

Table 9.5

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

WITH NO ATTENUATION OF SALTS IN APPLIED WATER AND NO CONJUNCTIVE USE PUMPAGE FOR SALT MANAGEMENT
WITH 100 TDS SBA WATER

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	100	1,240	100	170	140
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,260	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	8,360	100	780	1,072	1,140	1,460
Groundwater, Extraction only wells	4,660	450	430	4,877	2,850	6,630
Groundwater, ASR wells	390	100	40	975	50	1,250
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	500	40	5,063	280	7,000
Total Urban Irrigation	13,935		1,360		4,390	3,230
Agricultural Irrigation						
SBA water	1,740	100	440	395	240	550
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		360	730
Subsurface groundwater inflow	950	1,500	950	1,500	1,940	2,040
Total Natural Supply	23,765		13,840		11,360	820
ARTIFICIAL RECHARGE						
Stream recharge	2,750	100	2,750	100	370	130
Injection well recherge (ASR wells))	1,550	100	1,550	100	210	140
Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	34,065		24,140		12,760	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	1,550	100	210	140
Zone 7 municipal pumpage, Extraction only wells	6,110	450	3,740	610
Conjunctive use pumpage, Extraction only wells	0	450	0	0
Pumpage for injected recycled water, Extraction only wells	4,160	450	2,550	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	20,120		11,580	580
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	620	900	760	1,230
Total Demand	24,140		12,730	

Study 3 evaluates the effect of vadose zone salt attenuation and does not include any other salt management measures. It assumes 15% attenuation (permanent loss of mass) of salts in the vadose zone.

As shown in Table 9.6, a 15% attenuation in salt loading from the irrigation water applied would result in an overall 33% reduction in salt loading from Study 1 to approximately 2,000 tons/year. Delivered water quality would not be affected significantly and the ten-year projected groundwater quality would increase by approximately 70 mg/L TDS to 520 mg/L (Table 9.1).

Study 4 also evaluates the effect of vadose zone salt attenuation and does not include any other salt management measures. It assumes 30% attenuation (permanent loss of salt mass) in the vadose zone.

As shown in tables 9.1 and 9.7, Study 4 provides a 67% reduction in salt loading to approximately 1,000 tons/year. Delivered water quality would not be affected significantly and the ten-year projected groundwater quality would increase by about 30 mg/L TDS to 480 mg/L. It should be noted that the general staff, the technical advisory group, and the citizen's advisory group conclusions are that there is no significant actual long-term loss of salt in the vadose zone.

Study 5 evaluates the effect of instituting 16 TAF of conjunctive use. It assumes that 16 TAF additional groundwater pumpage for conjunctive use will be implemented using only already planned year 2010 (Study 1) facilities. This represents the maximum conjunctive use that can be implemented with those facilities.

As described in Chapter 8, when conjunctive use groundwater pumping is practiced, a given volume of groundwater (higher-TDS) is pumped for salt management and an equal volume of treated surface water (lower TDS) is recharged into the basin. The conjunctive use assumed in Study 5 would be implemented by using the maximum available stream recharge capacity (approximately 50 cfs on Arroyo Mocho for six months of the year) and by injecting the difference using available ASR wells capacity. As a result of the conjunctive use, approximately 52% of total Zone 7 demand would be met with groundwater.

As shown in tables 9.1 and 9.8, Study 5 would reduce salt loading in the main basin to approximately 800 tons/year but would also increase the Zone 7 delivered water TDS by 60 mg/L to 360 mg/L. The ten-year projected groundwater quality would increase by approximately 30 mg/L TDS to 480 mg/L. The incremental O&M costs would be equivalent to approximately $10/AF (i.e., when spread across/melded into the projected 45 TAF of Zone 7 treated water deliveries in 2010 plus the 7.2 TAF of groundwater pumping quota).

Table 9.6

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

WITH 15% ATTENUATION OF SALTS IN APPLIED WATER AND NO CONJUNCTIVE USE PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	8,360	250	780	2,679	**2,420**	3,100
Groundwater, Extraction only wells	4,660	450	430	4,877	**2,420**	5,630
Groundwater, ASR wells	390	250	40	2,438	**110**	2,750
Domestic groundwater pumpage	120	450	70	771	**60**	860
LWRP reclaimed water irrigation	405	650	40	6,581	**300**	7,500
Total Urban Irrigation	13,935		1,360		5,310	3,900
Agricultural Irrigation						
SBA water	1,740	250	440	989	**500**	1,140
Groundwater	200	450	50	1,800	**100**	2,000
Total agricultural irrigation	1,940		490		600	1,220
Subsurface groundwater inflow	950	1,500	950	1,500	1,940	2,040
Total Natural Supply	23,765		13,840		12,770	920
ARTIFICIAL RECHARGE						
Stream recharge	2,750	250	2,750	250	930	340
Injection well recherge (ASR wells))	1,550	250	1,550	250	530	340
Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	34,065		24,140		15,050	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	1,550	250	530	340
Zone 7 municipal pumpage, Extraction only wells	6,110	450	3,740	610
Conjunctive use pumpage, Extraction only wells	0	450	0	0
Pumpage for injected recycled water, Extraction only wells	4,160	450	2,550	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	20,120		11,900	590
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	620	900	760	1,230
Total Demand	24,140		13,050	
WATER/SALT BALANCE	0		2,000	

Table 9.7

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

WITH 30% ATTENUATION OF SALTS IN APPLIED WATER AND NO CONJUNCTIVE USE PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	8,360	250	780	2,679	**1,990**	2,550
Groundwater, Extraction only wells	4,660	450	430	4,877	**2,000**	4,650
Groundwater, ASR wells	390	250	40	2,438	**90**	2,250
Domestic groundwater pumpage	120	450	70	771	**50**	710
LWRP reclaimed water irrigation	405	650	40	6,581	**250**	6,250
Total Urban Irrigation	13,935		1,360		4,380	3,220
Agricultural Irrigation						
SBA water	1,740	250	440	989	**410**	930
Groundwater	200	450	50	1,800	**90**	1,800
Total agricultural irrigation	1,940		490		500	1,020
Subsurface groundwater inflow	950	1,500	950	1,500	1,940	2,040
Total Natural Supply	23,765		13,840		11,740	850
ARTIFICIAL RECHARGE						
Stream recharge	2,750	250	2,750	250	930	340
Injection well recherge (ASR wells))	1,550	250	1,550	250	530	340
Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	34,065		24,140		14,020	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	1,550	250	530	340
Zone 7 municipal pumpage, Extraction only wells	6,110	450	3,740	610
Conjunctive use pumpage, Extraction only wells	0	450	0	0
Pumpage for injected recycled water, Extraction only wells	4,160	450	2,550	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	20,120		11,900	590
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	620	900	760	1,230
Total Demand	24,140		13,050	
WATER/SALT BALANCE	0		970	

Table 9.8

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

NO ATTENUATION OF SALTS IN APPLIED WATER AND 16 TAF AVERAGE CONJUNCTIVE USE PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	4,310	250	400	2,694	1,470	3,680
Groundwater, extraction only wells	8,440	450	780	4,869	5,160	6,620
Groundwater , ASR wells	660	250	60	2,750	220	3,670
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total urban irrigation	13,935		1,350		7,280	5,390
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1940		490		710	1,450
Subsurface groundwater inflow	1,150	1,500	1,150	1,500	2,350	2,040
Total Natural Supply	23,965		14,030		15,260	1,090
ARTIFICIAL RECHARGE						
Stream recharge	13,810	250	13,810	250	4,690	340
Injection well recherge, ASR wells	5,920	250	5,920	250	2,010	340
Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	49,695		39,760		22,780	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,625	250	890	340
Zone 7 municipal pumpage, Extraction only wells	3,335	450	2,040	610
Conjunctive use pumpage, Extraction only wells	18,370	450	11,240	610
Pumpage for injected recycled water, Extraction only wells	3,600	450	2,200	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	36,230		21,450	590
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	150	900	180	1,200
Total Demand	39,780		22,020	
WATER/SALT BALANCE	(20)		760	

Study 6 evaluates the effect of instituting 22 TAF of conjunctive use. It assumes that 22 TAF of additional groundwater pumpage for conjunctive use will be implemented using existing facilities plus four more ASR wells (i.e., nine total ASR wells).

This volume of conjunctive use was selected because it balances the net salt loading. The conjunctive use assumed in Study 6 would be implemented by using the maximum available stream recharge capacity (approximately 50 cfs on the Arroyo Mocho plus the Chain of Lakes for six months of the year) and by injecting the difference with the nine ASR wells. As a result of the conjunctive use, approximately 74% of total Zone 7 demand would be met with groundwater (almost the reverse of base case Study 1).

As shown in tables 9.1 and 9.9, Study 6 would eliminate net salt loading in the main basin and stabilize the ten-year projected groundwater quality at current levels. Study 6 would also increase the Zone 7 delivered water TDS by 90 mg/L to 390 mg/L. Costs would increase by approximately $20/AF delivered.

Study 7 evaluates the effect of wellhead demineralization. It assumes Zone 7 groundwater pumpage would be demineralized from 450 mg/L TDS to 100 mg/L TDS. The demineralization facility would be sized at 13 TAF to account for the 12 TAF of pumpage estimated in Study 1, plus 1 TAF (~10%) of water expected to be lost as brine.

As shown in tables 9.1 and 9.10, Study 7 would reduce the year 2010 salt loading in the main basin by over half to approximately 1,700 tons/year, and would improve the Zone 7 delivered water quality by 90 mg/L to 210 mg/L. The ten-year projected groundwater quality would increase by 60 mg/L to approximately 510 mg/L. The cost increase associated with Study 7 would be approximately $100/AF.

Study 8 also evaluates the effect of wellhead demineralization. It assumes that all of the Zone 7, City of Pleasanton, and Cal Water groundwater pumpage would be demineralized from approximately 450 mg/L TDS to 100 mg/L TDS. A centralized reverse osmosis facility or multiple facilities would be sized at 20 TAF to account for all municipal pumpage and 10% brine loss.

As shown in tables 9.1 and 9.11, Study 8 would reduce the salt loading in the main basin to 900 tons/year and would improve the Zone 7 delivered water quality by approximately 90 mg/L to 210 mg/L. Pleasanton and Cal Water average delivered TDS levels would be even lower than noted above, because under Study 8 assumptions, they would be supplementing their Zone 7 purchases with their own 100 mg/L demineralized facilities' water. The cost increase would be in the range of $160/AF and would likely involve other non-Zone 7 demineralization facilities. The ten-year projected groundwater quality would increase by 30 mg/L to approximately 480 mg/L.

Study 9 is one of seven "composite" studies that evaluated the effect of increased conjunctive use plus wellhead demineralization. Each composite study was sized to

Table 9.9

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

NO ATTENUATION OF SALTS IN APPLIED WATER AND 22 TAF AVERAGE CONJUNCTIVE USE PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	2,900	250	270	2,685	990	3,670
Groundwater, extraction only wells	9,860	450	920	4,823	6,030	6,550
Groundwater , ASR wells	660	250	60	2,750	220	3,670
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total urban irrigation	13,945		1,360		7,670	5,640
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1940		490		710	1,450
Subsurface groundwater inflow	1,330	1,500	1,330	1,500	2,710	2,040
Total Natural Supply	24,155		14,220		16,010	1,130
ARTIFICIAL RECHARGE						
Stream recharge	14,120	250	14,120	250	4,800	340
Injection well recherge, ASR wells	10,930	250	10,930	250	3,720	340
Recycled water injection	6,006	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	55,205		45,270		25,350	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,625	250	890	340
Zone 7 municipal pumpage, Extraction only wells	3,505	450	2,140	610
Conjunctive use pumpage, Extraction only wells	26,230	450	16,050	610
Pumpage for injected recycled water, Extraction only wells	1,200	450	730	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	41,860		24,890	590
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	20	900	20	1,000
Total Demand	45,280		25,300	
WATER/SALT BALANCE	(10)		50	

Table 9.10

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

RO ALL ZONE 7 MUNICIPAL PUMPAGE AND NO CONJUNCTIVE USE GW PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	8,420	250	780	2,699	2,860	3,670
Groundwater, Zone 7 Extraction only wells	2,480	100	230	1,078	340	1,480
Groundwater, ASR wells	420	100	40	1,050	60	1,500
Groundwater, others (no Demin)	2,080	450	190	4,926	1,270	6,680
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,925		1,350		4,960	3,670
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	990	1,500	990	1,500	2,020	2,040
Total Natural Supply	23,795		13,870		12,610	910
ARTIFICIAL RECHARGE						
Stream recharge	3,460	250	3,460	250	1,180	340
Injection well recherge (ASR wells))	1,680	250	1,680	250	570	340
RO Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	34,935		25,010		15,180	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	1,680	250	570	340
Zone 7 municipal pumpage, Extraction only wells	5,810	450	3,550	610
Zone 7 municipal pumpage to waste, brine	1,158	450	710	610
Conjunctive use pumpage, Extraction only wells	0	450	0	0
Pumpage for injected RO recycled water, Extraction only wells	4,080	450	2,500	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	21,028		12,410	590
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	570	900	700	1,230
Total Demand	24,998		13,500	
WATER/SALT BALANCE	10		1,680	

Table 9.11
Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

RO ALL MUNICIPAL PUMPAGE (INCLUDING PLEASANTON & CWS) AND NO CONJUNCTIVE USE GW PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	8,490	250	790	2,687	2,890	3,660
Groundwater, Zone 7 Extraction only wells	2,400	100	220	1,091	330	1,500
Groundwater, ASR wells	440	100	40	1,100	60	1,500
Groundwater (pleasanton & cws)	1,650	100	150	1,100	220	1,470
Groundwater, others	430	450	40	4,838	260	6,500
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,935		1,350		4,190	3,100
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	1,010	1,500	1,010	1,500	2,060	2,040
Total Natural Supply	23,825		13,890		11,880	860
ARTIFICIAL RECHARGE						
Stream recharge	3,690	250	3,690	250	1,250	340
Injection well recherge (ASR wells))	1,750	250	1,750	250	590	340
RO Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	35,265		25,330		14,540	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	1,750	250	590	340
Zone 7 municipal pumpage, Extraction only wells	5,710	450	3,490	610
Zone 7 municipal pumpage to waste, Demin brine	1,131	450	690	610
Conjunctive use pumpage, Extraction only wells	0	450	0	0
Pumpage for injected RO recycled water, Extraction only wells	3,840	450	2,350	610
Other municipal pumpage	8,957	450	5,480	610
Total municipal pumpage	21,388		12,600	590
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	530	900	650	1,230
Total Demand	25,318		13,640	
WATER/SALT BALANCE	**10**		**900**	

reduce the salt loading to zero (or lower) and to maintain delivered water quality below the current baseline level of 300 mg/L TDS. Study 9 assumes that all of the Zone 7 groundwater pumpage would be demineralized from approximately 450 mg/L TDS to 100 mg/L TDS. In addition, 7 TAF of conjunctive use would be implemented, the minimum necessary to meet the constraints specified above.

Under these assumptions, the baseline (Study 1) 12 TAF of Zone 7 pumpage would be demineralized with reverse osmosis, and an additional 7 TAF of lower aquifer (450 mg/L TDS) groundwater would be pumped, demineralized, and replaced by recharging the groundwater basin with surface water.

As shown in tables 9.1 and 9.12, Study 9 would reduce the salt loading in the main basin to 100 tons/year and stabilize the ten-year projected groundwater quality at the current level of 450 mg/L TDS. Study 9 would improve the Zone 7 delivered water quality by approximately 90 mg/L to 210 mg/L and the cost increase would be in the range of $160/AF.

Study 10 evaluates the effect of using maximum conjunctive use based on stream recharge capacity plus enough wellhead demineralization to eliminate net salt loading. It assumes that 10 TAF of the baseline Zone 7 groundwater pumpage would be demineralized from approximately 450 mg/L TDS to 100 mg/L TDS. In addition, 16 TAF of stream recharge and groundwater pumpage for conjunctive use would be implemented using existing facilities.

As shown in tables 9.1 and 9.13, Study 10 would eliminate the net salt loading in the main basin and result in a slight reduction in the total mass of salt loading to the main basin. The ten-year projected groundwater quality would stabilize at the current level of 450 mg/L TDS, and the Zone 7 delivered water quality would improve by approximately 50 mg/L to 250 mg/L. The cost increase would be in the range of $90/AF.

Study 11 evaluates the effect of conjunctive use plus demineralization of high TDS shallow groundwater. It assumes that 5 TAF of stream recharge and groundwater pumpage for conjunctive use would be implemented using existing facilities. The 5 TAF of conjunctive use pumpage would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

In all previously described studies using demineralization, it was assumed that lower aquifer water with approximately 450 mg/L TDS would be demineralized. A fundamental difference and premise of Study 11 is that the salts residing in the higher TDS upper aquifer would eventually migrate vertically and degrade the higher quality lower aquifer. By pumping and demineralizing the high TDS upper aquifer water that potential degradation may be avoided.

Table 9.12

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

RO ALL ZONE 7 MUNICIPAL PUMPAGE AND 7 TAF AVERAGE CONJUNCTIVE USE GW PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	7,010	250	650	2,696	2,380	3,660
Groundwater, Zone 7 Extraction only wells	3,640	100	340	1,071	490	1,440
Groundwater, ASR wells	670	100	60	1,117	90	1,500
Groundwater, others (No Demin)	2,080	450	190	4,926	1,270	6,680
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,925		1,350		4,660	3,450
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	1,020	1,500	1,020	1,500	2,080	2,040
Total Natural Supply	23,825		13,900		12,370	890
ARTIFICIAL RECHARGE						
Stream recharge	8,520	250	8,520	250	2,900	340
Injection well recherge (ASR wells))	2,680	250	2,680	250	910	340
RO Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	41,025		31,100		17,000	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,680	250	910	340
Zone 7 municipal pumpage, Extraction only wells	3,480	450	2,130	610
Zone 7 municipal pumpage to waste, Demin brine	1,718	450	1,050	610
Conjunctive use pumpage, Extraction only wells	7,330	450	4,480	610
Pumpage for injected RO recycled water, Extraction only wells	3,680	450	2,250	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	27,188		15,900	580
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	500	900	610	1,220
Total Demand	31,088		16,900	

WATER/SALT BALANCE	10	100

Table 9.13

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

RO 10 TAF OF ZONE 7 MUNICIPAL PUMPAGE AND 16 TAF AVERAGE CONJUNCTIVE USE GW PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	4,640	250	430	2,698	1,580	3,670
Groundwater, Zone 7 Extraction only wells (NO Demin)	3,520	450	330	4,800	2,150	6,520
Groundwater, Zone 7 Extraction only wells (Demin)	2,510	100	230	1,091	340	1,480
Groundwater, ASR wells	660	250	60	2,750	220	3,670
Groundwater, others (No Demin)	2,080	450	190	4,926	1,270	6,680
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,935		1,350		5,990	4,440
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	1,300	1,500	1,300	1,500	2,650	2,040
Total Natural Supply	24,115		14,180		14,270	1,010
ARTIFICIAL RECHARGE						
Stream recharge	13,230	250	13,230	250	4,500	340
Injection well recherge (ASR wells))	5,890	250	5,890	250	2,000	340
RO Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	49,235		39,300		21,590	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,625	250	890	340
Zone 7 municipal pumpage, Extraction only wells	3,575	450	2,190	610
Zone 7 municipal pumpage to waste, Dmin brine	957	450	590	620
Conjunctive use pumpage, Extraction only wells	19,230	450	11,770	610
Pumpage for injected RO recycled water, Extraction only wells	1,200	450	730	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	35,887		21,250	590
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	20	900	20	1,000
Total Demand	39,307		21,660	
WATER/SALT BALANCE	(10)		(70)	

As shown in tables 9.1 and 9.14, Study 11 would eliminate the positive net salt loading in the main basin and result in a further reduction of 2,200 tons of salt per year in the main basin. The ten-year projected groundwater quality would improve from the current level of 450 mg/L TDS to 380 mg/L, and the Zone 7 delivered water quality would improve modestly by approximately 30 mg/L to 270 mg/L. The increase in cost would be approximately $40/AF. Study 11 may have an even greater positive impact on the salt balance in the main basin depending on the specific location chosen for the upper aquifer wells to be pumped. For example, available data indicates that the upper aquifer water may exceed 1,000 mg/L TDS in areas west of the Camp Parks well site.

Zone 7 groundwater model preliminary simulations (Chapter 10) indicated that the Study 11 assumed pumping of 5 TAF/year of shallow groundwater from the Camp Parks site would not be feasible. This finding led to developing studies 11A and 11B.

Studies 11A and 11B, variations of Study 11, evaluate the effect of conjunctive use plus demineralization of high TDS groundwater. Studies 11A and 11B assume that 10 TAF and 3 TAF, respectively, of stream recharge and groundwater pumpage for conjunctive use would be implemented using existing facilities. In addition, 1.5 and 3 TAF, respectively, of new shallow aquifer conjunctive use pumpage would be demineralized from 1,000 mg/L TDS to 100 mg/L TDS.

As shown in tables 9.1, 9.14A and 9.15, both studies 11A and 11B would eliminate the positive net salt loading in the main basin. The ten-year projected groundwater quality for both would stabilize at the current level of 450 mg/L TDS. However, Zone 7 delivered water quality would degrade slightly by 20 mg/L to 320mg/L in the case of study 11A but would improve modestly by approximately 20 mg/L to 280 mg/L in the case of Study 11B. The increase in cost would be approximately $20/AF for Study 11A and $30/AF in Study 11B. As noted above, studies 11A and 11B may have an even greater positive impact on the salt balance in the main basin depending on the specific location chosen for the upper aquifer wells to be pumped (e.g., Camp Parks well site).

Study 12 is the same as Study 11A (10 TAF conjunctive use and 1.5 TAF demineralization of upper aquifer water) except for the assumption of a 15% attenuation of salts in the vadose zone.

As shown in tables 9.1 and 9.16, Study 12 would eliminate the positive net salt loading in the main basin and would result in a reduction of 1,200 tons of salt per year in the main basin. The ten-year projected groundwater quality would improve from the current level of 450 mg/L TDS to 410 mg/L. Zone 7 delivered water quality (320 mg/L) and the resultant Zone 7 treated water rate increase ($20/AF) would be the same as shown in Study 11A. As noted above in Study 11A and Study 11B, Study 12 may also have an even greater positive impact on the salt balance in the main basin depending on the TDS of the specific upper aquifer wells to be pumped. Also, as noted earlier, the general conclusion on vadose attenuation is that salts are not permanently tied up in the vadose zone.

Table 9.14

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

RO 5 TAF OF ZONE 7 MUNICIPAL PUMPAGE AND 5 TAF AVERAGE CONJUNCTIVE USE GW PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	7,320	250	680	2,691	2,490	3,660
Groundwater, Zone 7 Extraction only wells (NO Demin)	2,090	450	190	4,950	1,280	6,740
Groundwater, Zone 7 Extraction only wells (Demin)	1,260	100	120	1,050	170	1,420
Groundwater, ASR wells	660	250	60	2,750	220	3,670
Groundwater, others (No Demin)	2,080	450	190	4,926	1,270	6,680
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,935		1,350		5,860	4,340
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	980	1,500	980	1,500	2,000	2,040
Total Natural Supply	23,795		13,860		13,490	970
ARTIFICIAL RECHARGE						
Stream recharge	6,520	250	6,520	250	2,220	340
Injection well recherge (ASR wells))	2,300	250	2,300	250	780	340
RO Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	38,615		28,680		17,310	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,625	250	890	340
Zone 7 municipal pumpage, Extraction only wells	3,745	450	2,290	610
Zone 7 municipal pumpage to waste, Demin brine	519	450	320	620
Conjunctive use pumpage, Extraction only wells	5,410	1,000	7,360	1,360
Pumpage for injected recycled water, Extraction only wells	4,160	450	2,550	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	24,759		18,490	750
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	530	900	650	1,230
Total Demand	28,689		19,530	
WATER/SALT BALANCE	(10)		(2,220)	

Table 9.14A

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

RO 1500 AF (FROM 1000 mg/l) OF ZONE 7 MUNICIPAL PUMPAGE AND 10 TAF AVERAGE CONJUNCTIVE USE GW PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	5,880	250	550	2,673	2,000	3,640
Groundwater, Zone 7 Extraction only wells (NO dmin)	4,410	450	410	4,840	2,700	6,590
Groundwater, Zone 7 Extraction only wells (demin)	380	100	40	950	50	1,250
Groundwater, ASR wells	660	250	60	2,750	220	3,670
Groundwater, others (No demin)	2,080	450	190	4,926	1,270	6,680
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,935		1,360		6,670	4,900
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	990	1,500	990	1,500	2,020	2,040
Total Natural Supply	23,805		13,880		14,320	1,030
ARTIFICIAL RECHARGE						
Stream recharge	11,230	250	11,230	250	3,820	340
Injection well recherge (ASR wells))	2,950	250	2,950	250	1,000	340
RO Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	43,985		34,060		19,960	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,625	250	890	340
Zone 7 municipal pumpage, Extraction only wells	3,075	450	1,880	610
Zone 7 municipal pumpage to waste, demin brine	0	450	0	0
Zone 7 municipal pumpage to waste, demin brine (from 1000 mg/l water)	200	1,000	270	1,350
Conjunctive use pumpage, Extraction only wells(Deep aquifer water)	10,340	450	6,330	610
Conjunctive use pumpage, Extraction only wells(1000 MG/L GW)	1,500	1,000	2,040	1,360
Pumpage for injected RO recycled water, Extraction only wells	4,160	450	2,550	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	30,200		19,040	630
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	460	900	560	1,220
Total Demand	34,060		19,990	
WATER/SALT BALANCE	0		(30)	

Table 9.15

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

RO 3000 AF (FROM 1000 mg/l) OF ZONE 7 MUNICIPAL PUMPAGE AND 3 TAF AVERAGE CONJUNCTIVE USE GW PUMPAGE FOR SALT MANAGEMENT

WATER SUPPLY COMPONENTS	APPLIED WATER		RECHARGE WATER		SALT	SALT LOAD IN TONS PER
	ACRE-FEET	TDS IN mg/l	ACRE-FEET	TDS IN mg/l	LOAD IN TONS	1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	7,680	250	710	2,704	2,610	3,680
Groundwater, Zone 7 Extraction only wells (NO demin)	2,230	450	210	4,779	1,360	6,480
Groundwater, Zone 7 Extraction only wells (demin)	750	100	70	1,071	100	1,430
Groundwater, ASR wells	660	250	60	2,750	220	3,670
Groundwater, others (No demin)	2,080	450	190	4,926	1,270	6,680
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,925		1,350		5,990	4,440
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	970	1,500	970	1,500	1,980	2,040
Total Natural Supply	23,775		13,850		13,600	980
ARTIFICIAL RECHARGE						
Stream recharge	5,170	250	5,170	250	1,760	340
Injection well recherge (ASR wells))	2,050	250	2,050	250	700	340
RO Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	36,995		27,070		16,880	

WATER DEMAND COMPONENTS	WATER REMOVED		SALT	SALT REMOVED IN TONS PER
	ACRE-FEET	TDS IN mg/l	LOAD IN TONS	1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,625	250	890	340
Zone 7 municipal pumpage, Extraction only wells	4,105	450	2,510	610
Zone 7 municipal pumpage to waste, DEMIN brine	0	450	0	0
Zone 7 municipal pumpage to waste, DEMIN brine (from 1000 mg/l water)	300	1,000	410	1,370
Conjunctive use pumpage, Extraction only wells(Deep aquifer water)	630	450	390	620
Conjunctive use pumpage, Extraction only wells(1000 MG/L GW)	3,000	1,000	4,080	1,360
Pumpage for injected RO recycled water, Extraction only wells	4,160	450	2,550	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	23,120		15,910	690
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	540	900	660	1,220
Total Demand	27,060		16,960	
WATER/SALT BALANCE	**10**		**(80)**	

Table 9.16

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

RO 1500 AF (FROM 1000 mg/l) OF ZONE 7 MUNICIPAL PUMPAGE, 12 TAF AVERAGE CONJUNCTIVE USE GW PUMPAGE FOR SALT MANAGEMENT AND 15% ATTENUATION

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	5,880	250	550	2,673	**1,700**	3,090
Groundwater, Zone 7 Extraction only wells (NO de	4,410	450	410	4,840	**2,290**	5,590
Groundwater, Zone 7 Extraction only wells (demin	380	100	40	950	**40**	1,000
Groundwater, ASR wells	660	250	60	2,750	**190**	3,170
Groundwater, others (No demin)	2,080	450	190	4,926	**1,080**	5,680
Domestic groundwater pumpage	120	450	70	771	**60**	860
LWRP reclaimed water irrigation	405	650	40	6,581	**300**	7,500
Total Urban Irrigation	13,935		1,360		5,660	4,160
Agricultural Irrigation						
SBA water	1,740	250	440	989	**500**	1,140
Groundwater	200	450	50	1,800	**100**	2,000
Total agricultural irrigation	1,940		490		600	1,220
Subsurface groundwater inflow	990	1,500	990	1,500	2,020	2,040
Total Natural Supply	23,805		13,880		13,200	950
ARTIFICIAL RECHARGE						
Stream recharge	11,230	250	11,230	250	3,820	340
Injection well recherge (ASR wells))	2,950	250	2,950	250	1,000	340
RO Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	43,985		34,060		18,840	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,625	250	890	340
Zone 7 municipal pumpage, Extraction only wells	3,075	450	1,880	610
Zone 7 municipal pumpage to waste, DEMIN brine	0	450	0	0
Zone 7 municipal pumpage to waste, DEMIN brine (from 1000 mg/l water)	200	1,000	270	1,350
Conjunctive use pumpage, Extraction only wells(Deep aquifer water)	10,340	450	6,330	610
Conjunctive use pumpage, Extraction only wells(1000 MG/L GW)	1,500	1,000	2,040	1,360
Pumpage for injected ROrecycled water, Extraction only wells	4,160	450	2,550	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	30,200		19,040	630
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	460	900	560	1,220
Total Demand	34,060		19,990	
WATER/SALT BALANCE	0		(1,150)	

Study 13 evaluates the impacts of pumping high TDS groundwater to the creeks (seasonal groundwater export) during periods of high flow so as not to adversely affect downstream beneficial uses. It assumes that 3.6 TAF/year of 1,000 mg/L TDS groundwater would be pumped to the Arroyo Mocho during specified wet weather flow periods and as long as groundwater storage exceeded 200 TAF. Groundwater would be replaced by buying additional SWP entitlement water. The pumped groundwater is assumed to be released in areas where it would not recharge the main basin. This study assumes that prior agreement would be reached with ACWD describing how such pumping would be managed so as not to unacceptably impact their recharge operations.

As shown in tables 9.1 and 9.17, Study 13 would eliminate the net salt loading in the main basin and stabilize the projected ten-year groundwater quality at current levels. The TDS of Zone 7 delivered water would remain unchanged at 300 mg/L TDS and the resultant increase in cost would be approximately $8/AF. The costs do not include replacement water and possible mitigation costs for potential impacts to ACWD.

Zone 7 groundwater model preliminary simulations indicated that pumping 3.6 TAF/year shallow groundwater from the Camp parks site would not be feasible. This finding led to developing Study 13A.

Study 13A is a small variation of Study 13 that evaluates the impacts of reduced pumping of high TDS groundwater to the creeks (seasonal groundwater export) during periods of high flow so as not to adversely affect downstream beneficial uses.

The major difference between 13 and 13A is the amount of groundwater export. Study 13 would require 3.6 TAF/year groundwater export from both the Camp parks well site and from an additional line of wells along the Arroyo Mocho or in a future Bernal Property well field. It would eliminate the salt balance. Study 13A includes only the maximum feasible 1.5 TAF/year of groundwater export from the proposed Camp Parks well site.

As shown in tables 9.1 and 9.17a, Study 13A would reduce the net salt loading in the main basin to about 1,700 tons/year and the projected ten-year groundwater quality would increase by 60 mg/L to 510 mg/L. The TDS of Zone 7 delivered water would remain unchanged at 300 mg/L TDS and the resultant increase in cost would be less than $1/AF. The costs do not include replacement water and possible mitigation for potential impacts to ACWD.

Studies 14, 14A and 15 were performed after the September 1998 Zone 7 Board decision not to support RO recycled water injection into the groundwater basin. All the original studies included 6 TAF per year of RO recycled water injection. In studies 14 and 14A, RO recycled water injection was reduced to 3,640 AF/Y (the combined DSRSD and Livermore RO design capacities). The RO recycled water injected into the basin was assumed to be recovered from the injection location during the irrigation season by

Table 9.17

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

WITH 3,600 ACRE-FEET AVERAGE ANNUAL 1000 TDS GW PUMPAGE TO ARROYO MOCHO (WASTE)

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	8,580	250	800	2,681	2,920	3,650
Groundwater, Extraction only wells	4,340	450	400	4,883	2,660	6,650
Groundwater, ASR wells	490	250	50	2,450	170	3,400
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,935		1,360		6,180	4,540
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	1,060	1,500	1,060	1,500	2,160	2,040
Total Natural Supply	23,875		13,950		13,970	1,000
ARTIFICIAL RECHARGE						
Stream recharge	4,700	250	4,700	250	1,600	340
Injection well recherge (ASR wells))	1,950	250	1,950	250	660	340
RO Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	36,525		26,600		17,050	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	1,950	250	660	340
Zone 7 municipal pumpage, Extraction only wells	5,470	450	3,350	610
Conjunctive use pumpage, Extraction only wells	0	450	0	0
Pumpage for injected recycled water, Extraction only wells	3,520	450	2,150	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	19,240		11,240	580
ZONE 7 GW PUMPAGE TO ARROYO MOCHO	3,590	1,000	4,880	1,360
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	450	900	550	1,220
Total Demand	26,680		17,060	
WATER/SALT BALANCE	(80)		(10)	

STUDY 13A

Table 9.17A

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

WITH 1500 ACRE-FEET AVERAGE ANNUAL 1000 TDS GW PUMPAGE TO ARROYO MOCHO (WASTE)

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	8,450	250	790	2,674	2,870	3,630
Groundwater, Extraction only wells	4,530	450	420	4,854	2,770	6,600
Groundwater, ASR wells	440	250	40	2,750	150	3,750
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,945		1,360		6,220	4,570
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	990	1,500	990	1,500	2,020	2,040
Total Natural Supply	23,815		13,880		13,870	1,000
ARTIFICIAL RECHARGE						
Stream recharge	3,650	250	3,650	250	1,240	340
Injection well recherge (ASR wells))	1,750	250	1,750	250	590	340
RO Recycled water injection	6,000	100	6,000	100	820	140
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	35,215		25,280		16,520	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	1,750	250	590	340
Zone 7 municipal pumpage, Extraction only wells	5,730	450	3,510	610
Conjunctive use pumpage, Extraction only wells	0	450	0	0
Pumpage for injected recycled water, Extraction only wells	4,000	450	2,450	610
Other municipal pumpage	8,300	450	5,080	610
Total municipal pumpage	19,780		11,630	590
ZONE 7 GW PUMPAGE TO ARROYO MOCHO	1,550	1,000	2,110	1,360
Agricultural pumpage	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	540	900	660	1,220
Total Demand	25,270		14,790	

WATER/SALT BALANCE	10	1,730

06/28/02

pumping 120% of the volume injected. As Study 1 was the baseline case for the original studies, Study 1B was performed to define the baseline for studies 14 and 14A. In Study 15, RO recycled water injection was totally eliminated. Study 1A was performed to define the baseline case for Study 15.

Studies 14 and 14A evaluate the effect of ASR RO recycled water and other conjunctive use plus demineralization of high TDS groundwater. These studies assume that 4 TAF of stream recharge and groundwater pumpage for conjunctive use will be implemented using existing facilities. About 4.6 and 3.8 TAF respectively of conjunctive use pumpage would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

In Study 14, the recovered RO recycled water pumpage would be delivered for agricultural irrigation use where most of it would be applied outside the main basin. In Study 14A, the recovered recycled water pumpage would be delivered for urban irrigation over the main basin. Since the low TDS injected and recovered RO recycled water would be delivered outside the main basin in Study 14, the salt removal benefit is less than in Study 14A and, therefore, Study 14 requires more wellhead demineralization than Study 14A to eliminate the salt loading. In these two studies, the majority of the salt removal is provided by wellhead demineralization. The RO recycled water ASR volume does increase the local water supply by offsetting summer treated water irrigation demands.

As shown in tables 9.1, 9.18 and 9.19, Studies 14 and 14A would eliminate the positive net salt loading in the main basin. The ten-year projected groundwater quality would stabilize at the current level of 450 mg/L TDS. Zone 7 delivered water quality would improve to about 250 and 255 mg/L, respectively. The increase in cost would be approximately $40/AF for Study 14 and $30/AF for Study 14A.

Study 15 evaluates the effect of conjunctive use plus demineralization of high TDS groundwater without any RO recycled water injection. Study 15 assumes that 8.5 TAF of stream recharge and groundwater pumpage for conjunctive use would be implemented using existing facilities. The 5 TAF of shallow aquifer conjunctive use pumpage included would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

As shown in tables 9.1 and 9.20, Study 15 would eliminate the positive net salt loading in the main basin. The ten-year projected groundwater quality would stabilize at the current level of 450 mg/L TDS. Zone 7 delivered water quality would be slightly better than the baseline case at 270 mg/L. The increase in cost would be approximately $50/AF.

9.5 Discussion of Results

The original baseline case Study 1 basin management study (that included 6 TAF of RO recycled water injection) was predicted to result in an average net salt loading to the main basin of approximately 3,100 tons/year, based on projected year 2010 conditions.

Table 9.18

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

4 TAF OF CONJUNCTIVE USE, 4.5 TAF OF SHALLOW RO, 3640 AF RECYCLED WATER INJECTION AND CWR WELLS PUMPING FOR AGRICULTURE DEMAND (120% of Recycled water)

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	8,730	250	820	2,662	2,970	3,620
Groundwater, Zone 7 Extraction only wells (NO demi	540	450	50	4,860	330	6,600
Groundwater, Zone 7 Extraction only wells (demin)	1,220	100	110	1,109	170	1,550
Groundwater, ASR wells	780	250	70	2,786	270	3,860
Groundwater, others (No demin)	2,180	450	200	4,905	1,330	6,650
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,975		1,360		5,500	4,040
Agricultural Irrigation						
SBA water	870	250	220	989	300	1,360
CWR Project agricultural pumpage	870	160	220	633	190	860
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		610	1,240
Subsurface groundwater inflow	1,080	1,500	1,080	1,500	2,200	2,040
Total Natural Supply	23,935		13,970		13,230	950
ARTIFICIAL RECHARGE						
Stream recharge	8,210	250	8,210	250	2,790	340
Injection well recherge (ASR wells))	2,950	250	2,950	250	1,000	340
RO Recycled water injection	3,640	100	3,640	100	490	130
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	38,735		28,770		17,510	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,950	250	1,000	340
Zone 7 municipal pumpage, Extraction only wells	2,040	450	1,250	610
Zone 7 municipal pumpage to waste, DEMIN brine	0	450	0	0
Zone 7 municipal pumpage to waste, DEMIN brine (from 1000 mg/l water)	465	1,000	630	1,350
Conjunctive use pumpage, Extraction only wells(Deep aquifer water)	20	450	10	500
Conjunctive use pumpage, Extraction only wells(1000 MG/L GW)	4,650	1,000	6,320	1,360
Pumpage for injected RO recycled water, Extraction only wells	0	450	0	0
Other municipal pumpage	8,300	450	5,080	610
Addtional DSRSD's pumpage for recycled injection	2,240	450	1,370	610
Total municipal pumpage	20,665		15,660	760
CWR Project agricultural pumpage	4,370	160	950	220
Agricultural pumpage (groundwater)	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	320	900	390	1,220
Total Demand	28,755		17,390	
WATER/SALT BALANCE	20		120	

Table 9.19

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

4 TAF OF CONJUNCTIVE USE, 3.8 TAF OF SHALLOW RO, 3640 AF RECYCLED WATER INJECTION AND CWR WELLS PUMPING FOR AGRICULTURE DEMAND (120% of Recycled water)

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	8,690	250	820	2,649	2,950	3,600
CWR Wells pumpage	4,370	160	410	1,705	950	2,320
Adjustment for CWR wells pumpage	(4,370)	325	(410)	3,464	(1,930)	4,710
Groundwater, Zone 7 Extraction only wells (NO dem	800	450	80	4,500	490	6,130
Groundwater, Zone 7 Extraction only wells (demin)	1,000	100	90	1,111	140	1,560
Groundwater, ASR wells	780	250	70	2,786	270	3,860
Groundwater, others (No demin)	2,180	450	200	4,905	1,330	6,650
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,975		1,370		4,630	3,380
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
CWR Project agricultural pumpage	0	160	0	ERR	0	0
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	1,080	1,500	1,080	1,500	2,200	2,040
Total Natural Supply	23,935		13,980		12,460	890
ARTIFICIAL RECHARGE						
Stream recharge	8,260	250	8,260	250	2,810	340
Injection well recherge (ASR wells))	2,970	250	2,970	250	1,010	340
RO Recycled water injection	3,640	100	3,640	100	490	130
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	38,805		28,850		16,770	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	2,970	250	1,010	340
Zone 7 municipal pumpage, Extraction only wells	2,000	450	1,220	610
Zone 7 municipal pumpage to waste, DEMIN brine	0	450	0	0
Zone 7 municipal pumpage to waste, DEMIN brine (from 1000 mg/l water)	380	1,000	520	1,370
Conjunctive use pumpage, Extraction only wells(Deep aquifer water)	1,050	450	640	610
Conjunctive use pumpage, Extraction only wells(1000 MG/L GW)	3,800	1,000	5,170	1,360
Pumpage for injected recycled water, CWR wells for urban irrigation	4,370	160	950	220
Other municipal pumpage	8,300	450	5,080	610
Addtional DSRSD's pumpage for recycled injection	2,240	450	1,370	610
Total municipal pumpage	25,110		15,960	640
CWR Project agricultural pumpage	0	160	0	0
Agricultural pumpage (groundwater)	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	320	900	390	1,220
Total Demand	28,830		16,740	

WATER/SALT BALANCE	20	30

Table 9.20

Main Basin Water Balance and Salt Balance
2010 Steady State Conditions

8.5 TAF OF CONJUNCTIVE USE, 5 TAF OF SHALLOW RO, NO RECYCLED WATER INJECTION

WATER SUPPLY COMPONENTS	APPLIED WATER ACRE-FEET	APPLIED WATER TDS IN mg/l	RECHARGE WATER ACRE-FEET	RECHARGE WATER TDS IN mg/l	SALT LOAD IN TONS	SALT LOAD IN TONS PER 1,000 ACRE-FEET OF RECHARGE
NATURAL						
Rainfall recharge water			4,100	0	0	
Arroyo Valle:						
Lake/imported water recharge	1,240	250	1,240	250	420	340
Natural recharge	1,830	440	1,830	440	1,090	600
Total Arroyo Valle	3,070		3,070		1,510	
Arroyo Mocho natural recharge	2,610	480	2,610	480	1,700	650
Arroyo las Positas natural recharge	1,260	1,000	1,260	1,000	1,710	1,360
Urban Irrigation						
SBA water	7,810	250	710	2,750	2,650	3,730
Groundwater, Zone 7 Extraction only wells (NO demi	1,280	450	150	3,840	780	5,200
Groundwater, Zone 7 Extraction only wells (demin)	1,260	100	120	1,050	170	1,420
Groundwater, ASR wells	980	250	100	2,450	330	3,300
Groundwater, others (No demin)	2,080	450	200	4,680	1,270	6,350
Domestic groundwater pumpage	120	450	70	771	70	1,000
LWRP reclaimed water irrigation	405	650	40	6,581	360	9,000
Total Urban Irrigation	13,935		1,390		5,630	4,050
Agricultural Irrigation						
SBA water	1,740	250	440	989	590	1,340
Groundwater	200	450	50	1,800	120	2,400
Total agricultural irrigation	1,940		490		710	1,450
Subsurface groundwater inflow	1,100	1,500	1,100	1,500	2,240	2,040
Total Natural Supply	23,915		14,020		13,500	960
ARTIFICIAL RECHARGE						
Stream recharge	4,810	250	4,810	250	1,640	340
Injection well recherge (ASR wells))	7,890	250	7,890	250	2,680	340
Recycled water irrigation	0	0	0		0	0
TOTAL SUPPLY	36,615		26,720		17,820	

WATER DEMAND COMPONENTS	WATER REMOVED ACRE-FEET	WATER REMOVED TDS IN mg/l	SALT LOAD IN TONS	SALT REMOVED IN TONS PER 1,000 ACRE-FEET OF EXPORT
Municipal Pumpage				
Zone 7 municipal pumpage, ASR pumpage	3,890	250	1,320	340
Zone 7 municipal pumpage, Extraction only wells	1,490	450	910	610
Zone 7 municipal pumpage to waste, RO brine	0	450	0	0
Zone 7 municipal pumpage to waste,demin brine (from 1000 mg/l water)	480	1,000	650	1,350
Conjunctive use pumpage, Extraction only wells(Deep aquifer water)	3,620	450	2,210	610
Conjunctive use pumpage, Extraction only wells(1000 MG/L GW)	5,000	1,000	6,800	1,360
Pumpage for injected RO recycled water, CWR wells for urban irrigation	0	160	0	0
Other municipal pumpage	8,300	450	5,080	610
Addtional DSRSD's pumpage for ROrecycled injection	0	450	0	0
Total municipal pumpage	22,780		16,970	740
CWR Project agricultural pumpage	0	160	0	0
Agricultural pumpage (groundwater)	200	450	120	600
Mining export	0	520	0	0
Mining offhaul	400	500	270	680
Pond evaporation	2,800	0	0	0
Subsurface groundwater outflow	440	900	540	1,230
Total Demand	26,620		17,900	
WATER/SALT BALANCE	**100**		**(80)**	

Groundwater quality would degrade by 10 mg/L/year to 550 mg/L after ten years and delivered water quality would be on average 300 mg/L. Under the Study 1A baseline case (with no RO recycled water injection), year 2010 net loading would increase to 5,400 tons/year. Groundwater quality would degrade by 18 mg/L/year to 630 mg/L after ten years and delivered water quality would be on average 275 mg/L.

Salt Loading to the main basin in eight of the fifteen basin management studies described above would be reduced to zero or less. These include Studies 2, 6, 9, 10, 11, 12, 14 and 15. The remaining studies would result in salt loading to the main basin varying between 100 and 2,000 tons/year. Studies 3, 4, and 12 include vadose zone attenuation assumptions. Based on the recommendations of the Zone 7 Technical Advisory Group and Citizen GMAC, minimal, if any, permanent attenuation of salts is believed to occur within the soil and gravel above the main basin. These studies were retained as a point of reference rather than feasible implementation options.

Groundwater Quality Impacts based on the projected salt loadings associated with each of the studies show that the projected net increases in groundwater TDS would vary from -4 mg/L/year in Study 12 to +18 mg/L/year in Study 1A. Given the multiple factors involved in predicting such basin-wide responses with a spreadsheet-based model, actual net increase in TDS may be less than the values projected in Table 9.1. The values equitably compare the relative magnitude of the effects of the various salt management options investigated with respect to long-term groundwater quality impacts. Under all conditions, TDS may continue to increase for a decade after the salt balance has been reduced to zero until a new steady-state equilibrium is reached.

The projected TDS in the groundwater after ten years of implementation of the salt management studies associated with studies 1 through 15 could vary by as much as +/-100 mg/L from the current level of 450 mg/L. It should be noted that these values were computed based on average hydrology and assumed hypothetical mixing of upper and lower aquifers, therefore, actual changes in loading and groundwater TDS at individual wells in a given year could vary significantly from these projections depending on the actual ten-year hydrology between 2000 and 2010. In either case, the basin is close to approaching the 500 mg/L TDS recommended secondary MCL standard and basin plan groundwater quality objective.

Delivered Water Quality Impacts under baseline Study 1 conditions (maximizing imported surface water deliveries) would result in a Zone 7 delivered water TDS of approximately 300 mg/L. The resultant TDS associated with other basin management studies varies from 180 mg/L for the Delta Fix to 390 mg/L for Study 5 (maximizing groundwater deliveries through conjunctive use). Other studies which would improve the delivered water quality compared to the current basin management practice are those that include demineralization as a component of the overall strategy. Studies which result in increased TDS in the delivered water are those based on implementation of conjunctive use as the primary mode of salt management.

Note that the delivered water TDS values cited are the overall average annual value from the 75-year simulations. Actual annual values under a given study will vary depending on the actual year hydrology and impacts on SBA water quality. Under Study 1 for example delivered water TDS would range from 250 to 440 mg/L (see detail tables for each study in Reference M (far right column) for the ranges of calculated TDS).

Costs—Incremental operational costs for the basin management studies described by studies 1 through 15 range from $0 to $160 per acre-foot of treated water delivered in 2010. The least expensive solution which yields a zero or negative salt loading to the main basin is the Delta Fix (Study 2) with assumed incremental costs of $0 per acre-foot of treated water delivered. It should be noted that the $17 billion delta fix will likely be paid in part by Zone 7 customers (probably via taxes) but not in Zone 7 water rates.

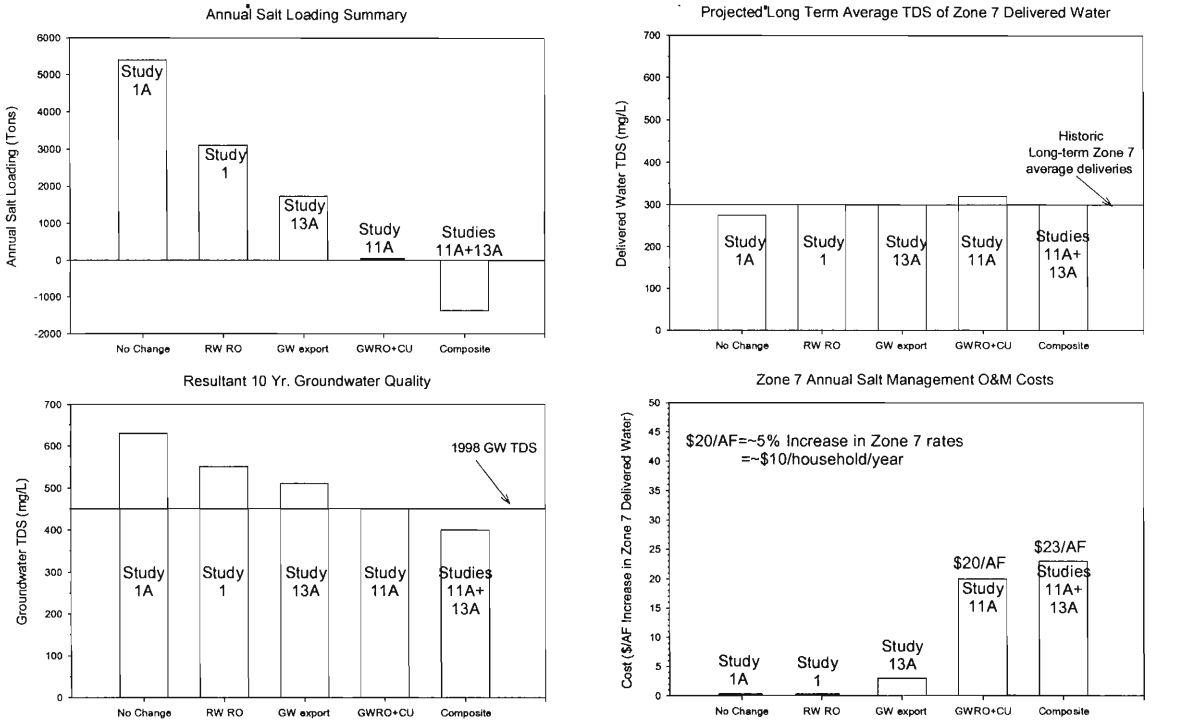
The next least-cost solutions yielding no net increase in salt loading are studies 6, 11 A&B, 14 and 15 with costs of $20, $20, $40 and $50 per acre-foot, respectively. Study 5, which still results in an estimated salt loading of 800 tons/year, has an incremental operational cost of only $10 per acre-foot of treated water delivered (but results in 360 mg/L TDS delivered water quality). Studies 7, 8, 9, and 10 have incremental operational costs of $110, $160, $160, and $100 per acre-foot of treated water delivered, respectively.

Composite Studies —A composite basin management study composed of a number of individual salt management studies may be best suited to balance the likely multiple requirements for an effective and acceptable overall salt management practice (i.e., balanced salt loading, low cost, decreased TDS of delivered water, etc.). Depending on the priorities of these requirements and public acceptance of individual strategies, the combination of studies implemented could vary from year to year.

To demonstrate the effectiveness of a potential composite salt management strategy, seasonal groundwater export (Study 13A) was paired first with Study 11A and then with Study 11B (wellhead demineralization) in figures 9.1 and 9.2, respectively. These four clustered bar graphs present the relative impacts on salt loading, groundwater quality, delivered water quality, and the cost of selected individual and composite strategies. Study 1A (left-most bar) is shown in each case as the "base case" for comparative purposes.

The effect of including RO recycled water injection (Study 1) is shown by the second bar from the left. The effect of adding seasonal groundwater export (under Study 1 base case conditions with RO recycled water injection) is shown in the third bar from the left. The effect of instituting high TDS groundwater demineralization (under Study 1 base case conditions) is shown by the fourth bar from the left. The fifth bar from the left shows the "composite" study (Study 13A plus 11A or B) cumulative results (under Study 1 base case conditions).

Figure 9.1
Individual and Composite Salt Management Studies at 2010 Condition
Option 1 - Maintain Historic Delivered Water Quality and Groundwater TDS



RWRO = 6 TAF of RO Recycled Water (RW) Injection
GW export = RWRO and 1.5 TAF groundwater (1000 mg/L) discharge to waste
GWRO + CU = RWRO and demineralization of 1.5 TAF groundwater (1000 mg/L) and 10 TAF conjunctive use (CU)
Composite = RWRO and GW export and GWRO + CU

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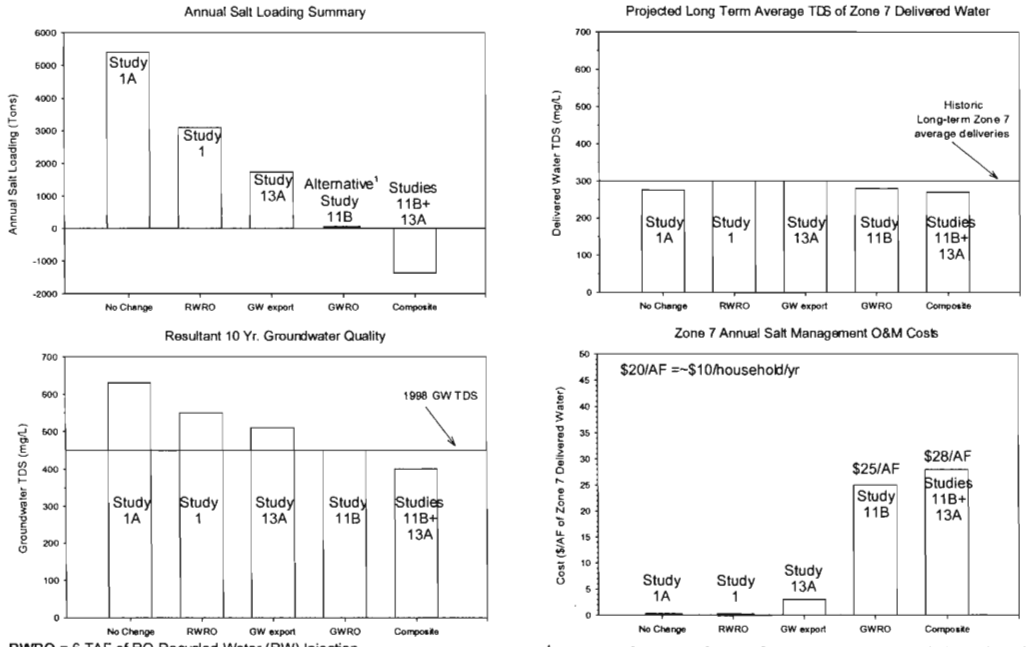
Figure 9.1 demonstrates that a composite salt management study composed of 1.5 TAF of groundwater export, 1.5 TAF of high TDS groundwater demineralization, and 10 TAF conjunctive use would result in a negative net salt loading (on average), an unchanged long-term average TDS of the delivered water, a modest decrease in the long-term TDS of the groundwater, and an incremental operational cost of approximately $23/AF of treated water deliveries.

Figure 9.2 below depicts a slightly more expensive composite strategy, but one that would improve both groundwater quality and delivered water quality. The major difference from Figure 9.1 is 3.0 TAF of high TDS groundwater demineralization (Study 11B) instead of 1.5 TAF in Study 11A. Such a composite salt management study would increase incremental operational costs by approximately $28/AF of treated water deliveries.

Figure 9.2
Individual and Composite Salt Management Studies at 2010 Condition
Option 2 - Improve Delivered and Groundwater TDS



RWRO = 6 TAF of RO Recycled Water (RW) Injection
GW export = RWRO and 1.5 TAF groundwater (1000 mg/L) discharge to waste
GWRO = RWRO and demineralization of 3 TAF groundwater (1000 mg/L)
Composite = RWRO, GW export, and GWRO

[1] Alternative Strategy 11B is to RO enough groundwater to balance the salt loading (~3 TAF of 1000 mg/L groundwater)

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9.6 Feasibility Screening of Year 2010 Studies

These screening level studies demonstrate that a salt management strategy can have both advantages and disadvantages associated with it. This is especially true given that a successful strategy will likely have to meet multiple, potentially competing goals, as discussed in Chapter 7. These could include, for example: net loading less than x tons/year, delivered water quality less than y mg/L, and incremental cost less than $z per acre-foot of treated water deliveries. Composite studies (such as studies 11-15) appear most capable of providing maximum flexibility in meeting multiple goals. They should also be more adaptable in addressing unpredictable annual variations in water supply and quality than approaches relying on a single strategy.

A feasibility screening of the salt management studies identified earlier in this chapter was conducted as summarized in Figure 9.3 to help narrow the focus of additional investigations. The feasibility screening was composed of five different screens including:

- Technical Feasibility
- Timing
- Economics
- Delivered water quality

Figure 9.3
Feasibility Screening of
Year 2010 Salt Management Studies

Study	Name	Screen #1	Feasible Studies	Screen #2	Feasible Studies	Screen #3	Feasible Studies	Screen #4	Feasible Studies	Screen #5	Feasible Studies
		Technical Feasibility		Timing		Economics		Delivered water quality		Public or institutional acceptance	
1/1B	Status Quo (with RO Recycled water injection)		1/1B		1/1B		1/1B		1/1B		
1A	Status Quo (without RO Recycled water injection)		1A		1A		1A		1A		
2	Delta Fix		2								
3	15% Attenuation										
4	30% Attenuation										
5	16 TAF GW Pumpage for Conjunctive Use		5		5		5				
6	22 TAF GW pumpage for conjunctive use		6		6		6				
7	Demineralize Z7 GW Pumpage		7		7						
8	Demineralize all Pumpage		8		8						
9	Comp. CU & 19 TAF Demin		9		9						
10	Comp. CU & 10 TAF Demin		10		10						
11	Comp. CU & 5 TAF Demin										
11A	Comp. CU & 1.5 TAF Demin		11A		11A		11A				
11B	Comp. CU & 3 TAF Demin		11B		11B		11B		11B		
12	Comp. CU, Demin, & attenuation										
13	Seasonal groundwater export (3.6 TAF/ year)		13		13		13		13		
13A	Seasonal groundwater export (1.5 TAF/ year)		13A		13A		13A		13A		
14	Comp. CU & 4.5 TAF Demin		14		14		14		14		
14A	Comp. CU & 3.8 TAF Demin		14A		14A		14A		14A		
15	Comp. CU & 5 TAF Demin, no RO recycled water injection		15		15		15		15		15

Explanation of Screens

1 Is the implementation technically feasibly?
2 Is timing of alternative predictable?
3 Is resultant cost ($/AF) acceptable ?
4 Is the resultant predicted delivered WQ acceptable?
5 Could alternative be accepted and implemented near-term?

Description of Composite Studies

9. 19 TAF demineralized municipal pumpage, 7 TAF conjunctive use
10. 10 TAF demineralized municipal pumpage, 16 TAF conjunctive use
11. 5 TAF demineralized municipal pumpage (1000 mg/L), 5 TAF conjunctive use
12. Same as #11a, also includes 15% attenuation
14. CWR injection wells pumping for AG use (inject and recover mode)
14a. CWR injection wells pumping for urban irrigation use (inject and recover mode)
15. No recycled water injection, 5 TAF demineralized municipal pumpage and 8.5 TAF conjunctive use pumpage

- Public and institutional acceptance

The feasibility screens were initially applied to the original studies (with RO recycled water injection). Study 11B passed all screens except for the public acceptance ability of the groundwater injection component of RO recycled water. If and when the public were to accept the injection of RO recycled water into the groundwater basin, Study 11B would be the highest ranked, least cost management strategy. Since none of these original studies passed all the screens, studies 14, 14a and 15 were developed and the feasibility screens were reapplied. Following is a discussion of each feasibility screen and the screening results.

The first screen, technical feasibility, eliminates studies that depend upon vadose zone attenuation or unattainable amounts of localized shallow groundwater pumping to remove salts. As noted earlier, the extent, if any, of attenuation of dissolved salts in the vadose zone is uncertain. Based on the best available evidence and guidance from the Zone 7 Groundwater Advisory Committee, it has been assumed that although there may be a time lag between salts applied over the main basin and impacts on the groundwater, all salts applied over the main basin will eventually migrate vertically to the aquifer. Based on this assumption, none of the studies including attenuation (3,4, or 12) would be acceptable.

Study 11 was found to be technically infeasible because it would not be possible to pump 5 TAF per year from the shallow aquifer at the Camp Parks well site, based on the preliminary groundwater model simulation for Study 11. The model predicted that only 1.5 TAF/year of sustained pumpage would be available from this site. It would require too many shallow well locations (which at this time is not believed physically feasible) to be able to sustain the required 5 TAF/year shallow groundwater pumpage.

The second screen shown in Figure 9.3 is timing. While highly desirable, Study 2, the Delta Fix, does not pass this screen since it cannot be predicted with any certainty what CalFed alternative may be implemented and when. While the Delta Fix cannot be relied on as the sole strategy (particularly in the near-term) to mitigate the current salt loading to the main basin, the implementation of other studies can be conducted in a manner to allow the Delta Fix to be added to the mix of available studies if and when a Delta Fix is realized.

The economics screen eliminates studies that are likely to be considered impractical because of high costs. Based on the planning level O&M costs in Table 9.1, none of the studies that rely on significant amounts (10 to 20 TAF) of typical production well (450 mg/L TDS) demineralization pass this screen. This rules out studies 7, 8, 9, or 10 where the operational costs range from approximately $100 to $160/AF of treated water delivered. The maximum incremental operational cost of the other studies investigated is $50/AF of treated water delivered.

The delivered water quality screen eliminates studies that may control salt loading but cause an unacceptable increase in the TDS of the Zone 7 delivered water. Studies that rely on conjunctive use as the primary mode of salt reduction (5, 6, and 11A) without significant wellhead demineralization to maintain delivered water TDS levels, fail to pass this screen.

The final screen eliminates studies that are unlikely to be deemed acceptable by the general public or involved public institutions and agencies. Studies 1 and 1B (Status Quo) did not pass because they did not eliminate the salt imbalance and the also included RO recycled water injection into the main basin, which was unacceptable to a portion of the public. Study 1A (Status Quo without RO recycled water injection) failed to pass this screen because groundwater basin quality degradation would continue at an even higher rate than under Study 1. As described in Chapters 7 and 8, the status quo is not compatible with the goal of maintaining sustainable groundwater quality. The status quo at some point could be in conflict with state and federal non-degradation requirements. From a public opinion perspective, allowing continued degradation may also not be considered responsible stewardship of the groundwater resource.

Studies 13 and 13A (seasonal groundwater export) do not, at this time, pass the acceptance screen because of the inter-agency coordination issues that need to be addressed regarding the export of additional salts through the Niles cone. It is possible that an agreement could be reached with ACWD with respect to seasonal groundwater export at some time in future. If and when this happens, implementation of seasonal groundwater export as one component in a composite study would be desirable.

Study 11B, a composite of conjunctive use (stream recharge and groundwater pumping) and 3 TAF of wellhead demineralization would eliminate the salt balance in 2010 and maintain delivered water quality. It would be economically reasonable compared to other salt neutral and delivered water quality neutral strategies. The main limitation of this study is that it includes 6 TAF/year of RO recycled water injection, which is unacceptable to the public at this time. Studies 14 and 14A which include groundwater injection, re-extraction, and delivery of RO recycled water for agricultural irrigation or urban irrigation, also did not pass this final screen for similar reasons.

Study 15, the only study that passed all the screens, is a composite of conjunctive use and 5 TAF of wellhead demineralization. Since the Camp Parks well site would not yield more than 1.5 TAF from the shallow aquifer, it would require multiple shallow groundwater pumping locations (or multiple demineralization facility sites). This study would eliminate the salt imbalance at a relatively low cost, improve or maintain delivered water quality, and is believed to be acceptable to public. To be successful it requires reaching agreement with LAVWMA/EBDA on brine export.

In summary, Studies 11B and 15 both appear promising. Study 11B is less expensive than 15 but it does not pass the public acceptability screen at this time because it includes RO

recycled water injection. The seasonal groundwater export studies 13 and 13a would also be economically attractive as partial future solutions, assuming institutional arrangements with ACWD could be addressed in a mutually satisfactory manner.

Based on these Chapter 4 results, baseline studies 1A and 1 and corresponding salt neutral studies 11B and 15 were developed and evaluated in more detail using the Zone 7 groundwater and system operation numeric models. Results are presented in Chapter 10.

Chapter 10

Key 2010 Salt Management Strategies Modeling

Chapter 10

Key 2010 Salt Management Strategies Modeling

10.1 Introduction

The 15 basic salt management strategies (referred to as "studies") described in Chapter 9 were first developed and refined by using the Zone 7 "spreadsheet" model which routes water and TDS through the water system on an annual basis for 2010 land and water use conditions and historic 1922-96 hydrology. The spreadsheet model analysis was used in part to confirm that a strategy is a viable plan for managing water facilities to meet customer demands under any historic hydrologic (1922-96) conditions. Zone 7, with input from the GMAC and water retailers, developed and evaluated each of the fifteen salt management strategies. The salt management strategies were evaluated using screening criteria that included: technical feasibility, timing, economics, impacts on delivered water quality and public or institutional acceptance. A significant conclusion was that composite salt management strategies (i.e., approaches using several individual salt management strategies) were most promising.

Zone 7 staff, with consultant assistance, developed two more sophisticated models to further evaluate the viability of the strategies and to evaluate the delivered water quality impacts of each strategy. A numerical groundwater basin model and a linear programming water system operations optimization model that routes water and salt through our system on a monthly basis were used to evaluate different basin salt management and water supply strategies. The simulation results from these models were presented at numerous GMAC, Technical Advisory Group (TAG) retailer meetings and several Board Groundwater committee meetings. All groups concluded that the strategies were viable (workable) and that the results provided reasonable estimates of future groundwater and delivered water quality.

Groundwater Model—In 1996, Zone 7 staff retained CH2M Hill to assist with the development of a groundwater flow and solute transport (salt) model for the main groundwater basin for use in the Salt Management Plan and for studying future main basin management options. The model uses Visual MODFLOW for Windows version 2.61 by Waterloo Hydrologic, Inc. This modeling package includes groundwater flow and solute transport simulation. Visual MODFLOW uses the three-dimensional MODFLOW code to simulate flow and the three-dimensional MT3D code to simulate solute transport. The Zone 7 hydrologic inventory data from 1974-96 were used to evaluate and calibrate the model. Then the salt balance data from 1974-96 were modeled for solute transport. Section 3.7 (Groundwater Model) describes the groundwater model and calibration in more detail. The overall agreement between the model groundwater quality results and actual

groundwater quality provides a high degree of confidence in the regional water quality simulation capabilities of this groundwater model.

CH2M Hill completed a groundwater modeling evaluation of several salt management strategies in June 1998. At that time all of the strategies had anticipated RO recycled water injection as an integral part of future Zone 7 basin management activities. Between May and August 1998, public concerns over the injection of RO recycled water for potable reuse became a serious issue and in September 1998 the Zone 7 Board passed a resolution requiring demonstrated public acceptance prior to supporting injection. Following the September 1998 resolution on DSRSD's CWR project, Zone 7 staff developed additional strategies that did not include RO recycled water injection but that would still meet salt balance goals. Zone 7 staff completed the groundwater modeling simulations needed for these new strategies. The final report, *Phase 4 Groundwater Modeling: Salt Management Plan Simulations by Dan Wendell and Mike Basial of CH2M HILL* (Reference N), was completed in January 1999 and includes the simulation results for all modeled strategies (including the modeling completed by Zone 7).

Water System Operations Model—In 1997, Zone 7 staff contracted with Water Resources Management, Inc. (WRMI) for the development of a water operations optimization model. The model details are described in Section 2.6. Zone 7 staff working with WRMI, completed several model simulations designed to predict the delivered water quality at each of the Zone 7 turnouts. Retailers' groundwater pumping was input and simulations of each retailer's delivered water quality were also generated. Projected groundwater quality information from the groundwater model runs was used as input to this model. The results of these modeling simulations are presented in this chapter.

These modeling capabilities have provided Zone 7 the ability to much more rigorously evaluate alternative management strategies by which Zone 7 could manage the groundwater basin through the coordinated use of existing and planned facilities to correct the salt imbalance. The modeling simulations show how the groundwater basin and distribution system can be managed for sustainable groundwater quality and delivered water quality.

All the strategies except 14 and 14a were evaluated using the numerical groundwater model for the basin. Strategies 1, 11B and 15 were further evaluated using the linear programming water operations optimization model (WRMI). That model routes water and salt through the Zone 7 system on a monthly basis and computes monthly delivered water quality to each treated water turnout. This chapter describes the use of the models for evaluating salt management strategies and the model simulation results for strategies 1, 1A, 11B and 15.

10.2 Baseline and Key Strategy Assumptions and Descriptions

Out of the 15 salt management strategies evaluated in Chapter 9, eight strategies including 1, 1A, 11B, 13, 13a, 14, 14a and 15 made it through the first four screens (technical

feasibility, timing, economics and delivered water quality). Strategy 1, 1A and 13a did not pass the public/institutional screen because they do not maintain groundwater quality. These strategies would create 3,100, 5,400 and 1,730 tons/year net salt loading, respectively. Strategies 11B, 13, 14, 14a and 15 would be salt neutral (i.e., zero net salt loading in 2010).

Strategies 1A and 1 failed the final screen ("public or institutional acceptance"), but are carried into this chapter for more detailed evaluation and description to serve as quantitative baselines for the two salt neutral strategies 11B and 15. Strategy 11B which is less expensive than 15, did not pass the final screen ("public or institutional acceptance") at this time because it included RO recycled water injection into the main groundwater basin. If and when RO recycled water injection is deemed acceptable or any other low TDS source (~100 mg/L) of groundwater recharge becomes feasible, Strategy 11B would be a preferred salt management strategy. Strategy 15 is the only strategy that currently passed all the screens. At this time it is the best strategy that would balance the salt loading without using RO recycled water (RW) injection.

Table 10.1 presents a summary of the key salt management strategies discussed in this chapter. Following is an explanation of terms used in Table 10.1.

Policy Options are described in Section 7.2. Option 1 is the Status Quo with basin groundwater quality continuing to degrade. Option 2 is to maintain Status Quo until a trigger or regulatory limit is reached. Option 3 is stabilize groundwater quality at current quality and Option 4 is to improve groundwater quality.

Net salt loading values are the expected salt loading to the main basin under the investigated salt management strategy and are rounded to the nearest 100 tons/year.

Net increase in TDS converts the net salt loading in the basin to a corresponding average annual increase in TDS (mg/L/year) of the groundwater. Implicit in this conversion is the assumption that all salts have been uniformly mixed with groundwater.

Projected groundwater TDS after 10 years assumes that the current groundwater contains 450 mg/L TDS and computes the expected TDS after 10 years based on salt loading. Implicit in this calculation is the assumption that the upper and lower aquifers are mixed and that all salt loading at the surface reaches the groundwater basin.

TDS of Zone 7 deliveries are calculated assuming constant surface water (250 mg/L) TDS and groundwater (450 mg/L) TDS concentrations. It should be noted that actual SBA concentrations could vary from 100 to over 700 mg/L and the actual groundwater TDS values also can vary, as described in Chapter 4.

Table 10.1
SUMMARY OF KEY SALT BALANCE STRATEGIES AT 2010 CONDITIONS

		LONG TERM AVERAGE							
Strategy No.	NAME	Policy Option	Net Salt Loading Tons/y	Net Increase in GW TDS mg/l	Projected GW TDS After 10 Yrs. mg/l	TDS of Zone 7 Deliveries mg/l	Zone 7 Incremental Operational Cost per Year	Per Acre-foot of TW Delivery	% Rate Increase
1A	Status Quo No RO RW injection	I	5400	18	630	275	$0	$0	0.0%
1	Status Quo plus 6 TAF RO RW injection	I	3100	10	550	300	$0	$0	0.0%
11B	Composite of 6 TAF RO RW injection, Increased Conjunctive Use & Demineralization of high TDS(1,000 mg/L) GW	III	0	0	450	277	$2,351,000	$40	7.9%
15	Composite of Increased Conjunctive use & Demineralization of High TDS GW	III	0	0	450	270	$2,607,000	$50	9.8%

Assumptions:
1 All strategies do not include salt loading due to future development outside the main basin or new recycled water irrigation water use.
2 Incremental operational cost is based upon total treated water deliveries (45,100 AF Zone 7 plus 7,214 AF GPO pumpage).
3 Percent increase to Zone 7 water rate is based upon 1998 rate of $508/AF.

Annual incremental operational costs are conceptual planning level costs for unit operations and maintenance only. These costs include $60/AF for municipal groundwater pumping, $20/AF marginal cost to treat the water at one of the treatment plants, $400/AF for wellhead demineralization, $150/AF of brine disposed from associated wellhead demineralization, $40/AF for groundwater pumping to waste, and $70/AF SWP entitlement variable charges for replacement water.

10.2.1 *Common Assumption for All Strategies (Baseline 1998 Conditions)*

The following is a list of the assumptions that were used in all strategies except as noted otherwise. A brief description of these assumptions is also available in Section 9.5.

Zone 7 Water System Facilities—Although all the strategies include facilities in addition to those presently (1998) available, the majority of the strategies involve use of facilities already scheduled for construction as part of the Zone 7 expansion program (i.e., no new capital costs incurred solely for salt management).

Demand and Supply—Zone 7's treated water demand for 2010 is 45,100 AF and untreated demand is 8,700 AF/year. The hydrologic study period used for local supply and SWP water supply is 75 years (1922 through 1996). The SWP demand is assumed to be 4.1 MAF. The existing Zone 7 SWP entitlement is 46 TAF. An additional 15 TAF is assumed to be available by 2010. The available surface water supply for treated water deliveries is limited by the SWP yield for the year, Zone 7's water treatment plant capacity, the maximum instantaneous SBA flow rate, and the maximum monthly delivery from the SWP.

Water Quality—SBA water TDS was assumed at 250 mg/L, ASR pumpage TDS at 250 mg/L, and groundwater TDS at 450 mg/L. Annual average delivered water quality is calculated using these consistent concentration values proportioned to the blend of surface and groundwater delivered each year.

Wells—These strategies assume that there will be some groundwater pumpage required to meet peak demands. The required groundwater pumpage is the sum of pumpage for daily peaking and seasonal peaking. It was assumed that if ASR is successful, Zone 7 could use ASR wells to inject low TDS surface water into the basin and pump it out to meet peak demands. The studies assumed injection capacity of ASR wells to be approximately 8,300 AF/year by year 2010. If ASR wells were not to be used (due to well clogging problems), increased wellhead demineralization could be used to maintain delivered water TDS and the Chain of Lakes could be used for surface water recharge.

Storage—It is assumed that when total groundwater storage at the beginning of the water year is over 240 TAF, Zone 7 will pump groundwater for deliveries and surface water supplies will be carried over for the following year. It was assumed that Zone 7 would be allowed to carryover 10 TAF of local storage from one year to the next. Lake Del Valle supplies include the local water used as direct inflow and local water used after storage in the lake. It does not include the local water released from the lake for recharge to satisfy prior rights on the Arroyo Valle.

Recharge—The artificial stream capacity includes existing Arroyo Mocho recharge capacity, existing Arroyo Valle recharge capacity, and the recharge capacity of Lake I in the Chain of Lakes. The existing Arroyo Mocho recharge capacity is about 19 cfs from April through September and 14 cfs from October through March. The existing recharge capacity on the Arroyo Valle is approximately 3 cfs (reach 1&2). It was assumed that the stream capacity from June through August would be unusable due to the SBA capacity limit. Therefore, stream capacity is used for only nine months of the year. Delivery into Lake I is assumed to be 30 cfs for six months of the year. It is anticipated that Zone 7 would make recharge releases between October and June down the Arroyo Mocho at a rate at 50-60 cfs. Of this, 20-25 cfs would recharge in the Arroyo Mocho and 30-35 cfs would be diverted for storage and recharge in the Chain of Lakes.

Salts—All strategies except strategies 3, 4 and 12, assume that there is no vadose zone attenuation and that 100% of applied salts ultimately mix with and impact the groundwater.

10.2.2 Strategy 1A—Status Quo (Without RO Recycled Water Injection)

Strategy 1A is considered the baseline case and is based on Zone 7's historic operational criteria. The historic criteria are to maximize surface water deliveries and pump groundwater only for peaking and drought conditions. Strategy 1A does not include any salt management measures and minimizes operational costs.

Strategy 1A results in an average salt loading of 5,400 tons/year (Table 9.4a) and a delivered water TDS of 275 mg/L under year 2010 conditions. Since this is the baseline case in which no changes in operation and no additional facilities are required other than those already assumed to be in place in the year 2010, there are no incremental costs associated with this strategy. Strategy 1A defines the baseline conditions for salt management Strategy 15.

10.2.3 Strategy 1—Status Quo Plus 6 TAF/Y RO Recycled Water Injection

Baseline Strategy 1 varies from baseline Strategy 1A in that Strategy 1 includes 6 TAF of RO recycled water injection into the main basin. Since this 6 TAF/Y RO recycled water injection is a new source of recharge, it was assumed that Zone 7 would increase groundwater pumpage to offset this new supply. Strategy 1A also does not include any salt management measures other than the assumed 6 TAF of RO recycled water injection and increased groundwater pumpage (to offset the recycled water injection volume) common to strategies 1-13.

RO recycled water (or other low TDS water) injection or stream recharge of 6 TAF per year is 2,300 AF more than the amount potentially available through the existing Livermore and DSRSD projects. The Livermore and DSRSD projects could produce 840 AF/Y and 2,800 AF/Y, respectively. Strategy 1 assumed that these projects would be expanded and the additional 2,300 AF/Y would be recharged in the future Chain of Lakes. This is a significant potential component since the assumed injection of 100 mg/L TDS water and extraction of 450 mg/L groundwater elsewhere represents 2,300 tons per year of salt removal from the basin in 2010. Since Zone 7 would have to purchase additional supplies to meet 2010 demand, the cost to purchase the RO and injected recycled water from DSRSD and Livermore was assumed to be covered by Zone 7's connection fee program.

Strategy 1 conditions result in a salt loading of 3,100 tons/year and delivered water quality of 300 mg/L. Delivered water quality TDS increases from Strategy 1 due to increased non-ASR pumpage to offset recycled water injection. The groundwater basin salt loading for Strategy 1 decreases to 3,100 from 5,400 tons/year in Strategy 1A. Since this is also a baseline case and no additional Zone 7 facilities are required other than those already assumed to be in place in the year 2010, there are no capital or O&M incremental costs

associated with this strategy. Strategy 1 defines the baseline for salt management strategies 1 through 13.

10.2.4 Strategy 11B—Increased Conjunctive Use and Demineralization of High TDS Groundwater

Strategy 11B evaluates the effect of conjunctive use plus demineralization of high TDS groundwater. This strategy assumes that 3 TAF of stream recharge and groundwater pumpage for conjunctive use will be implemented using existing facilities. The 3 TAF of new shallow groundwater pumpage would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

A fundamental premise of this strategy is that the salts residing in the higher TDS upper aquifer would eventually migrate vertically and degrade the higher quality lower aquifer. Section 2.6 discusses the groundwater movement between the upper and lower aquifers. By pumping and demineralizing the high TDS upper aquifer water, the movement of upper aquifer water to the lower aquifer can be minimized. Other more expensive salt removal alternatives involved demineralizing the lower TDS lower aquifer production wells (strategies 7 to 10 described in Section 9.6). These strategies require demineralization of a larger volume of lower TDS water to achieve the same salt removal shallow water demineralization and hence are more expensive. A key assumption is that the cost of this range of brackish water demineralization is a function of the volume of groundwater and not the TDS (i.e., O&M costs are constant for 450 mg/L or 1,000 mg/L groundwater).

As part of the groundwater modeling (section 10.3) for Strategy 11B, four high TDS groundwater sites were modeled: Camp Parks site, a line of wells along Arroyo Mocho, the Hopyard well field, and a future Bernal Property well field. The groundwater modeling simulation for Strategy 11B indicated that two shallow wells at the Camp Parks site could sustain about 900 AF/Y. Two wells along Arroyo Mocho would contribute about 800 AF/Y, one well in Hopyard well field about 900 AF/Y, and one well in the future Bernal Property well field would contribute 900 AF/Y. All of these shallow wells could go dry in the event of a prolonged drought. To make use of the demineralization facility during prolonged drought conditions, deep well pumpage could be used to replace the shallow well pumpage. Therefore, having a deep well and shallow wells connected to each demineralization facility would be the most flexible operational configuration arrangement.

Another net salt removal advantage of shallow over deep groundwater demineralization would occur if the pumpage were to be diverted to the arroyos during peak wet weather flows (i.e., seasonal groundwater export). This would be a lower cost alternative than pumping and demineralization, assuming necessary permitting and operational arrangements were negotiated with ACWD. In Strategy 11B, it was assumed that a first phase demineralization facility (1,700 AF/year) would be located at or near the Camp Parks well site. It would demineralize the pumpage from new or possibly renovated existing Camp Parks shallow wells plus pumpage from new shallow wells along Arroyo Mocho.

The second phase (1,800 Af/year) would require either a second demineralization facility located in the vicinity of the Hopyard well field or in the future Bernal Property well field, or else pipelines back to an expanded demineralization facility at the Camp Parks well site.

Strategy 11B eliminates the net salt loading (Table 9.15) to the main basin. The ten-year projected groundwater quality would stabilize at the current level of 450 mg/L TDS. Zone 7 delivered water quality would improve modestly by about 20 mg/L to about 280 mg/L. The increase in cost would be $40/AF.

10.2.5 Strategy 15—Increased Conjunctive Use and Demineralization of High TDS Groundwater

Strategy 15 evaluates the effect of conjunctive use plus demineralization of high TDS groundwater without any RO recycled water injection. Strategy 15 assumes that 8.5 TAF of stream recharge and groundwater pumpage for conjunctive use would be implemented using existing facilities. 5 TAF of shallow aquifer groundwater pumpage would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

Strategy 15 eliminates the positive net salt loading (Table 9.20) in the main basin. The ten-year projected groundwater quality would stabilize at the current level of 450 mg/L TDS. Zone 7 delivered water quality would remain at the baseline case Strategy 1A level (275 mg/L). The increase in cost would be approximately $50/AF.

The main differences between Strategy 15 and Strategy 11B are: 1) Strategy 15 has no RO recycled water injection, 2) Strategy 15 has more conjunctive use (8.5 TAF/year) and more ASR well recharge, and 3) Strategy 15 has more demineralization of high TDS groundwater pumpage (5 TAF/year versus 3 TAF/year).

As described earlier under Strategy 11B, a fundamental premise of Strategy 15 is also that the salts residing in the higher TDS upper aquifer would eventually migrate vertically and degrade the higher quality lower aquifer. Section 2.6 discusses the groundwater movement between the upper and lower aquifers. By pumping and demineralizing the high TDS upper aquifer water, the movement of upper aquifer water to the lower aquifer can be avoided. Strategy would similarly require two or three wellfields and one or more demineralization facilities. The assumption for siting and operating these wells and demineralization facilities are the same as for Strategy 11B except that the three wells in the future Bernal Property well field would need to be sized to contribute 2,900 AF/year.

Increased ASR injection in the western portion of the basin would improve the TDS in the lower aquifer in the Bernal and West Amador sub-basins. Alternatively, injecting in selective wells and pumping from different wells could create managed plumes of low TDS groundwater in the lower aquifer versus "bubbles" around the ASR wells. This low TDS water could also be pumped during drought conditions.

10.3 Groundwater Modeling Evaluations

As described in Chapter 9, Zone 7 developed over 15 "screening level" salt balance strategies in 1998. The goal of these strategies was to provide a preliminary evaluation of the relative effectiveness of available salt management strategies on the groundwater basin as a whole, to evaluate impacts on overall average delivered water quality TDS, and to provide planning level cost estimates. These strategies were performed using the "spreadsheet" water and salt routing model. This spreadsheet model used 2010 conditions and 1922-96 hydrology. Using all the system constraints, water supply and demand conditions, and salt management strategy conditions, this model determined how the treated and untreated demands would be met, and how the remaining surface water would be used for artificial recharge for each hydrologic year for the period 1922-96.

The spreadsheet model determined what the groundwater storage would be at the end of each year and the annual average TDS of Zone 7 water deliveries. The model also performed steady state average main basin salt loading calculations for each strategy. This type of evaluation was performed for each of the 15 salt management strategies. The model produced 75-year average recharge and discharge data that were subsequently used in the groundwater model.

One limitation of the "spreadsheet" model is that it treats the groundwater basin as a "bucket" and cannot deal with the full complexities of how groundwater would actually move in the basin and how the TDS of delivered water quality would vary in the Zone 7 distribution system under each strategy. These questions can be answered only by using the previously described numerical groundwater model (Section 3.7) and the water system operations optimization model (Section 2.6) together.

Zone 7's numerical groundwater model was developed in part to further evaluate potential basin management strategies. Zone 7 has used the model for the Salt Management Plan, Well Master plan, and for siting monitoring wells for the CWR and Livermore injection projects to track potential future injected water. All 15 salt management strategies except strategies 14 and 14a were evaluated using the model.

The numerical groundwater model includes the Visual MODFLOW for Windows version 2.61 by Waterloo Hydrologic, Inc. package to simulate groundwater flow and the three-dimensional MT3D code to simulate solute transport. These modeling programs are in common use and accepted by regulatory agencies for evaluating existing and potential water resource management strategies.

The Zone 7 model grid has four layers and a uniform 500 x 500 feet grid in the X and Y directions covering the entire Livermore-Amador Valley groundwater basin. It is a three dimensional model and the thickness of the grid cells varies throughout the model area. The top three layers represent the upper unconfined aquifer, the deep confined aquifer and an intervening aquitard layer, respectively. The model layer elevations for the major portion of

the model are based upon a number of geologic well logs. The model was calibrated using 20 years of actual hydrologic inventory data. Section 3.7 describes the model and calibration in more detail.

The groundwater model simulations were performed to evaluate the impacts of salt management plan strategies on groundwater basin water levels and water quality. The simulations were performed using 75-year average water flux conditions (steady state) for each salt management strategy. Based upon the steady state flow modeling, transient solute transport simulations were performed for a 50-year period. Since the groundwater movement and mixing is a slow process, the 50-year period was selected to allow enough time for the groundwater basin quality to stabilize. Complete modeling simulation results for all the simulated strategies are summarized in the report "Phase 4 Groundwater Modeling: Salt Management Plan Simulations" (Reference N).

10.3.1 Initial Groundwater Quality Conditions

Figures 10.1 and 10.2 present the initial groundwater quality conditions used in the simulations for the upper and lower aquifers. These initial conditions define the groundwater quality at the beginning of each model simulation. The initial conditions maps represent the actual groundwater quality in the basin for the 1990-95 period and are prepared based upon the available actual data for the 1990-95 period. All groundwater quality TDS maps represent low TDS water as blue and high TDS water as red with a transition from blue to red used for intermediate TDS levels. The gray color dotted line represents the 500 mg/L contour.

As shown in Figure 10.1, the north portion of the Dublin sub-basin has a groundwater TDS of less than 400 mg/L in the shallow aquifer. This is due to the low TDS recharge from irrigation water (less than 100 mg/L) delivered by EBMUD. The rest of the Dublin subbasin has higher TDS (over 700 mg/L) groundwater in the shallow aquifer. This area has high TDS groundwater mainly due to chlorides and other salts precipitated in the valley fill materials and the high TDS recharge from urban irrigation. These salts dissolve in the groundwater and increase the groundwater TDS. The Camp subbasin shallow groundwater TDS ranges from 700-1,000 mg/L. This is mainly due to the salts dissolving into groundwater from the valley fill materials. The north portion of the Amador subbasin has high TDS shallow groundwater due mainly to high TDS recharge (1,500 mg/L) from the Arroyo Las Positas and recharge from urban irrigation. The rest of the Amador subbasin in the south has low TDS shallow groundwater due to the low TDS recharge on the Arroyo Mocho and Valle.

Most of the shallow groundwater in the Bernal sub-basin has high TDS due to high TDS recharge from irrigation recharge and high TDS subsurface inflow from Dublin subbasin, except some areas in the south where shallow groundwater TDS is not as high as the north due to inflow of low TDS Arroyo Valle artificial stream recharge. In the Mocho II sub-basin, in the north, the shallow groundwater has high TDS due to the high TDS recharge

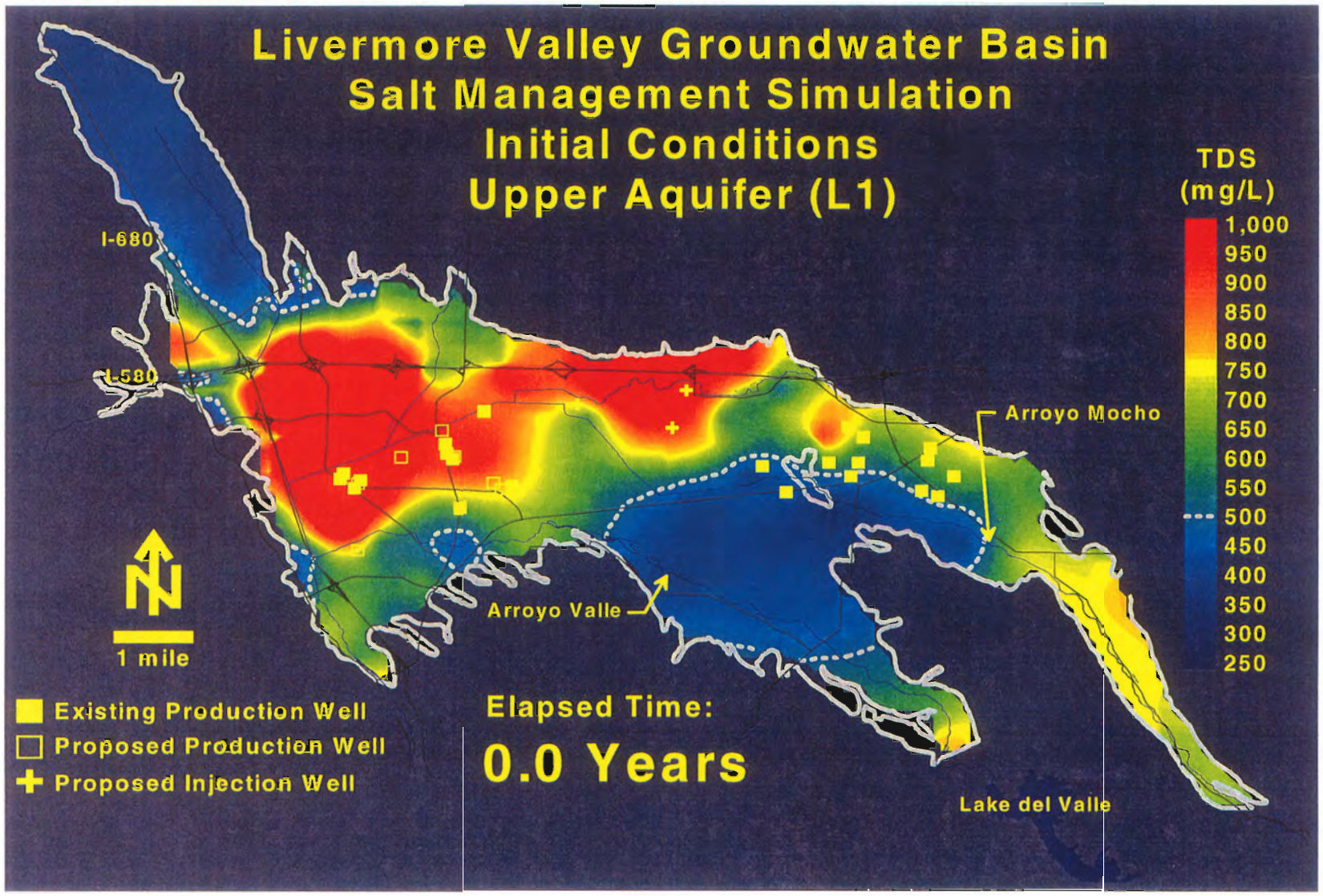

FIGURE 10-1

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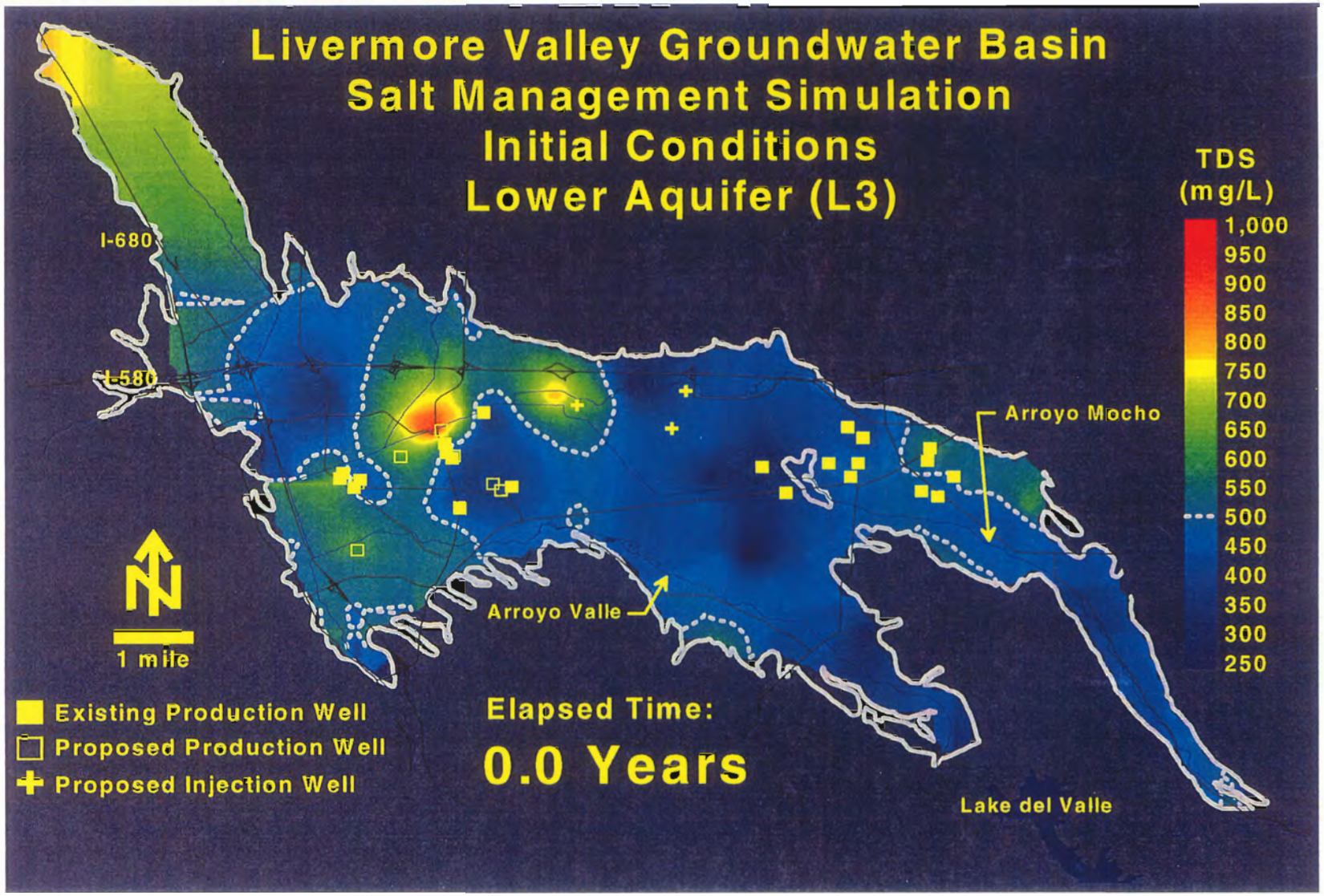

FIGURE 10-2

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\SFO\MJB\TDS Maps.xls: L3 Initial
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Chemograph Wells
Livermore Valley Groundwater Basin
Salt Management Simulations

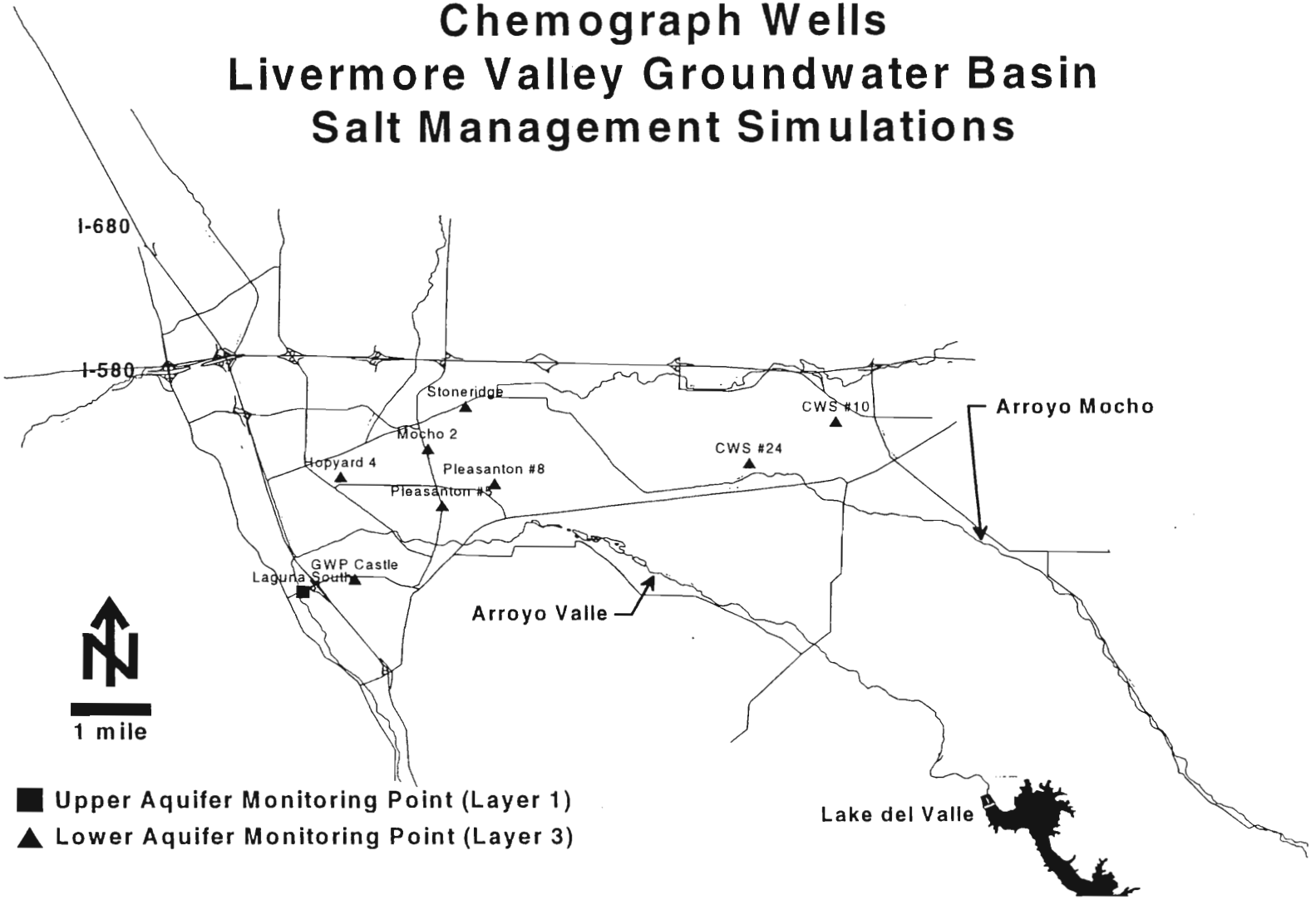

FIGURE 10.2A

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from the Arroyo Las Positas with concentrations approaching 1,000 mg/L, and to the south the groundwater quality is similar to the Arroyo Mocho water quality with concentrations barely exceeding 500 mg/L.

As shown in Figure 10.2, there is less groundwater TDS variation in the deep aquifer than in the shallow aquifer. The groundwater quality in the Dublin sub-basin varies from 350 mg/L to about 700 mg/L. The groundwater quality in the Bernal sub-basin ranges from 400 mg/L to 700 mg/L. Most of the Amador sub-basin is below 500 mg/L. Most of the Mocho II sub-basin is below 500 mg/L except a portion in the east where the TDS is 500-700 mg/L. This area is less influenced by the low TDS Arroyo Mocho artificial recharge.

Graphs showing groundwater TDS changes with time for nine selected locations (Figure 10.2A) were produced for all the strategies evaluated. The nine locations were selected to represent the major existing or potential future municipal pumping locations. These nine locations are Hopyard 4, Mocho 2, Stoneridge, Pleasanton #5, Pleasanton #8, CWS #10, CWS # 24, GWP Castle and Laguna South. All these locations except "Laguna South" represent TDS in the lower aquifer.

TABLE 10.1a - Initial GW Conditions

Well Location	Groundwater TDS in mg/L
Hopyard-4	409
Mocho-2	476
Stoneridge	361
Pleasanton # 5	375
Pleasanton # 8	367
CWS # 10	404
CWS # 24	299
GWP for Castlewood (SFWD)	542
Laguna South	582

Hopyard 4 represents the Hopyard wellfield, Mocho 2 represents the Mocho and Camp Parks well fields, Stoneridge represents the Stoneridge well field, Pleasanton #5 represents the Pleasanton #5 & #6 wells, CWS #10 represents CWS wells in the Mocho II sub-basin, CWS #24 represents CWS wells in the East-Amador sub-basin, GWP Castle represents the San Francisco Water District well field in the Bernal sub-basin and "Laguna South" represents the shallow aquifer groundwater near the Arroyo de Laguna in the Bernal sub-basin (basin subsurface outflow). Table 10.1a shows the representative groundwater quality for the nine locations at the beginning of the simulations (average 1990-95 data).

For each strategy, groundwater TDS maps at the end of the simulation (50 years) were created for the upper and lower aquifers. Lower aquifer groundwater model TDS was "animated" (i.e., annual time steps were captured in a computer slideshow movie) for the five selected strategies, 1A, 1, 10, 11B and 15. Following is a summary of the model output for the key Salt Management Plan strategies, 1, 1A, 11B and 15.

10.3.2 GW Model Results for Strategy 1A - Status Quo (Without RO Recycled Water Injection)

Strategy 1A is the baseline case for Strategy 15. Strategy 1A represents the historic operational practice of maximizing surface water delivery and pumping groundwater only for peaking and under drought conditions. This strategy minimizes operational costs.

Wellfields—Figure 10.3 presents the modeling predicted TDS changes over a 50-year period for the nine selected wellfield locations in the main basin for Strategy 1A. Figure 10.4 presents the zoomed in view showing the TDS changes only for a 25-year period. Table 10.2 lists the groundwater TDS and change from initial conditions after 25 years and 50 years for each location. From Figure 10.3 and Table 10.2 it is clear that the groundwater TDS would increase at all nine locations and the groundwater TDS increase would not be uniform. Under this scenario, the groundwater TDS at Stoneridge well increases at a higher rate during the earlier period of simulation. This is due to the fact that after the gravel mining operation stops in the vicinity of Stoneridge well (Kaiser operation), the upper aquifer high TDS groundwater (currently pumped by Kaiser) would move into the deep aquifer.

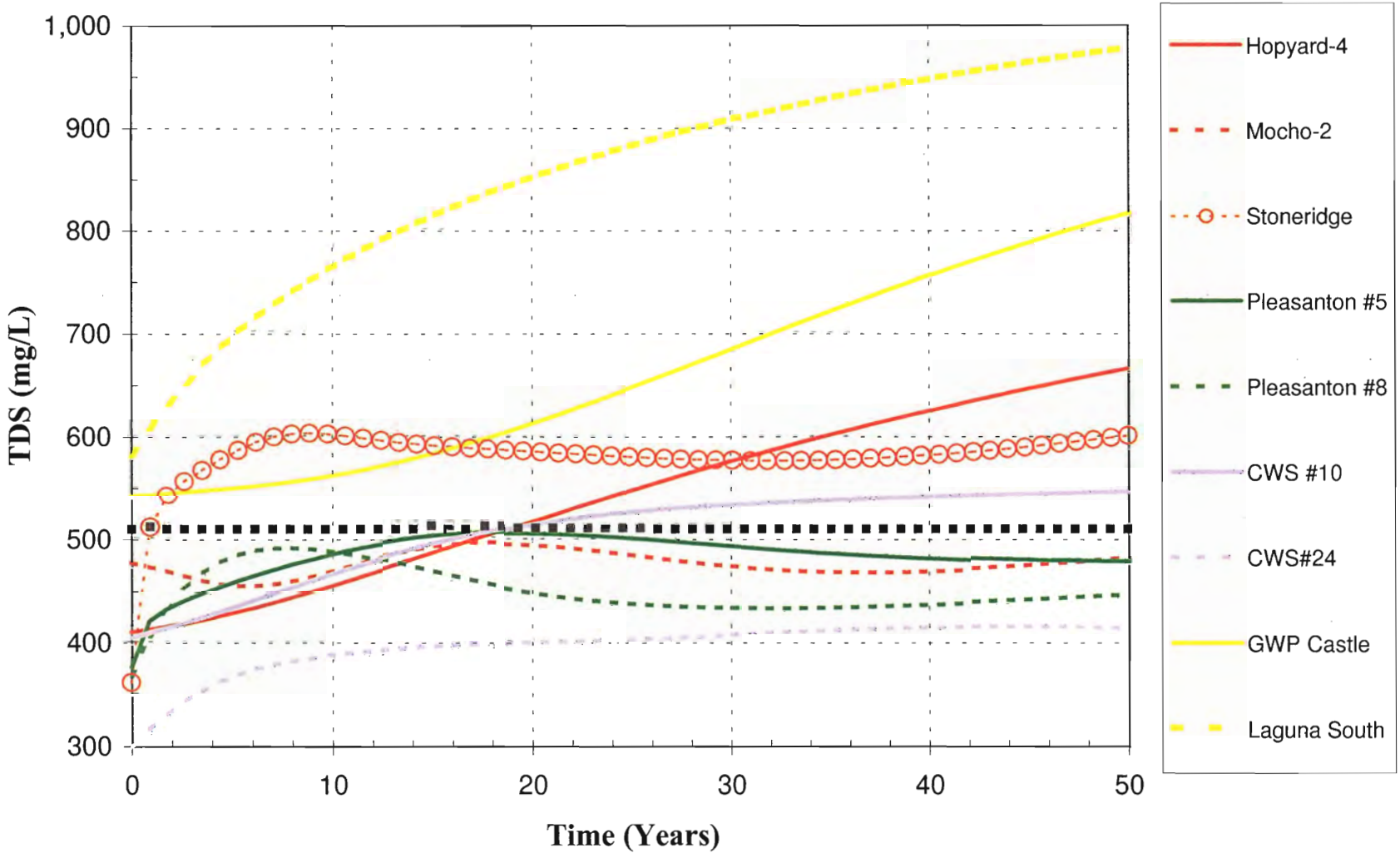

FIGURE 10.3

Scenario 1A: Base Case without Recycled Water Injection

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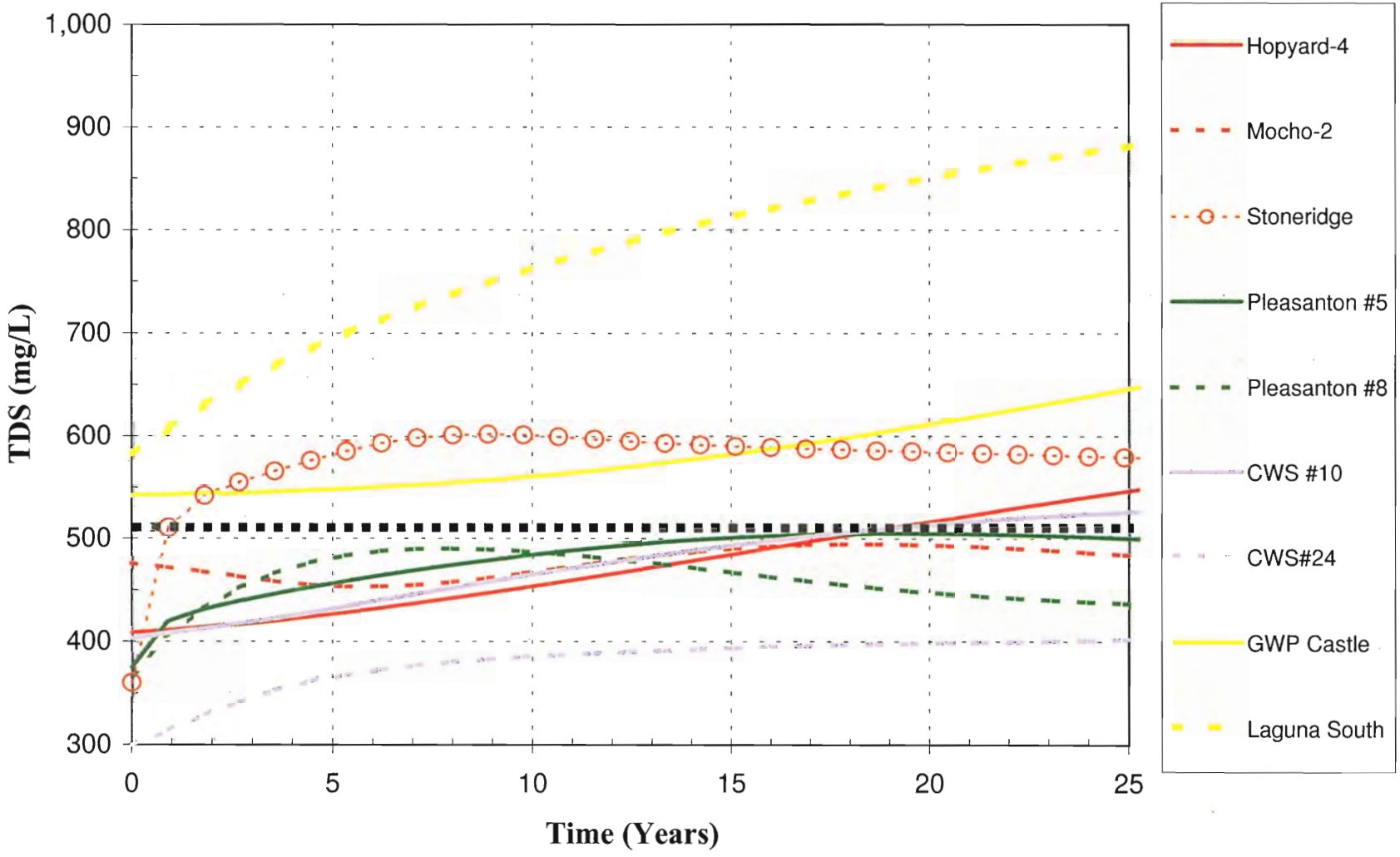

FIGURE 10.4

Scenario 1A: Base Case without Recycled Water Injection

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TABLE 10.2 - Strategy 1A Versus Initial Conditions Groundwater Model Simulation results

	Groundwater TDS and Net Change from Initial, mg/L			
Well Location	After 25 Years	Change	After 50 Years	Change
Hopyard-4	546	137	666	257
Mocho-2	484	8	481	5
Stoneridge	580	219	601	240
Pleasanton # 5	501	126	477	102
Pleasanton # 8	437	70	446	79
CWS # 10	526	122	546	142
CWS # 24	402	103	413	114
GWP for Castlewood (SFWD)	646	104	816	274
Laguna South	880	298	978	396

The groundwater TDS increases at Hopyard 4 and SFWD are also mainly due to the shallow aquifer high TDS groundwater moving to the deep aquifer. Under this scenario, the groundwater TDS increase at Mocho 2 is minimal and Pleasanton #8 would increase by only 70 to 80 mg/L. This is due to the low TDS Arroyo Valle stream recharge moving towards these locations. The groundwater TDS increase at CWS #10 & #24 is also less than at the Hopyard and SFWD locations due to the lower TDS Arroyo Mocho recharge influence. The groundwater TDS increase for the "Laguna South location" is highest. This location represents the shallow aquifer and the increase is mainly due to the high TDS recharge from urban irrigation and the lack of low TDS stream recharge in this part of the Bernal subbasin.

Upper Aquifer—Figures 10.5 and 10.6 map the basin-wide upper and lower aquifer groundwater TDS at the end of a 50-year period. From these figures, it is clear that the increase in upper aquifer TDS would be more than in the lower aquifer. Comparing Figure 10.5 with initial conditions for the upper aquifer (Figure 10.1), the far north portion of Dublin sub-basin would not change significantly. This is due to the low TDS recharge from low TDS urban irrigation (about 70-100 mg/L EBMUD deliveries). The groundwater quality in this area stays the same for all strategies. Under Strategy 1A, after 50 years the groundwater TDS in the rest of the Dublin sub-basin and in all of the Camp sub-basin would be over 1000 mg/L. Most of the Bernal sub-basin would be over 1,000 mg/L except a very small portion in the southeast where the TDS would be under 700 mg/L due to the influence of low TDS Arroyo Valle stream recharge. The high TDS area in the north portion of the Amador sub-basin along the Arroyo Positas increases. The rest of the Amador sub-basin in the south along the area of Arroyo Valle recharge would not change significantly. Similarly, the size of the high TDS area in the north part of the Mocho II

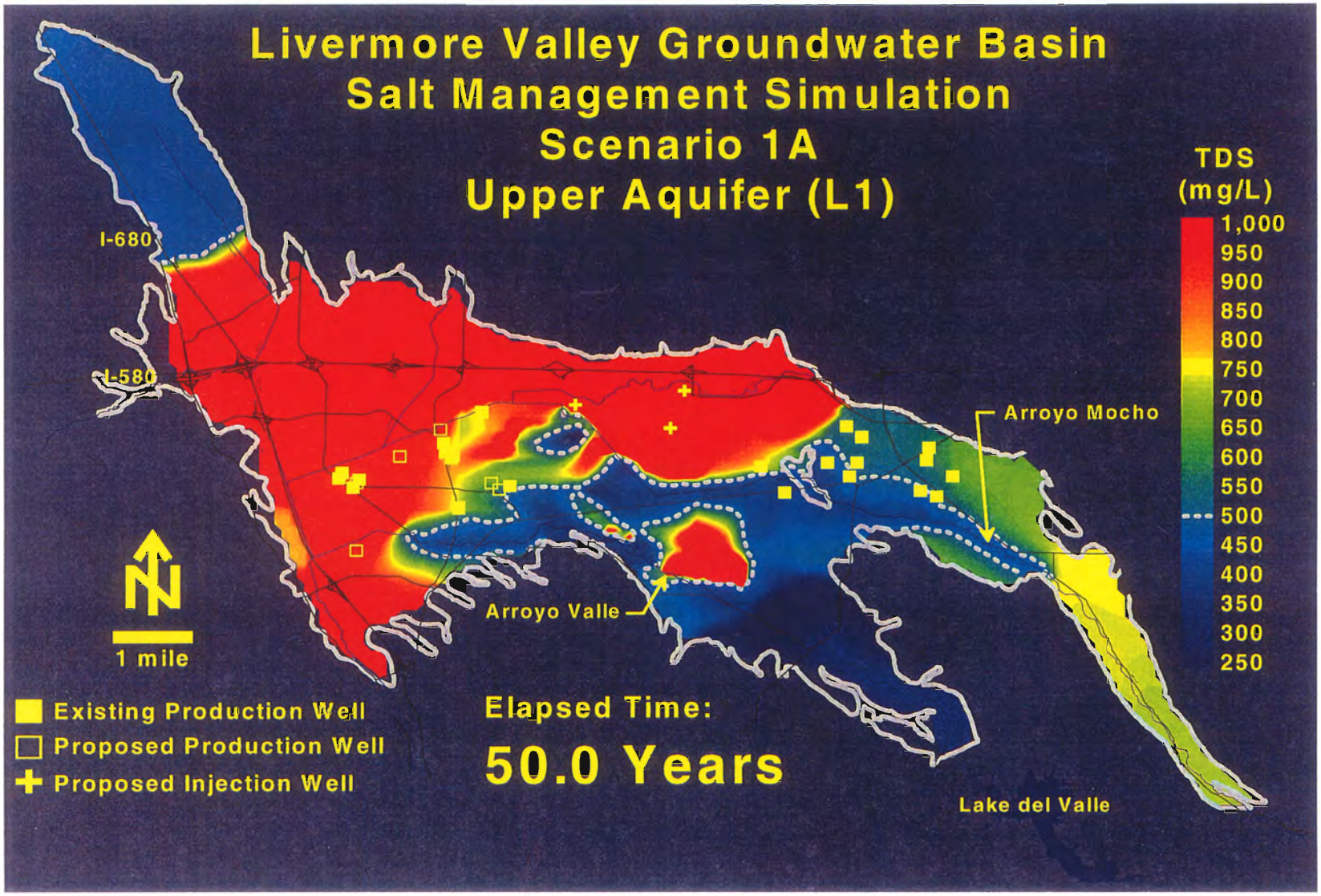

FIGURE 10-5

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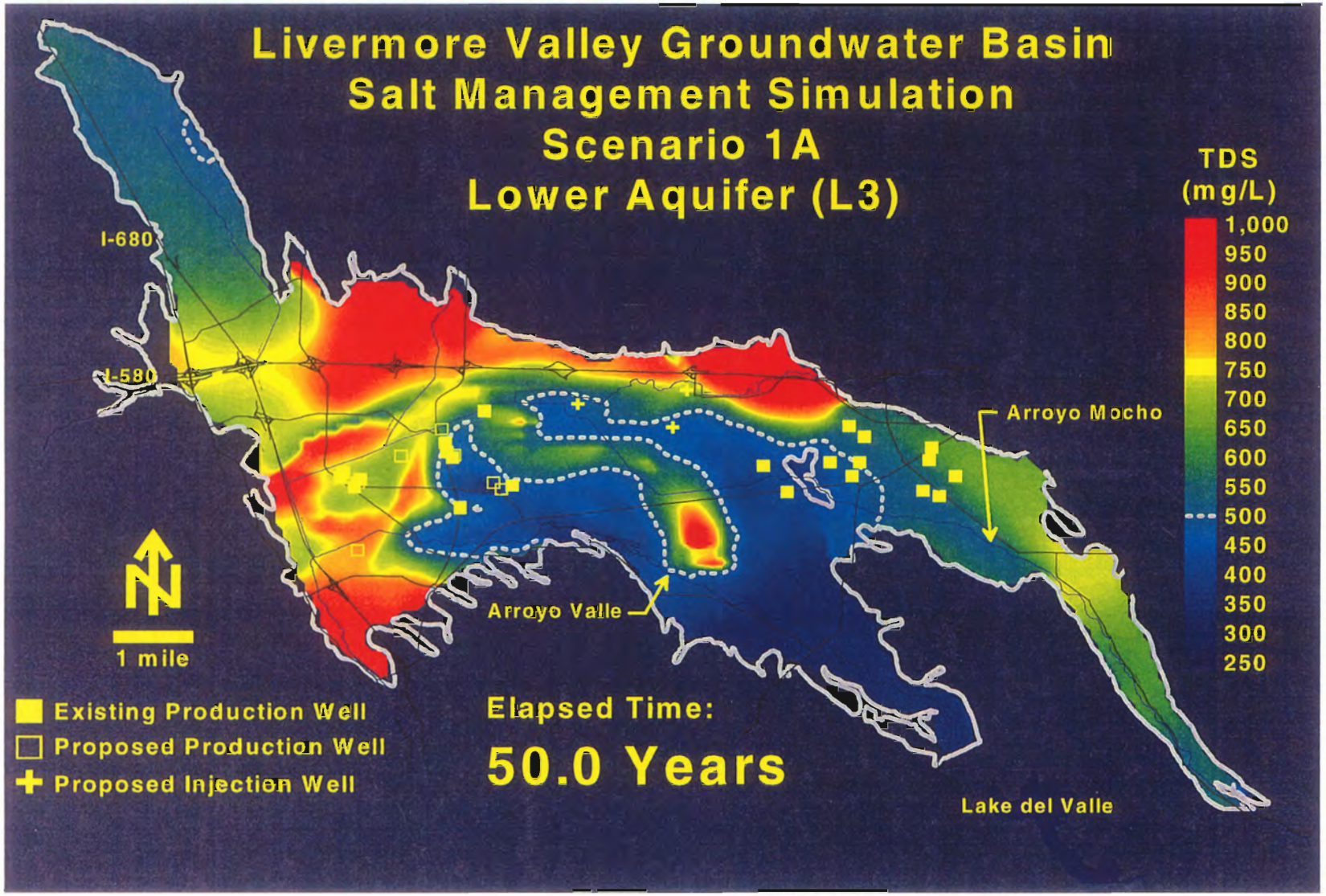

FIGURE 10-6

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subbasin would increase and the south portion would not change significantly due to the low TDS Arroyo Mocho recharge.

Lower Aquifer—Comparing Figure 10.6 with the initial conditions for the lower aquifer (Fig 10.2), the groundwater TDS would increase over most of the groundwater basin. The groundwater TDS in the south portion of Dublin sub-basin, in all of the Camp sub-basin, and in the Bernal sub-basin would increase significantly. The groundwater TDS in the area of the Amador sub-basin near the Stoneridge well would also increase significantly. Mocho II sub-basin groundwater TDS would also increase in the north, south and east portions. The groundwater TDS in the western portion of the Mocho II sub-basin would not increase significantly. Most of the groundwater TDS increase in the deep aquifer is due to the high TDS upper aquifer water moving into the deep aquifer over time.

10.3.3 GW Model Results for Strategy 1—Status Quo Plus 6 TAF/Y RO Recycled Water Injection

Strategy 1 is the baseline case for Strategy 11B. Strategy 1 represents the historic operational mode of maximizing surface water delivery and pumping groundwater only for peaking and drought conditions, except that it also includes the addition of 6 TAF/year or RO recycled water (or other low TDS water) injection into the Amador basin. Two thousand eight hundred (2,800) AF of RO RW was assumed to be injected by DSRSD at two sites. One of the sites was assumed to be located at El Charro Road and the Arroyo Mocho northwesterly of the Jamieson equestrian facility with the other near the southwest corner of the Livermore airport. Eight hundred forty (840) AF was assumed to be injected by Livermore in well #3S/1E 1N2 located north of the Livermore Water Reclamation Plant. The remaining 2,300 AF was assumed to be recharged into the upper aquifer through Lake I.

Wellfields—Figure 10.7 presents the TDS changes with time for a 50-year period for the nine locations in the main basin for Strategy 1. Figure 10.8 presents the zoomed in view showing the TDS changes for only the initial 25-year period. Table 10.3 lists the groundwater TDS and change from Strategy 1 for each location after 25 years and 50 years under this strategy.

Under this strategy, the groundwater TDS at the Mocho 2 and Stoneridge locations would be significantly lower and the Pleasanton #5 & #8 locations would be modestly lower as compared to Strategy 1A. The major reason for this improvement is the injection of RO recycled water (or other low TDS water) in the northern portion of the Amador subbasin. This low TDS water would move towards these pumping locations and reduce groundwater TDS in the deep aquifer. The groundwater TDS at the CWS #10, CWS #24, SFWD and Laguna South locations would be basically unchanged. This is due to the similar recharge and pumpage conditions under strategies 1 and 1A in the Bernal and Mocho II sub-basins. The groundwater TDS at the Hopyard 4 location would increase slightly.

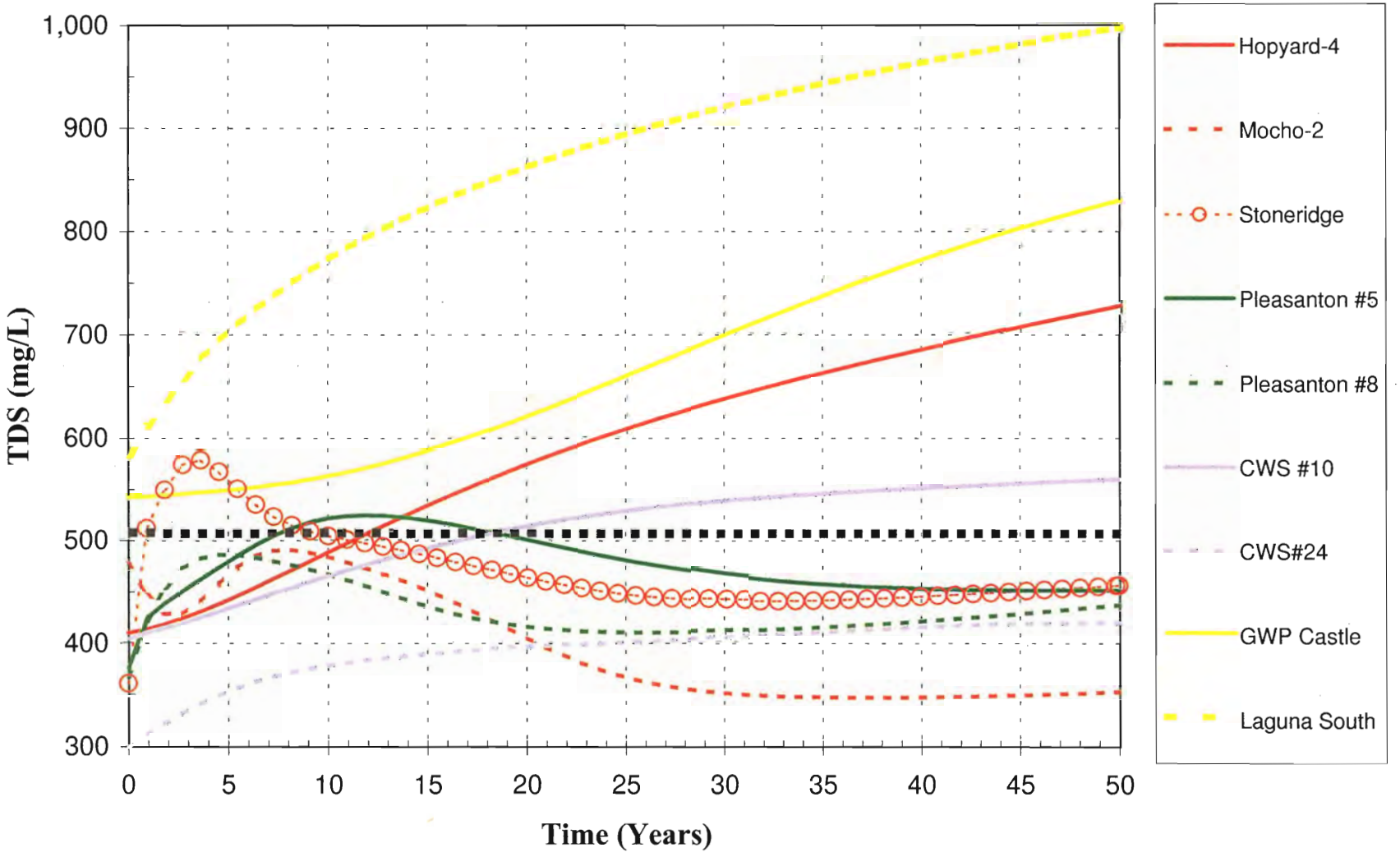

FIGURE 10.7

Scenario 1: Base Case with Recycled Water Injection

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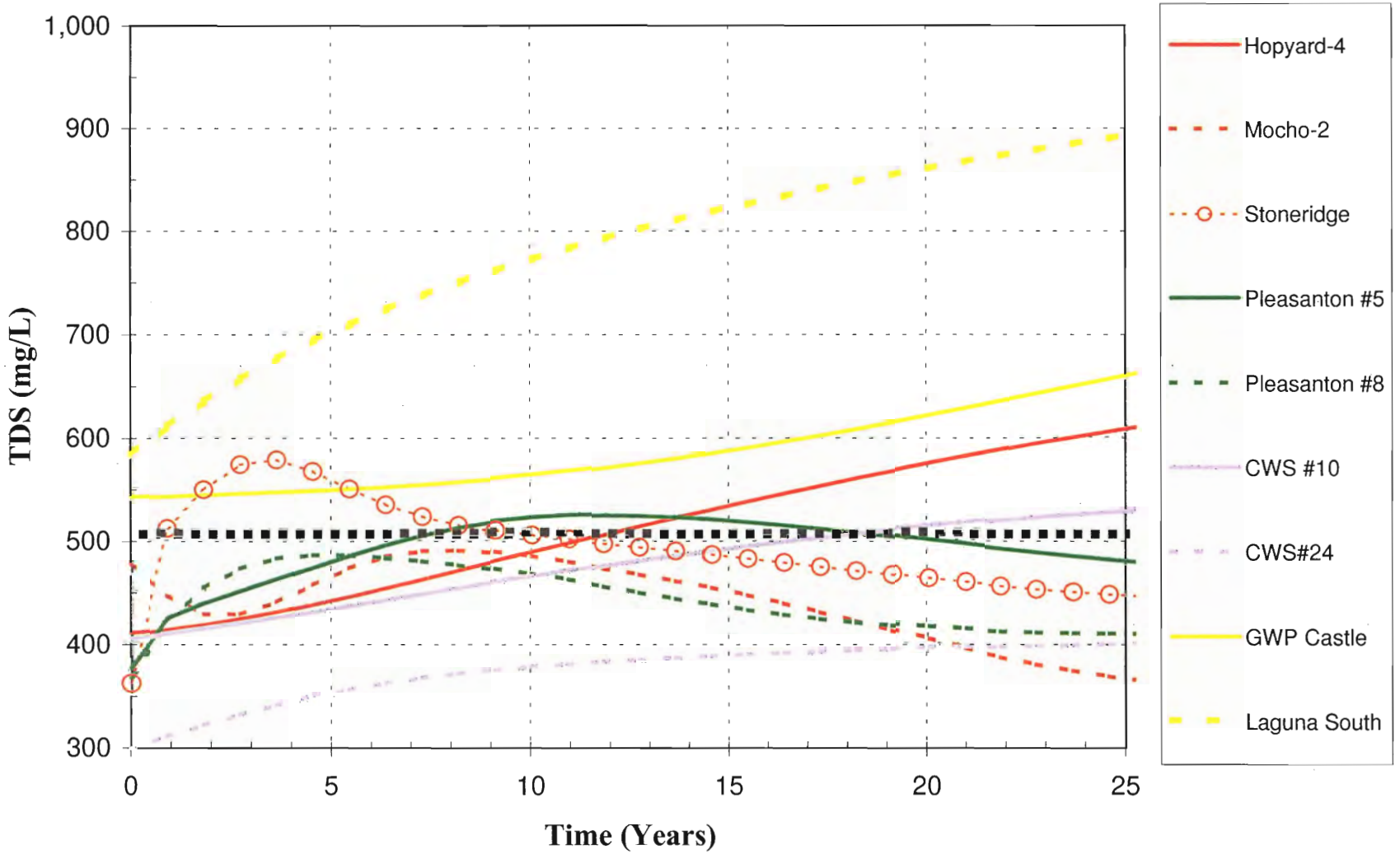

FIGURE 10.8

Scenario 1: Base Case with Recycled Water Injection

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TABLE 10.3 - Strategy 1 Versus Strategy 1A Groundwater Model Simulation Results

	Groundwater TDS and Change from Strategy 1A, mg/L			
Well Location	After 25 Years	Change	After 50 Years	Change
Hopyard-4	609	63	727	61
Mocho-2	366	-118	352	-129
Stoneridge	448	-132	456	-145
Pleasanton # 5	481	-20	451	-26
Pleasanton # 8	410	-27	437	-9
CWS # 10	529	3	560	14
CWS # 24	401	-1	420	7
GWP for Castlewood (SFWD)	659	13	828	12
Laguna South	893	13	996	18

Upper Aquifer—Figures 10.9 and 10.10 map the upper and lower aquifer groundwater TDS at the end of a 50-year period. The only significant change in the upper aquifer groundwater TDS under this strategy over Strategy 1A is the lowered groundwater TDS in the area on the west of Lake I (Figure 10.9). This change is due to the increase in the low TDS recharge (2,300 AF/year) from Lake I.

Lower Aquifer—In the deep aquifer, the major difference between this strategy and Strategy 1A is that the groundwater TDS around the low TDS water injection sites is lower (Figure 10.10). Low TDS water injected into the basin moves towards the Mocho, Stoneridge and Pleasanton wells and this movement and mixing lowers the TDS in the deep aquifer in this area. The groundwater TDS in the deep aquifer in the rest of the areas is about the same as in Strategy 1A.

10.3.4 GW Model Results for Strategy 11B—Increased Conjunctive Use and Demineralization of High TDS Groundwater

Strategy 11B includes conjunctive use, demineralization of high TDS groundwater and RO recycled water (or other low TDS water) injection. This strategy assumes that 3 TAF of stream recharge and groundwater pumpage for conjunctive use will be implemented using existing facilities. The 3 TAF of new shallow groundwater pumpage would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

Wellfields—Figure 10.11 presents the TDS changes with time over a 50-year period at the nine locations in the main basin for Strategy 11B. Figure 10.12 presents the zoomed in view showing the TDS changes only for the initial 25-year period. Table 10.4 lists the

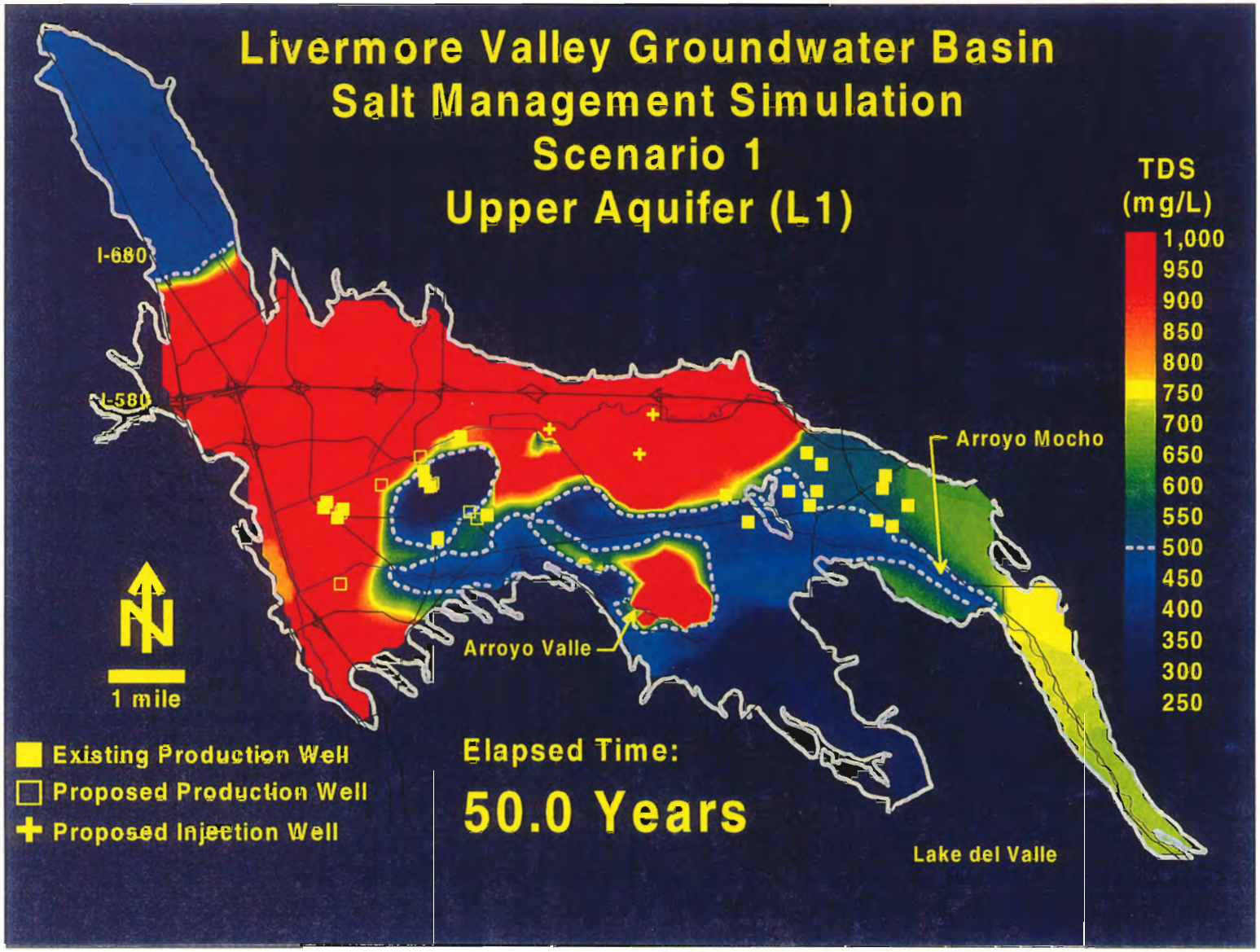


FIGURE 10-9

Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

\SFO\MJB\TDS Maps.xls: SMP01 L1 50 Yr
7/13/98

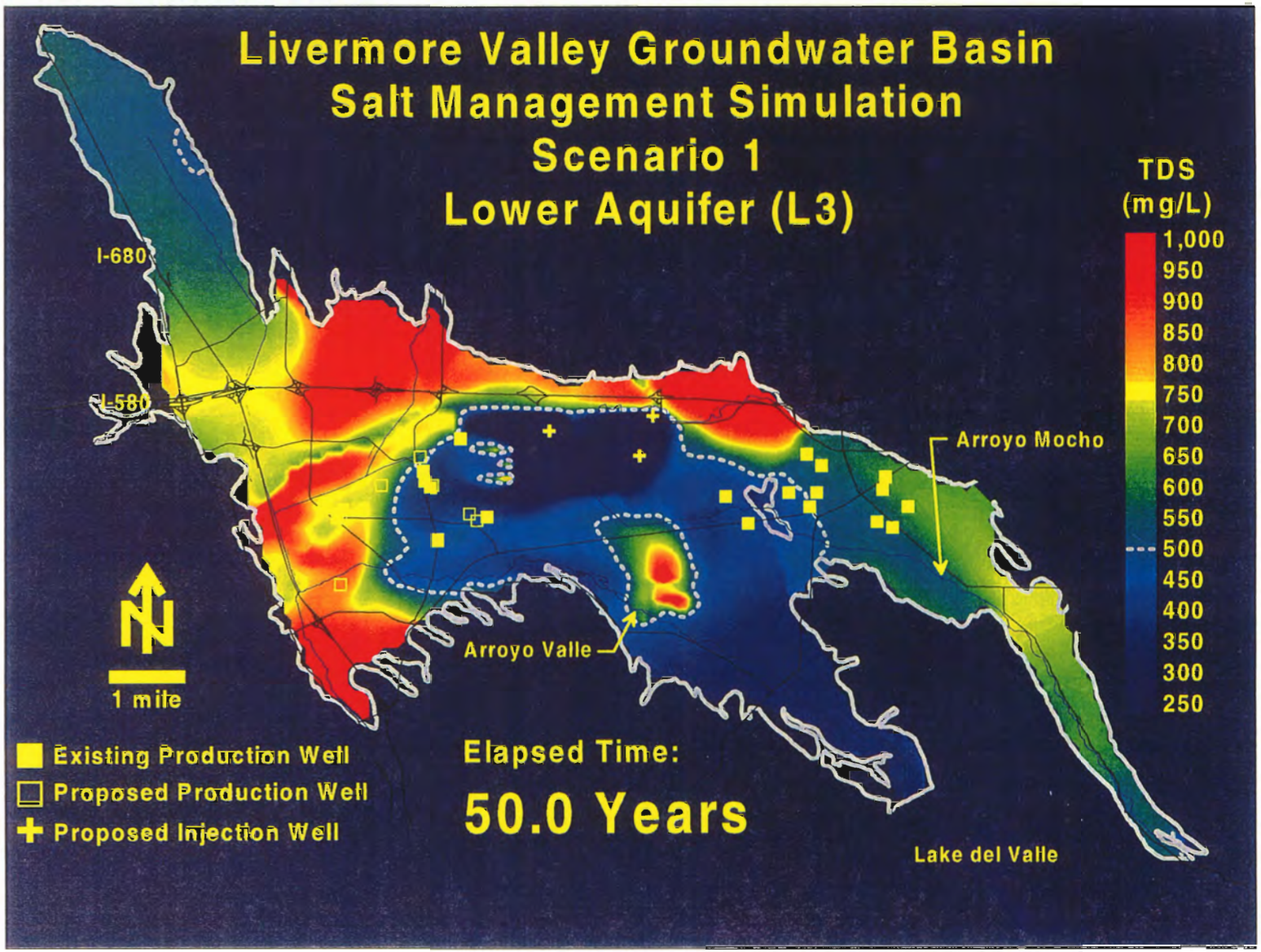


FIGURE 10-10

Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

\SFO\MJB\TDS Maps.xls: SMP01 L3 50 Yr
7/13/98

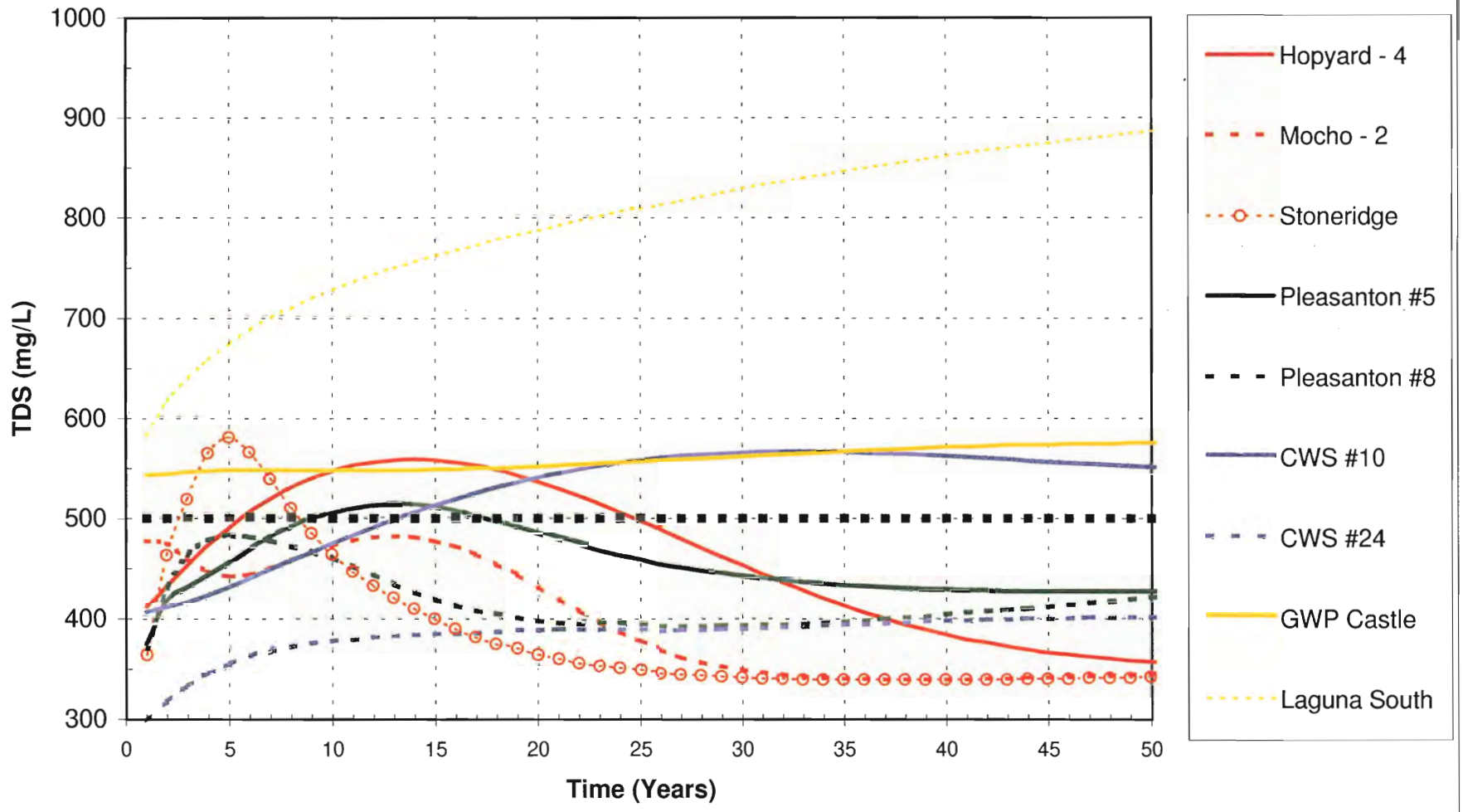


Figure 10.11
Scenario 11B: Conj use + Wellhead Demin
Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

E:\PROJECTS\SMP\SMPREPORT\CHP10\FIGURE 10.9 SMP11b

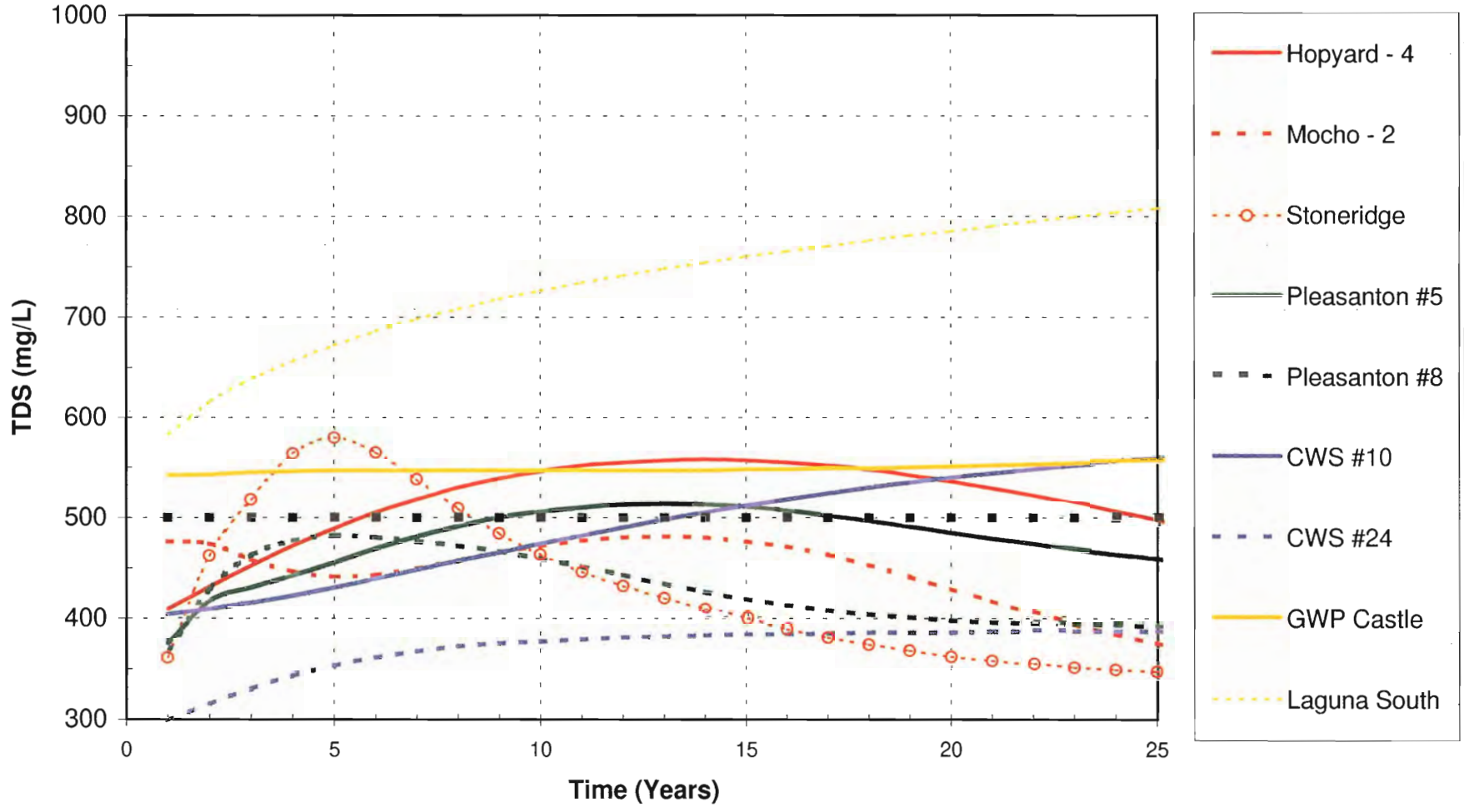


Figure 10.12
Scenario 11B: Conj use + Wellhead Demin
Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

groundwater TDS and changes compared to Strategy 1A for each location after 25 years and 50 years.

TABLE 10.4 - Strategy 11B Versus Strategy 1A Groundwater Model Simulation Results

	Groundwater TDS and Change from Strategy 1A, mg/L			
Well Location	After 25 Years	Change	After 50 Years	Change
Hopyard-4	488	-58	356	-310
Mocho-2	368	-116	346	-135
Stoneridge	345	-235	342	-259
Pleasanton # 5	454	-47	427	-50
Pleasanton # 8	392	-45	422	-24
CWS # 10	560	34	550	4
CWS # 24	387	-15	401	-12
GWP for Castlewood (SFWD)	557	-89	575	-241
Laguna South	812	-68	888	-90

From Table 10.4, the groundwater TDS after 25 and 50 years of operation under Strategy 11B would be lower than the baseline Strategy 1A at eight of the nine listed locations. After 25 years, the groundwater TDS at the Mocho and Stoneridge well locations would improve the most over Strategy 1A. At the Hopyard, Mocho and Stoneridge locations, the groundwater TDS would be even lower than initial conditions after 50 years. The future Bernal Property well field (GWP for Castlewood) location groundwater TDS would be significantly lower as compared to Strategy 1A. The Laguna South location groundwater TDS would be slightly lower from Strategy 1A. The Pleasanton #5 and #8 locations would also improve modestly from Strategy 1A. CWS wells groundwater TDS would be about the same as in Strategy 1A. This is due to the fact that the western part of the Amador and the Mocho II sub-basins where all of the CWS wells are located would be subjected to similar recharge and pumpage conditions under both strategies.

Upper Aquifer—Figures 10.13 and 10.14 map the upper and lower aquifer groundwater TDS at the end of 50-year period. Two major changes in the upper aquifer groundwater TDS under this strategy over Strategy 1A are:

1) The lowered groundwater TDS in the area on the west of Lake-I (Figure 10.13). This change is due to the increase in the low TDS recharge (2,300 AF/year RO recycled water) from Lake I.

2) The lower groundwater TDS in the central part of the Bernal subbasin as compared to Strategy 1A. This is due to the shallow groundwater pumpage for

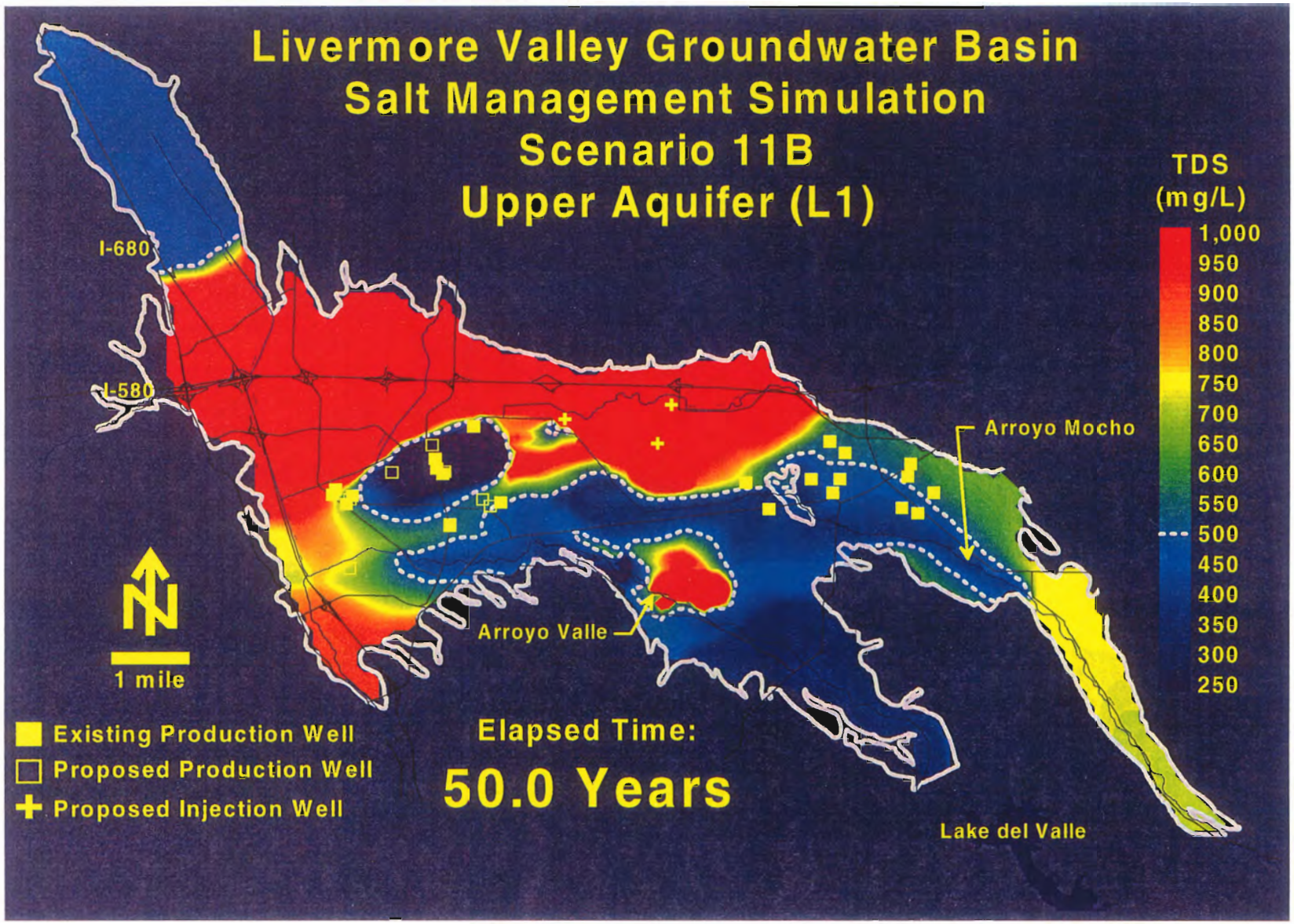


FIGURE 10-13

Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

\SFO\MJB\TDS Maps.xls: SMP11B L1 50 Yr
1/5/99

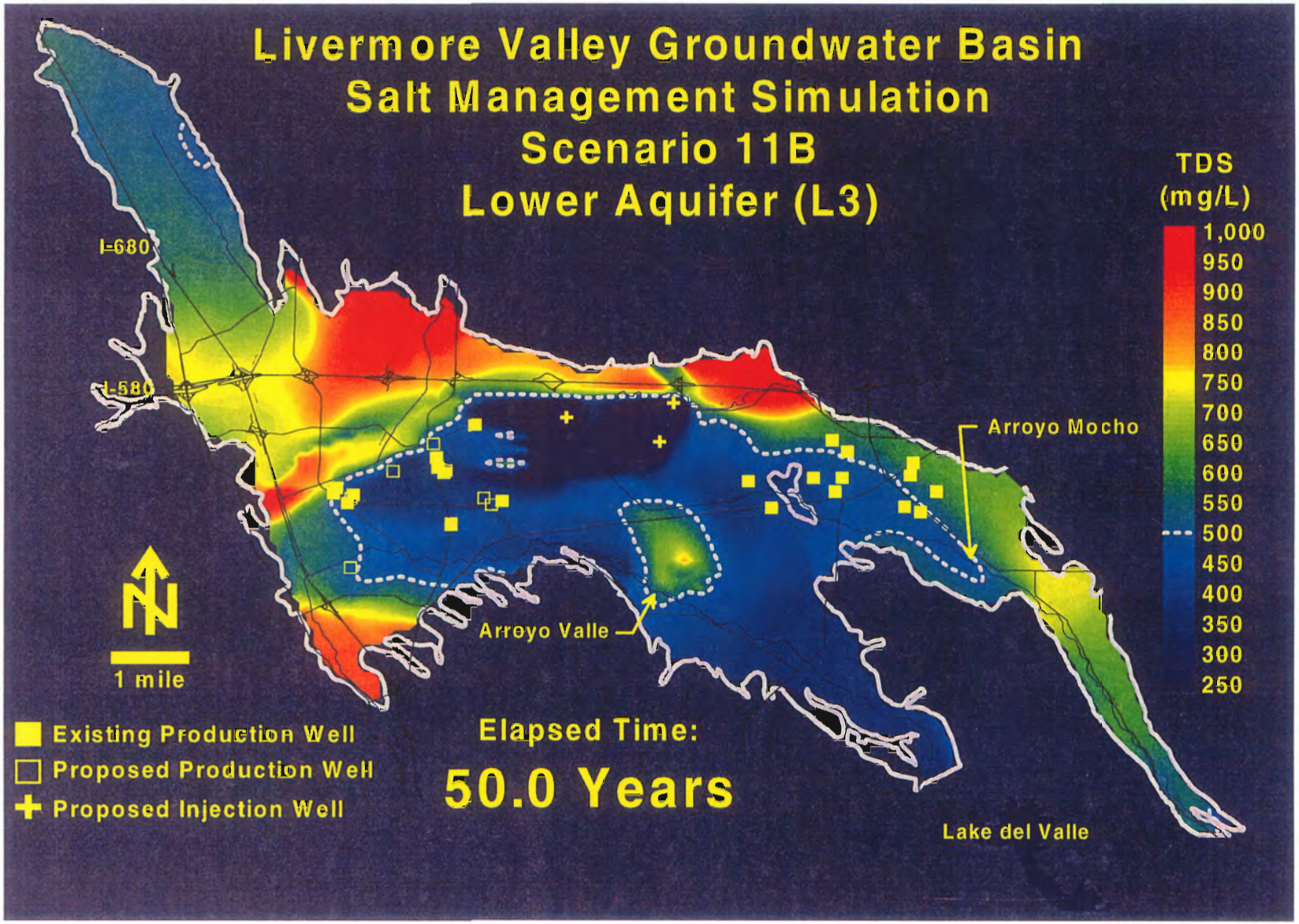


FIGURE 10-14

Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

\SFO\MJB\TDS Maps.xls: SMP11B L3 50 Yr
1/5/99

demineralization (3 TAF/year) under this strategy that would intercept the high TDS subsurface inflow from the Dublin sub-basin and high TDS recharge from urban irrigation. The low TDS Arroyo Valle recharge and recharge from Lake I would also move further into the Bernal basin due to the shallow groundwater pumpage.

The rest of the upper aquifer groundwater TDS would be about the same as in Strategy 1A.

Lower Aquifer—The major changes in deep aquifer groundwater TDS under this strategy from Strategy 1A are in the Amador sub-basin and the Bernal sub-basin (Figure 10.14). In general, the area of the basin with groundwater TDS below 500 mg/L (blue color) is larger than in Strategy 1A.

In the north part of the Amador sub-basin, the groundwater TDS around the low TDS water injection sites is significantly lower under this strategy. Low TDS water injected into the basin moves towards the Mocho, Stoneridge and Pleasanton wells and this movement and mixing lowers the TDS in the deep aquifer in this area. This is the main reason for the lower groundwater TDS at the Stoneridge, Mocho and Pleasanton well locations.

For most of the Bernal sub-basin, except for small portions along the north side and in the south, the groundwater TDS would be significantly lower than in Strategy 1A. The main reason for this change is the pumping of upper aquifer high TDS groundwater for demineralization which prevents it from moving into and degrading the deep aquifer.

The rest of the deep aquifer groundwater TDS would be about the same as in Strategy 1A.

Strategy 11B was the technically preferred strategy by the TAG and GMAC. However, the Zone 7 Board decided not to support RO recycled water injection into the main basin until further demonstration of public acceptance. Since Strategy 11B had been the preferred strategy, extra groundwater modeling work was done to: 1) Predict the flow (travel time and direction) and distribution of RO recycled water in the main basin, and 2) To predict the distribution of RO recycled water in future treated water deliveries.

1) Flow and Distribution of RO Recycled Water in the Main Basin Under Strategy 11B

Using the groundwater model simulation prepared for Strategy 11B, forward particle tracking was simulated to predict the flow direction and travel time of injected RO recycled water in the basin. The solute transport model was used to develop contours of the percentage of recycled water extending across the main basin lower aquifer. Following is a list of the principal assumptions for the modeling simulation used to predict the flow and percentage of recycled water in the main basin:

- Steady state model run using long-term average well pumpage and recharge data at year 2010 demand conditions (Strategy 11B).

- Zone 7 long-term average groundwater pumpage at about 15,000 AF per year. Zone 7 average pumpage distributed at Stoneridge well 2.3 TAF, Mocho well field 4.7 TAF, Hopyard well field 4.7 TAF and shallow groundwater pumpage of 3.3 TAF per year.

- Pleasanton average pumpage consistent with historic average, distributed at Pleasanton #5 0.7 TAF, Pleasanton #6 0.7 TAF, Pleasanton well #7 at 0.3 TAF, Pleasanton well #8 1.8 TAF per year.

- DSRSD average pumpage of 645 AF per year from the Camp Parks well field.

- CWS average pumpage of 3,069 AF per year with a distribution based upon their historic average for each well.

- DSRSD injecting 5,600 AF per year (50% blending, 2,800 AF RO recycled water and 2,800 AF Zone 7 provided treated water) in two injection wells.

- Livermore injecting 840 AF per year of RO recycled water without any blending.

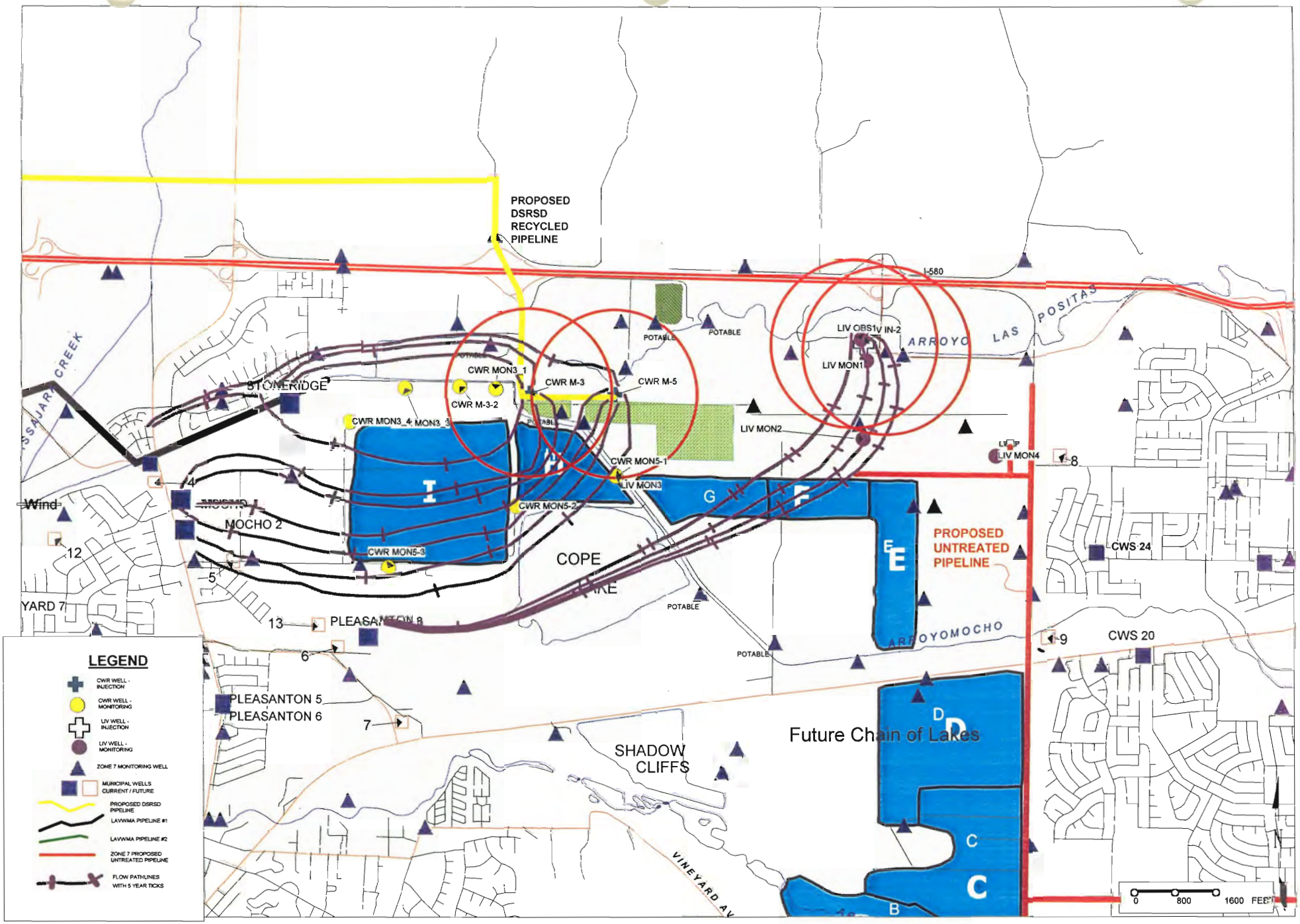
- 2300 AF per year of RO recycled water recharge in Lake I.

Figure 10.15 presents the pathlines of particles released in each injection well at the beginning of injection. The tick marks on the pathlines represent particle locations at five-year intervals. These pathlines indicate the direction and travel time of injected recycled water. These pathline maps were used in designing monitoring well locations for tracking the movement of recycled water in the groundwater basin. Noble gas tracers were to be added to injected water to track water movement and help verify model results.

Figure 10.16 displays contour lines showing the average percentage of RO recycled water in the deep aquifer after 50 years of operation. Figure 10.17 shows the percentage of recycled water in the deep aquifer at six production well locations over time.

In summary, the first water molecules from the RO RW injection wells could reach the Stoneridge well within three years. The Stoneridge well would receive the recycled water before any other existing production wells listed in Figure 10.17 and it would have the largest contribution at any time. It would take five years for water from the DSRSD RO facility to reach a 10% contribution in the Stoneridge well groundwater. For the 50-year model run, it appears that Stoneridge well would never exceed 40% water from RO recycled water. The Mocho wells would not exceed 30%.

FIGURE 3



ZONE 7 WATER AGENCY

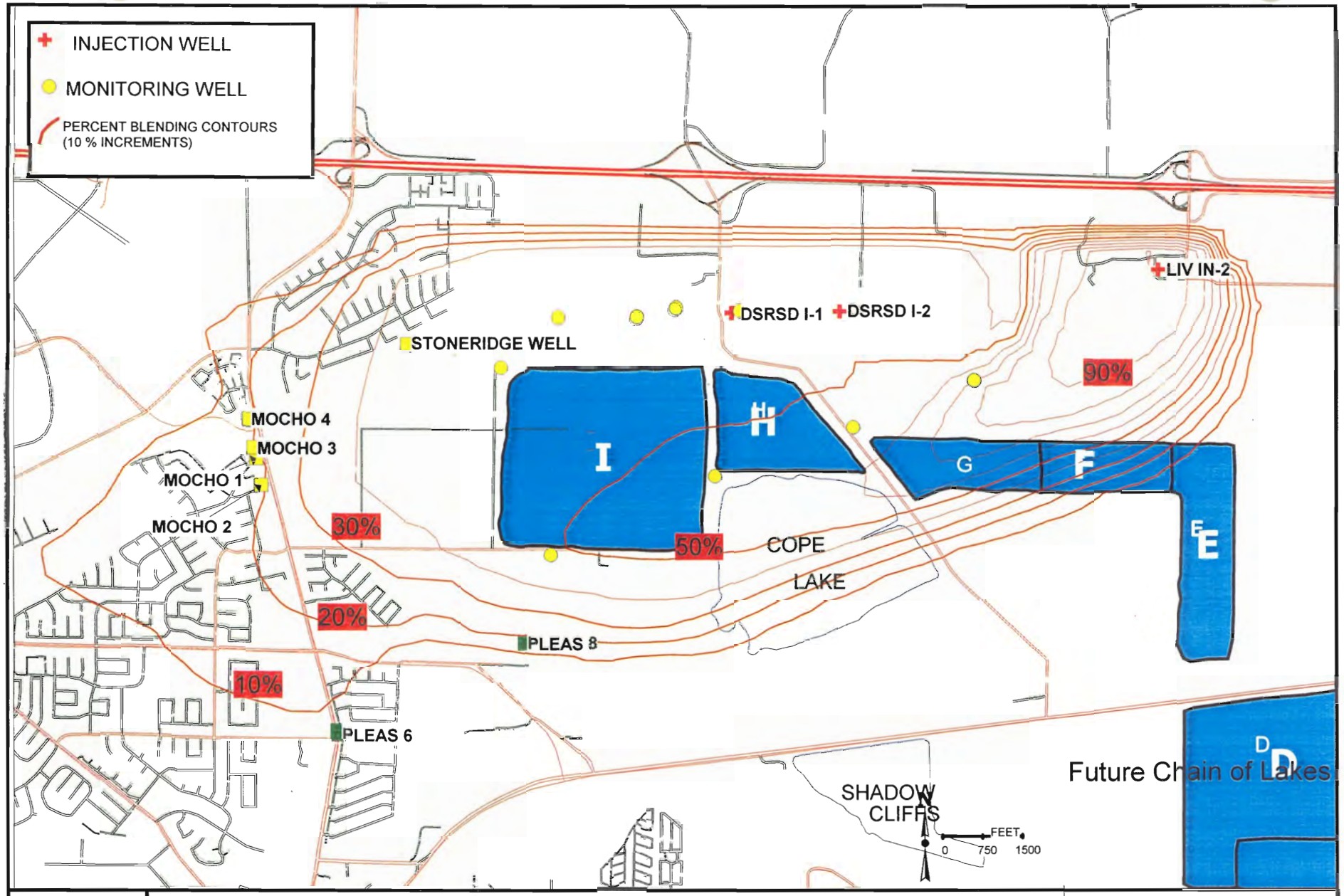
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	G. GATES
DESIGNED	JEFF TANG
CHECKED	DAVID LUNN
APPROVED	

STRATEGY 11b

GROUNDWATER MODEL PARTICLE TRACKING OF INJECTED RO RECYCLED WATER

SCALE	1" = 3000'
DATE	24 JUN. 1998
FILE NO.	FIGURE 10.15



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STRATEGY 11b

PECENT DISTRIBUTION of RO RECYCLED WATER in the DEEP AQUIFER AFTER 50 YEARS

DRAWN BY: G.GATES
DATE: 2 SEPT. 1998

FIGURE 10.16

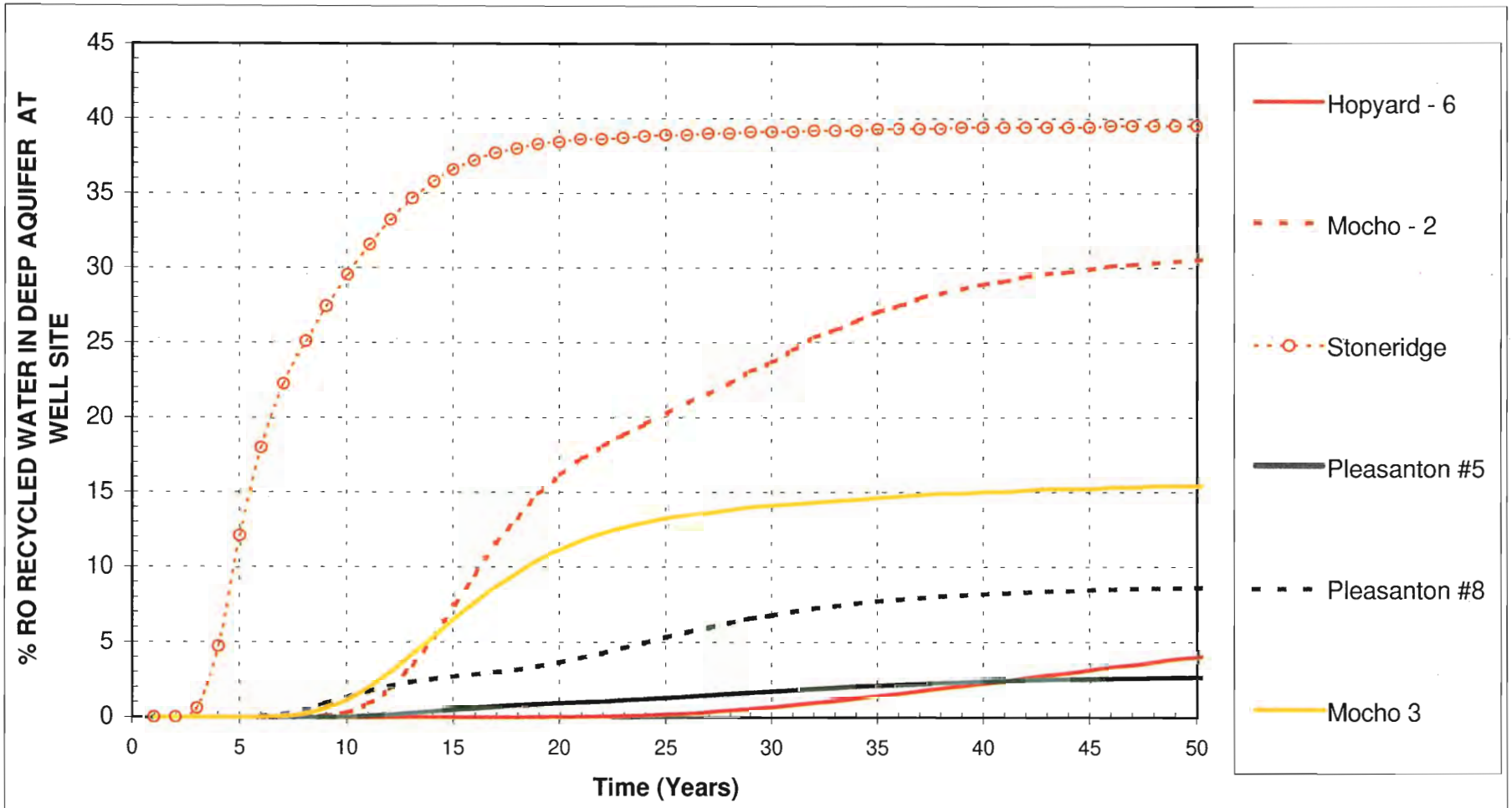


Figure 10.17
Scenario 11B: Conj use + Wellhead Demin
50% Blending for CWR and no blending for Livermore injection

It should be noted that the pathlines and travel times are very dependent on the distribution of groundwater pumpage between individual wells. By changing the groundwater pumpage distribution, the recycled water movement path could and would be affected. Also, these simulations assume that the various basin operating conditions described above would be exactly maintained throughout the entire 50-year simulation. In extreme dry and wet conditions, the recycled water movement would change since basin operating conditions would change. Other annual "fine tuning" is also likely as part of the adaptive management approach of Zone 7's annual operations plan.

RO recycled water movement can also be controlled by varying the amounts and locations of artificial stream and well recharge, and municipal pumpage. Under one conceptual scenario evaluated by Zone 7 staff (section 8.9), water injected in the vicinity of the proposed Livermore injection wells could be contained in the easterly end of the Amador sub-basin and extracted by new wells proposed to be constructed along the northerly edge of the Chain of Lakes Lake E. The extracted blend of groundwater and RO recycled water could be used for either non-potable (i.e., irrigation) or potable purposes.

RO recycled water movement could also be controlled by operating the injection wells as ASR wells and as needed to extract the injected water for irrigation or other non-potable purposes (strategies 14 and 14A, discussed in Chapter 9). However, ASR operation would provide limited salt removal benefits.

2) Modeling to Predict the Distribution of RO Recycled Water in Future Treated Water Deliveries

In October 1999, Zone 7 conducted modeling to provide information about the potential distribution of RO recycled water in the future treated water deliveries to the four valley retailers: Pleasanton, Livermore, California Water Service (CWS), and Dublin San Ramon Services District (DSRSD). First, the groundwater model was used to determine the distribution over time of recycled water in production wells as described earlier in this section. The Zone 7 distribution system pipeline model was then used to predict the contribution from each production source to Zone 7 turnouts of the valley retailers' systems.

Four different operational conditions were modeled for the distribution system: 1) Summer operation, 2) Summer peak-day operation, 3) January alternate operation (groundwater pumped westwardly), and 4) January typical operation. The output from the groundwater model simulations (Figure 10.17) and the output from the distribution system hydraulic model were integrated in a spreadsheet to compute the potential distribution of RO recycled water in future treated water deliveries to the four valley retailers.

In addition to the assumptions listed earlier in the section, the following apply to the water distribution system model simulations:

- Distribution model used year 2001 operations plan demands.

- "Summer Operation" used August 2001 average demand of 50 MGD, 12 MGD production at Patterson Pass Water Treatment Plant (PPWTP), 23 MGD production at Del Valle Water Treatment Plant (DVWTP), 6.5 MGD at Stoneridge well, 5.4 MGD at Hopyard well #6, and about 3 MGD at Mocho well #2 (or Mocho well #1).

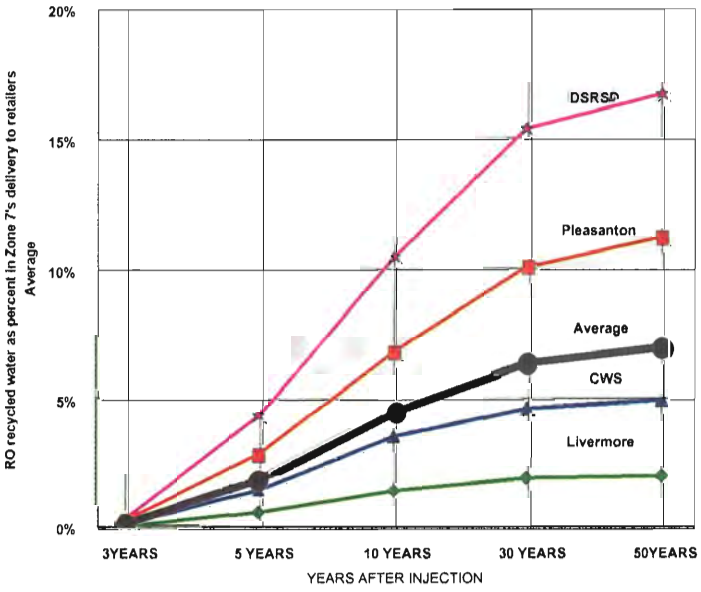
- "Summer Peak Day Operation" used 63 MGD as peak day demands, 13.4 MGD production at Patterson Pass Water Treatment Plant (PPWTP), 28 MGD production at Del Valle Water Treatment Plant (DVWTP), 6.5 MGD at Stoneridge well, 5.4 MGD at Hopyard well #6, 3 MGD at Mocho well #2 or Mocho #1, and 6 MGD at Mocho well #3.

- "January Operation" used January 2001 average demand of 19 MGD, 6.8 MGD production at Patterson Pass Water Treatment Plant (PPWTP), 11 MGD production at Del Valle Water Treatment Plant (DVWTP), and 6.5 MGD at Stoneridge well. It also assumed treated water injection into Hopyard wells #6 and #9. The "Alternate January" simulation assumed the rate control valve in the cross valley pipeline to be open which forces Stoneridge well pumpage to flow west. "Typical January" assumed the rate control valve in the cross valley pipeline to be closed which forces Stoneridge well pumpage to the east.

The results from these modeling simulations predict that water from the RO injection wells would first enter the Zone 7 distribution system within three years. Figure 10.18 shows the average annual percent contribution of RO recycled water Zone 7 would deliver to the various retailers. After 50 years, DSRSD would get the largest contribution, about 17%, while the City of Livermore would get the smallest contribution, about 2%.

The actual distribution of RO recycled water would not be constant but would vary from year to year, turnout to turnout, and would vary seasonally with changes in groundwater pumping. To show this seasonal variation in RO recycled water distribution we evaluated four conditions from the high demand "Summer Operations" to the low demand "Winter Operations" in January. Maps were prepared showing the seasonal distribution of RO recycled water throughout the Zone 7 distribution system. Tables were prepared presenting the computed RO recycled water as a percentage of that turnout's total delivery for the 3-, 5-, 10-, 30- and 50-year periods. Results are summarized below with an example map and table included for the summer operations conditions.

Figure 10.18



Summer Operations Distribution—Summer distributions represent the average high demand month conditions. Table 10.5 and Figure 10.19 show the distribution to each turnout for each retailer during typical August operations. The contribution to each of Pleasanton's eight turnouts has been computed for each time period. Within 50 years, Pleasanton turnouts would receive from 0-15% of their summer water supply from RO recycled water. Livermore and CWS turnouts would not receive any RO recycled water during a typical summer. DSRSD turnouts would receive from 0-22% of their summer water supply from RO recycled water.

Summer Peak-Day Distribution—Peak day distributions represent the highest demand day of the year, which is typically in July or August. Within 50 years Pleasanton turnouts would receive from 0-25% of their peak day water supply from RO recycled water. Livermore and CWS turnouts would not receive any RO recycled water during a typical summer peak day. DSRSD turnouts would receive from 0-17% of their peak day water supply from RO recycled water.

January Alternate (Groundwater Westward) Distribution—January distributions with groundwater being pumped to the west do not represent current winter operations but have been included to demonstrate the impacts of changing the pumping strategy. If during January Zone 7 pumped groundwater to the west, within 50 years Pleasanton turnouts would receive from 0-17% of their supply from RO recycled water.

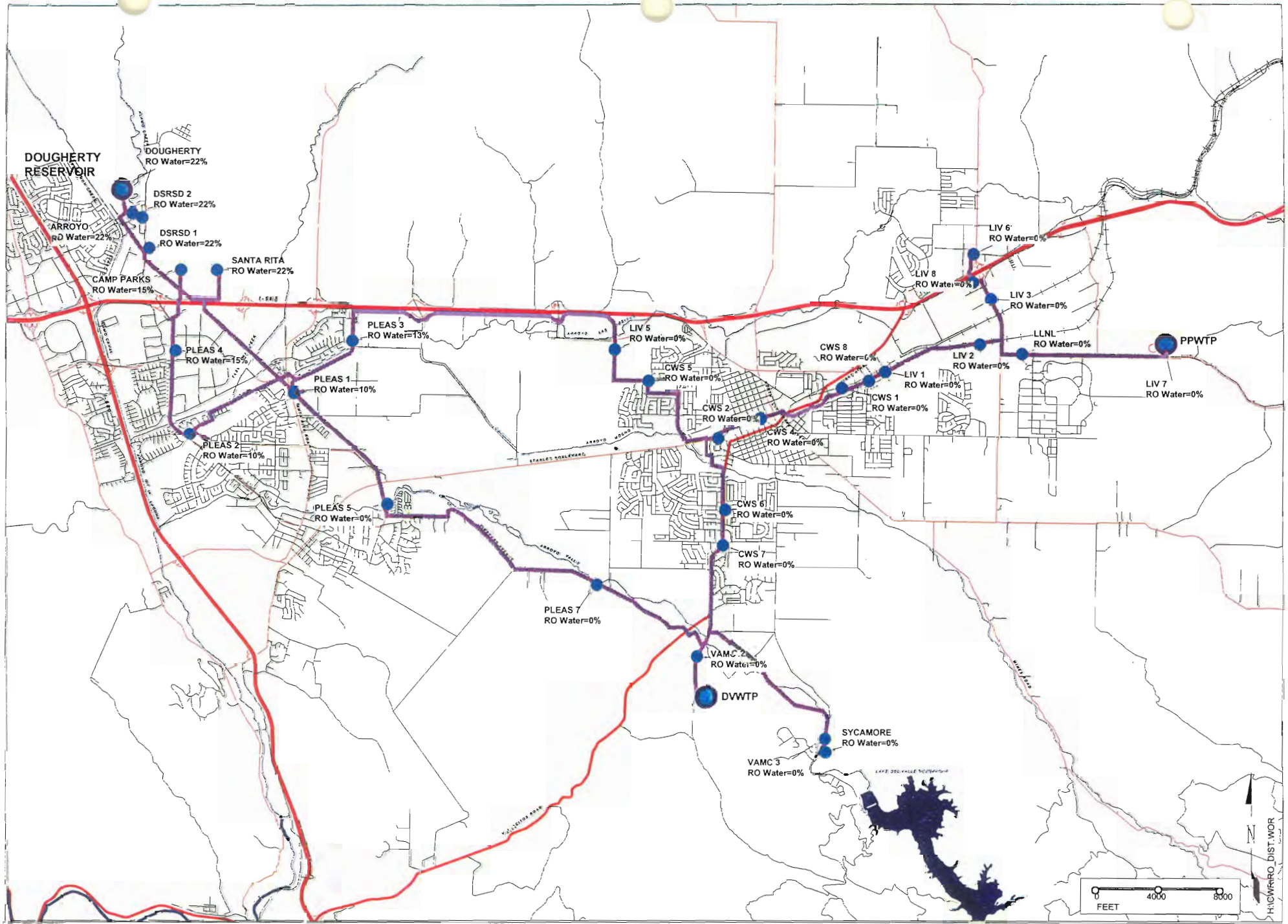
Livermore and CWS turnouts would not receive any RO recycled water if Zone 7 followed this winter operations plan and DSRSD turnouts would receive in the range of 0-9% RO recycled water.

January Typical (Groundwater Eastward) Distribution—January distributions with groundwater being pumped to the east represent current winter operations. Zone 7 pumps groundwater to the east in the winter to help equalize water quality, to facilitate salt removal as part of the Salt Management Plan, and to take the opportunity to inject surface water at the Hopyard well field. January distributions typically represent the low demand month. Under typical winter operations, within 50 years, Pleasanton turnouts would receive from 11-40% of their winter water supply from RO recycled water. Livermore turnouts would receive from 0-40%. CWS turnouts would receive from 0-40% RO recycled water. DSRSD turnouts would receive from 11-40% of their winter water supply from RO recycled water.

TABLE 10.5
RO RECYCLED WATER AS PERCENTAGE OF TOTAL TURNOUT DELIVERY

SUMMER OPERATION

RETAILER	ZONE 7 TURNOUT	WATER DELIVERY IN MGD	RO RECYCLED WATER AS PERCENTAGE OF TOTAL TURNOUT DELIVERY AFTER				
			3YEARS	5 YEARS	10 YEARS	30 YEARS	50YEARS
PLEASANTON	Pleas 1	5.38	0.00%	0.00%	0.16%	7.78%	10.05%
	Pleas 2	2.69	0.30%	3.57%	8.64%	12.00%	14.66%
	Pleas 3	4.27	0.32%	3.86%	9.33%	12.22%	12.87%
	Pleas 4	4.43	0.30%	3.57%	8.64%	12.00%	14.66%
	Pleas 5	2.37	0.00%	0.00%	0.00%	0.00%	0.00%
	Pleas 7 2"	0.16	0.00%	0.00%	0.00%	0.00%	0.00%
	Pleas 7 8"	0.16	0.00%	0.00%	0.00%	0.00%	0.00%
	P8 (future)	0.0005	0.30%	3.57%	8.64%	12.00%	14.66%
	RANGE		0% - 0.32%	0% - 3.86%	0% - 9.33%	0% - 12.22%	0% - 14.66%
LIVERMORE	LIV #1	1.11	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #2	0.0005	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #3	0.0005	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #5	1.27	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #6	2.06	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #7	5.86	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #8	0.79	0.00%	0.00%	0.00%	0.00%	0.00%
	RANGE		0%	0%	0%	0%	0%
CWS	CWS #1	2.85	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #2	2.53	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #4	1.74	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #5	1.27	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #6	1.58	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #7	0.0005	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #8	0.0005	0.00%	0.00%	0.00%	0.00%	0.00%
	RANGE		0%	0%	0%	0%	0%
DSRSD	DSRSD 1	3.96	0.41%	4.88%	11.89%	19.73%	21.85%
	DSRSD 2	1.74	0.41%	4.88%	11.89%	19.73%	21.85%
	DOUGHERTY	0.79	0.41%	4.88%	11.89%	19.73%	21.85%
	E. DUBLIN (Future)	0.95	0.00%	0.00%	0.00%	0.00%	0.00%
	CAMP PARKS W. DUBLIN	0.47	0.30%	3.57%	8.64%	12.00%	14.66%
	RANGE		0% - 0.41%	0% - 4.88%	0% - 11.89%	0% - 19.73%	0% - 21.85%
LARPD	LARPD/VA	0.000001	0.00%	0.00%	0.00%	0.00%	0.00%
	LARPD #1	0.00002	0.00%	0.00%	0.00%	0.00%	0.00%
	LARPD #2	0.00098	0.00%	0.00%	0.00%	0.00%	0.00%
	LARPD #3	0.00173	0.00%	0.00%	0.00%	0.00%	0.00%
	RANGE	0.00272	0%	0%	0%	0%	0%
VA	VA #2	0.019708	0.00%	0.00%	0.00%	0.00%	0.00%
	VA #3	0.26110	0.00%	0.00%	0.00%	0.00%	0.00%
	RANGE	0.28080	0%	0%	0%	0%	0%
GSA	SANTA RITA	0.82000	0.41%	4.94%	12.02%	20.04%	22.15%
DEPT. OF ARMY	CAMP PARKS	0.000001	0.30%	3.57%	8.64%	12.00%	14.66%
DUB. HOUS. AUTH.	ARROYO VISTA	0.08603	0.41%	4.88%	11.89%	19.73%	21.85%
GSA (EBRPD)	BOYS RANCH	0.00628	0.00%	0.00%	0.00%	0.00%	0.00%
LLNL		0.05673	0.00%	0.00%	0.00%	0.00%	0.00%
Total system	RANGE		0% - 0.41%	0% - 4.94%	0% - 12.02%	0% - 20.04%	0% - 22.15%



ZONE 7 WATER AGENCY

5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	G. GATES
DESIGNED	G. GATES
CHECKED	DAVID LUNN
APPROVED	

WATER RESOURCES ENGINEERING

SUMMER OPERATION

RO WATER PERCENTAGES (After 50 Years)

SCALE	1" =8000'
DATE	31 JAN 2000

FIGURE 10.19

10.3.5 GW Model Results for Strategy 15—Increased Conjunctive Use and Demineralization of High TDS Groundwater

Strategy 15 is the only strategy that passed all the screens for feasibility as described in Section 9.8. Strategy 15 includes conjunctive use, demineralization of high TDS groundwater and no RO RW injection. This strategy assumes that 8.5 TAF/Y of stream recharge and groundwater pumpage for conjunctive use will be implemented using existing facilities and 5 TAF/Y of new shallow groundwater pumpage would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

Wellfields—Figure 10.20 presents the TDS changes over time for a 50-year period at nine locations in the main basin under Strategy 15. Figure 10.21 presents the zoomed in view showing the TDS changes only for the initial 25-year period. Table 10.6 lists the groundwater TDS for each location after 25 years and 50 years.

TABLE 10.6 - Strategy 15 Versus Strategy 1A Groundwater Model Simulation Results

	Groundwater TDS and Change from Strategy 1A, mg/L			
Well Location	After 25 Years	Change	After 50 Years	Change
Hopyard-4	295	-251	258	-408
Mocho-2	421	-63	397	-84
Stoneridge	569	-11	547	-54
Pleasanton # 5	493	-8	426	-51
Pleasanton # 8	392	-45	387	-59
CWS # 10	573	47	554	8
CWS # 24	380	-22	389	-24
GWP for Castlewood (SFWD)	513	-133	493	-323
Laguna South	724	-156	760	-218

In comparing Table 10.6 and Table 10.2, it is clear that the groundwater TDS after 25 and 50 years of operation under Strategy 15 would be improved versus the baseline Strategy 1A at all the listed locations except at CWS #10. At the Hopyard, Mocho and future Bernal property well field (GWP for Castlewood) locations after 25 years, the groundwater TDS would improve (decrease) even when compared to initial (1990-95) conditions. For all other locations, TDS would increase versus the initial conditions but the increase would be less than that occurring under the baseline Strategy 1A.

The largest improvement would be in the Bernal sub-basin. Hopyard well field groundwater TDS after 25 years of operation would be 300 mg/L versus 550 mg/L under Strategy 1A. The future Bernal property wellfield would be at 510 mg/L after 25 years

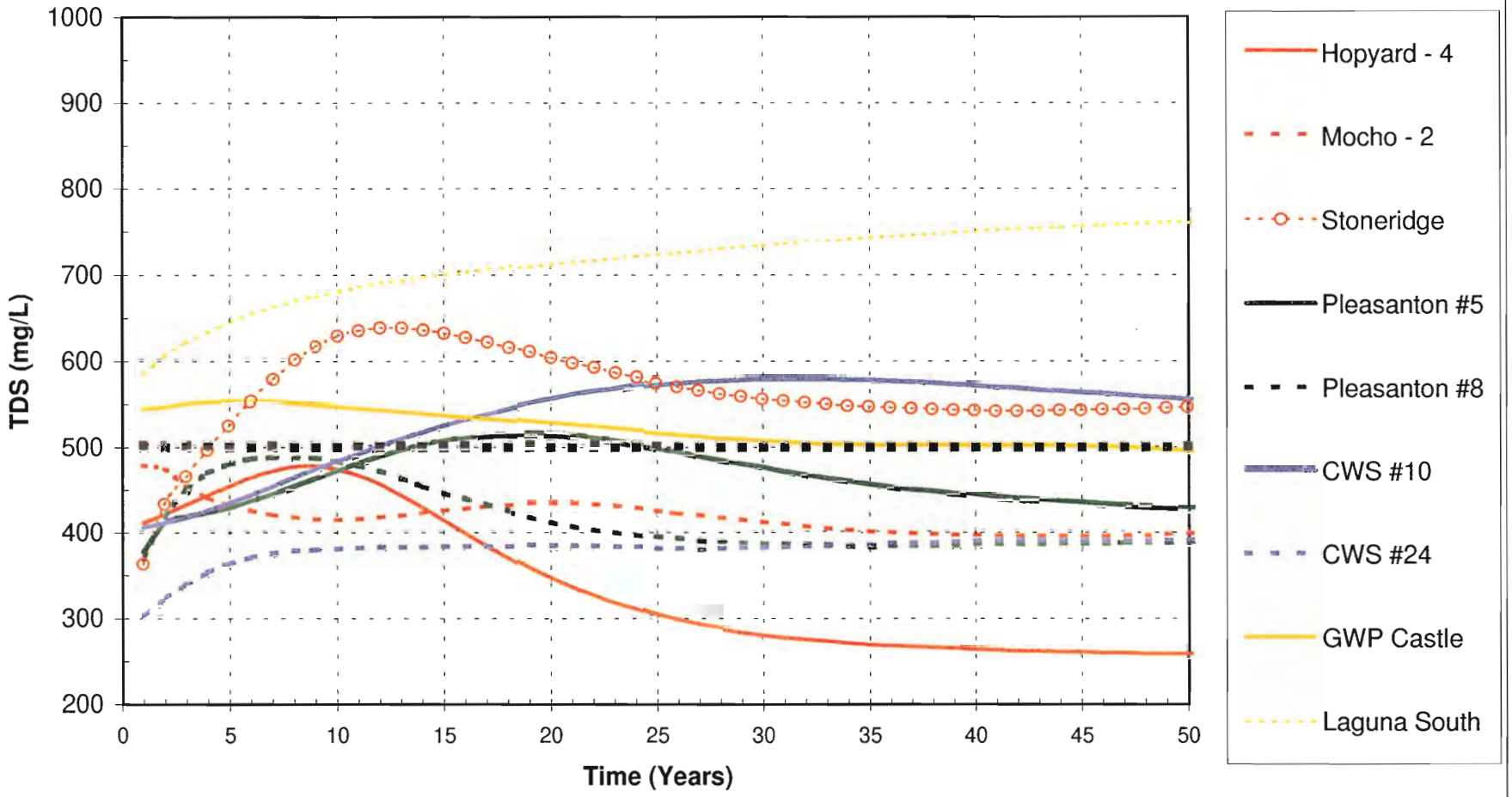


Figure 10.20
Scenario 15: Conj use + Wellhead Demin
Increased ASR injection
Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

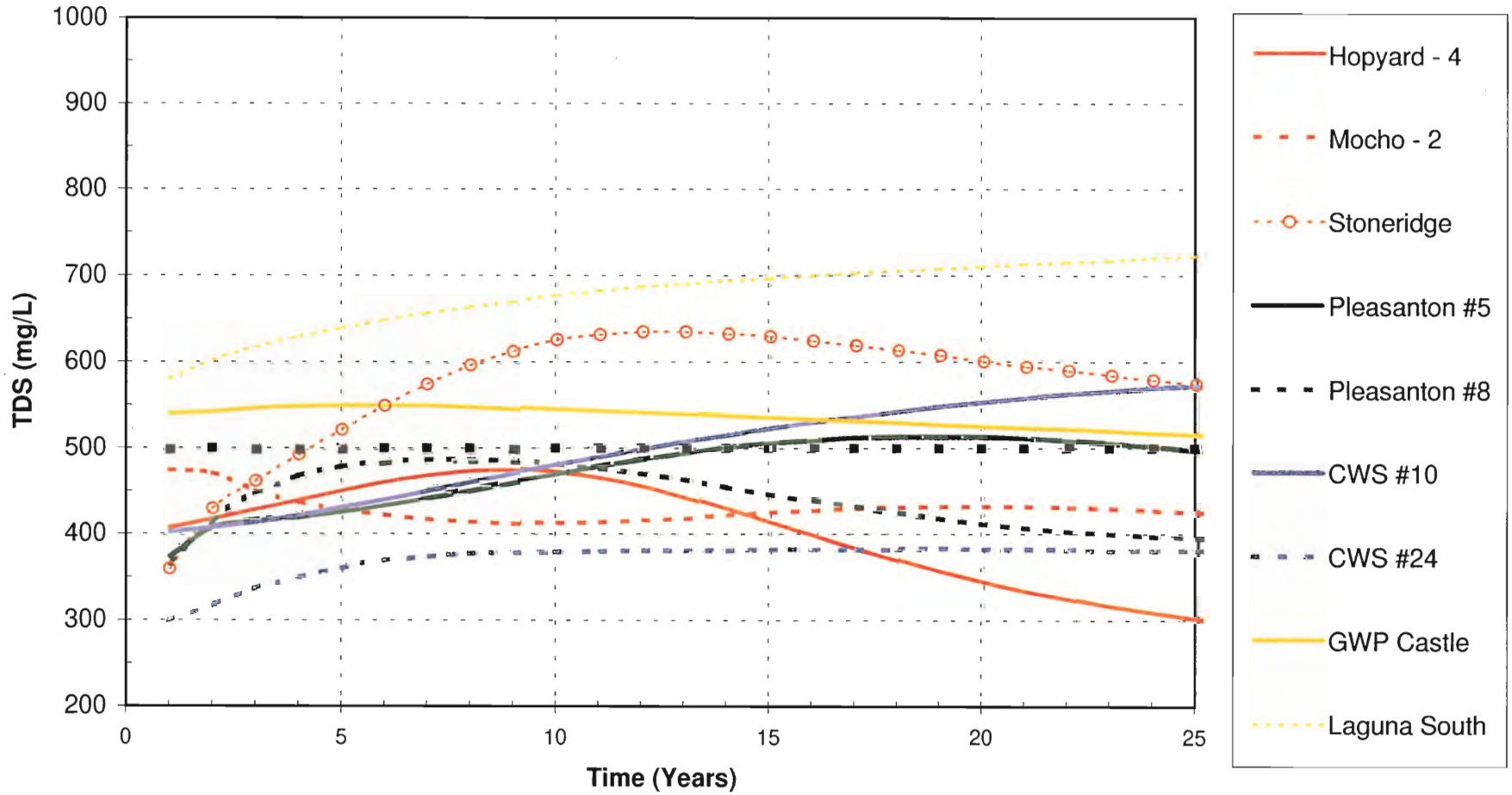


Figure 10.21
Scenario 15: Conj use + Wellhead Demin
Increased ASR injection
Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

versus 650 mg/L for Strategy 1A. The improvement in the Bernal sub-basin under this strategy would be due to the increased ASR injection and pumpage, and demineralization of shallow groundwater that would otherwise degrade the lower aquifer. Groundwater TDS at CWS #10 would increase at about the same rate under Strategy 1A. This is due to recharge and pumpage conditions in the Mocho II sub-basin remaining the same under both strategies.

Upper Aquifer—Figure 10.22 maps the upper aquifer groundwater TDS at the end of a 50-year period. The major changes in groundwater TDS in the upper aquifer compared to Strategy 1A are in the western part of the Amador sub-basin and the central part of the Bernal sub-basin. Although groundwater TDS levels in these areas of the basin would improve over Strategy 1A, TDS would remain at over 650 mg/L for the most part. This improvement is due to the shallow groundwater pumpage for demineralization (5 TAF/year) under this strategy. This pumpage would intercept the high TDS subsurface inflow from the Dublin sub-basin and high TDS recharge from urban irrigation. The low TDS recharge from Arroyo Valle and Lake I would move further into the Bernal sub-basin and lower the groundwater TDS. The rest of the upper aquifer groundwater TDS would be about the same as in Strategy 1A.

Lower Aquifer—Comparing the lower aquifer TDS map Figure 10.23 (Strategy 15) with Figure 10.6 (Strategy 1A), it is clear that the area of the basin with groundwater TDS below 500 mg/L (blue color) would be significantly larger under Strategy 15. The Bernal sub-basin lower aquifer and western portion of the Amador aquifer would benefit the most under Strategy 15. Most of the main basin lower aquifer would stabilize around or below 500 mg/L.

Subsurface inflow from the Dublin sub-basin into the Bernal sub-basin was also computed to determine if pumping shallow groundwater would significantly increase subsurface inflow and thereby negate some of the salt mitigating benefits of Strategy 15. The model simulation computed the subsurface inflow through this boundary to be about 760 AF/year without any shallow groundwater pumpage and only about 900 AF/year with 5 TAF/Y of shallow groundwater pumpage included in Strategy 15.

10.4 Water System Operations Model Evaluations (WRMI)

The water system operations model (WRMI) as currently configured can produce various output parameters on a monthly basis including groundwater recharge, groundwater storage, treatment plant production, Lake Del Valle storage, delivered water quality, flow at any point in the system, etc. The most useful output parameter for the salt management plan strategies was delivered water quality (TDS). The model provided the monthly water quality (TDS) of Zone 7 deliveries to each retailer's turnout under varying hydrologic conditions equivalent to the 1922-96 hydrologic period. The ranges of delivered water quality for each retailer presented below were derived from this WRMI output. The model

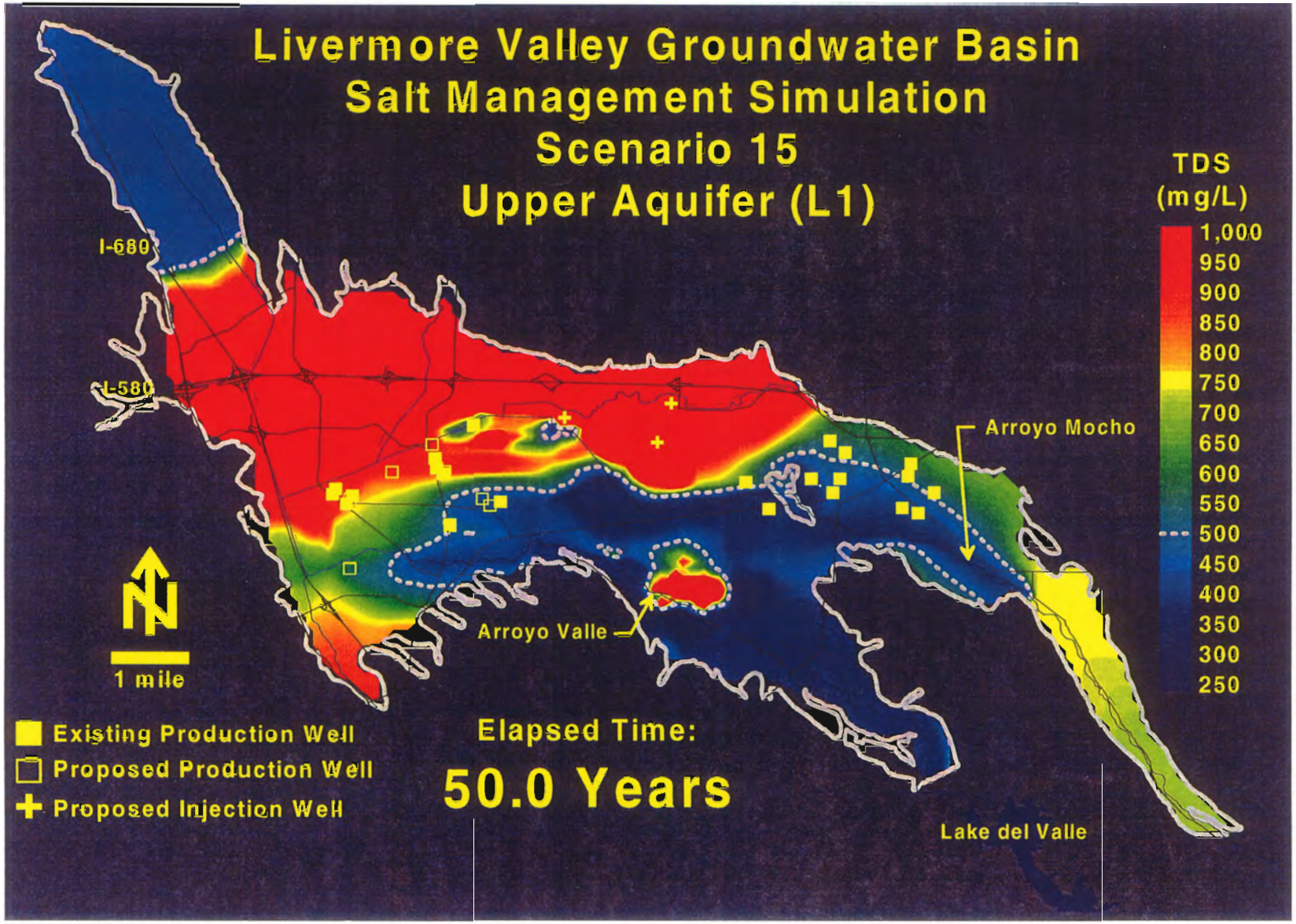


FIGURE 10-22

Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

\SFO\MJB\TDS Maps.xls: SMP15 L1 50 Yr
1/4/99

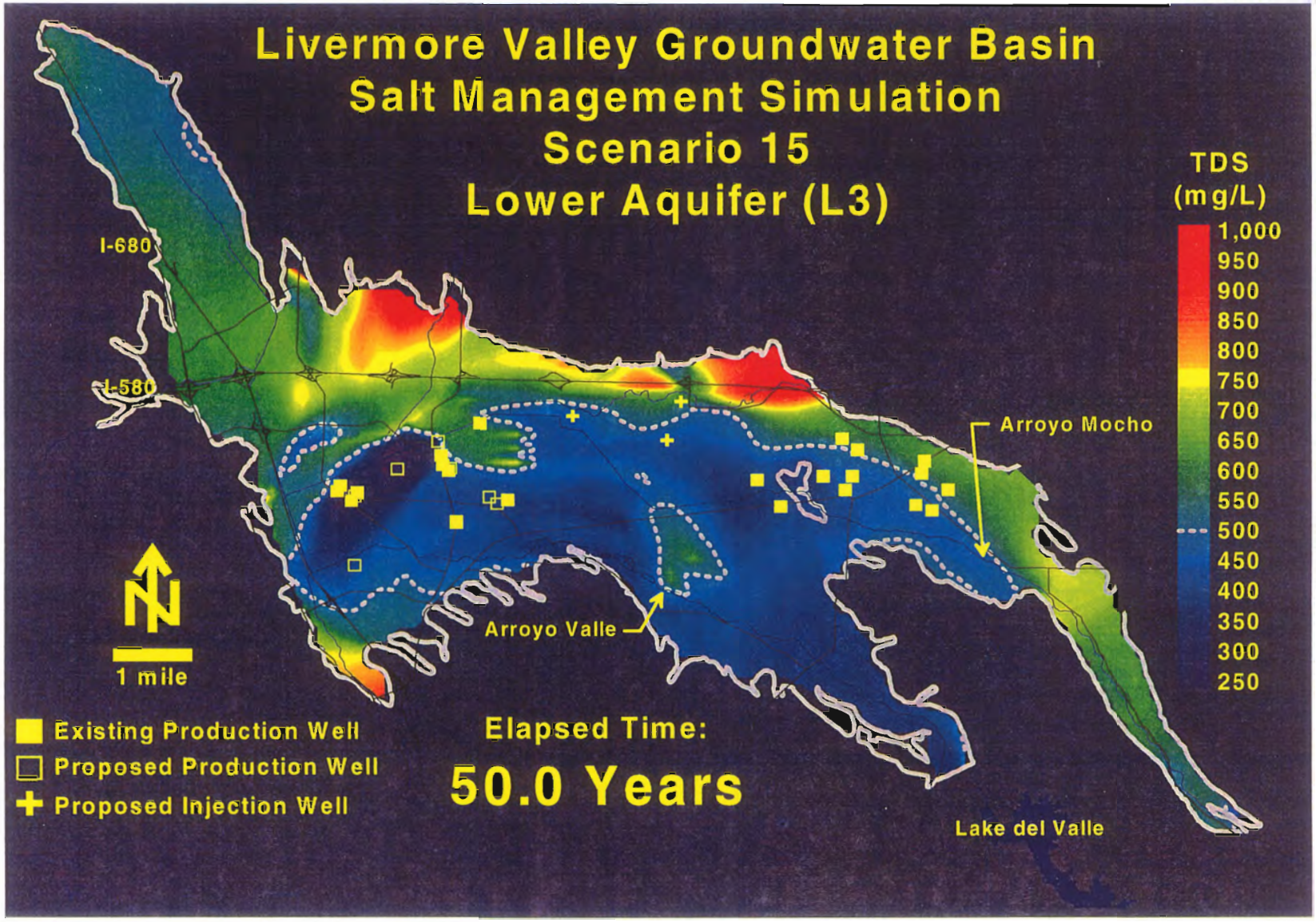


FIGURE 10-23

Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

\SFO\MJB\TDS Maps.xls: SMP15 L1 50 Yr
1/4/99

is also capable of calculating the TDS of each retailer's deliveries, taking into account their individual monthly groundwater pumpage (see Reference O).

The water system operations model was used to predict the Zone 7 delivered water quality for each retailer under key salt management strategies 1, 11B and 15 (Study 1A was not run since it had not been developed when this modeling was conducted). The groundwater source water quality input for these strategies required the use of output from the groundwater model simulation for each respective strategy. The groundwater water quality projected by the groundwater model for each municipal well after 25 years of steady state operation was used as input for the water system model wells.

Figures 10.24 through 10.26 present the modeled delivered water quality for strategies 1, 11B and 15 respectively. These figures plot delivered water quality (TDS in mg/L) against the hydrologic year type. The hydrologic year type is represented in probability of exceedence units. A 99% probability of exceedence means a very dry year with 99% chance of it being wetter in a given subsequent year. A 1% probability of exceedence means a very wet year with only 1% chance of it being wetter. The four lines represent each of the four retailers: red for Pleasanton, blue for Livermore, green for CWS, and purple for DSRSD. The broken lines represent the long-term annual average delivered water TDS for each retailer (approximately equivalent to the 50% exceedence values from the figure).

The solid lines present the predicted TDS variability by retailer under the full range of dry to wet hydrologic conditions. In general, the flatter the lines the lower the variability with changing hydrologic conditions. The closer the lines are to each other the lower the variability in delivered water quality variability among the retailers.

10.4.1 Water System Operations Model Results for Strategy 1

The main feature of Strategy 1 is the injection of 6 TAF/Y of recycled water versus status quo operations. Section 10.2 describes Strategy 1 in more detail. The range of modeled water quality variability in the Zone 7 system for Strategy 1 under various hydrologic conditions is shown in Figure 10.24.

Table 10.7 data, extracted from Figure 10.24, summarizes Zone 7 delivered water quality for each retailer under dry (90%), average (50%) and wet (10%) hydrologic conditions for Strategy 1.

ZONE 7 WATER AGENCY
WATER RESOURCES ENGINEERING

AVERAGE ANNUAL ZONE 7 TDS DELIVERED TO RETAILERS
UNDER 2010 DEMANDS - SMP STUDY 1

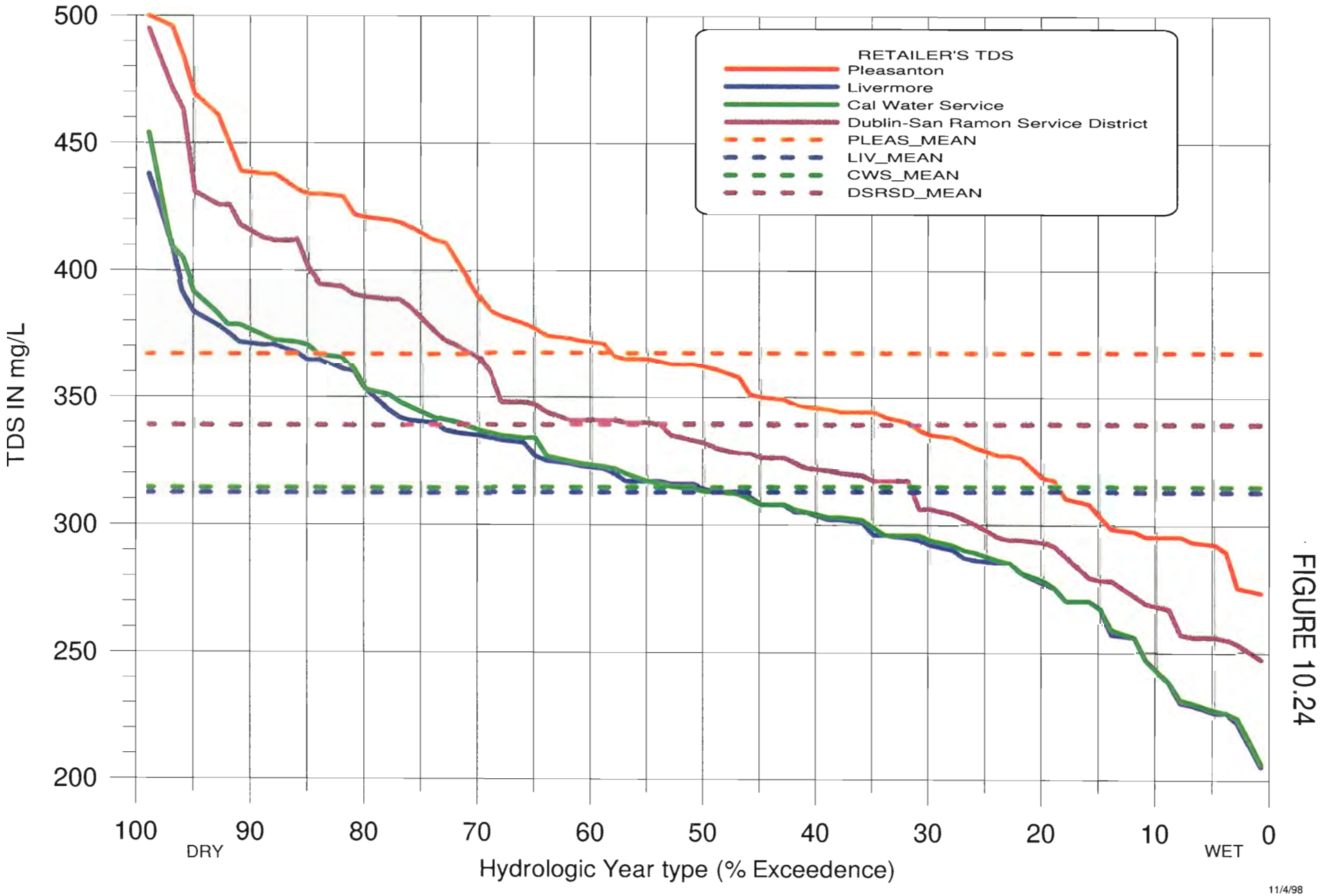


FIGURE 10.24

11/4/98

Table 10.7

Projected Annual Average TDS Delivered To Retailers Under Strategy 1

	Annual Average TDS (mg/L)		
	Dry Year (90%)	Average Year (50%)	Wet Year (10%)
Livermore	370	310	240
CWS	380	310	240
Pleasanton	440	360	300
DSRSD	420	330	270

Livermore and CWS would receive the lowest TDS, varying from 370 mg/L in dry years to 240 mg/L in wet years. In critically dry years (99%) the average would be as high as 440 mg/L and in very wet years (1%) as low as 200 mg/L.

Pleasanton would receive the highest TDS, varying from 440 mg/L in dry years to 300 mg/L in wet years. In critically dry years (99%) the average would be as high as 520 mg/L and in very wet years (1%) as low as 270 mg/L (Fig 10.24).

10.4.2 Water System Operations Model Results for Strategy 11B

The main features of Strategy 11B are increased conjunctive use (3 TAF/year), demineralization of high TDS groundwater pumpage (3 TAF/year), and the injection of 6 TAF/year of RO recycled water over current operation. Section 10.2 describes Strategy 11B in more detail. The range of modeled water quality variability in the Zone 7 system for Strategy 11B under various hydrologic conditions is shown in Figure 10.25.

Table 10.8 data, extracted from Figure 10.25, summarizes Zone 7 delivered water quality for each retailer under dry, average and wet hydrologic conditions under Strategy 11B. Table 10.8 also shows the net difference with respect to Strategy 1.

ZONE 7 WATER AGENCY
WATER RESOURCES ENGINEERING

AVERAGE ANNUAL ZONE 7 TDS DELIVERED TO RETAILERS
UNDER 2010 DEMANDS - SMP STUDY 11B

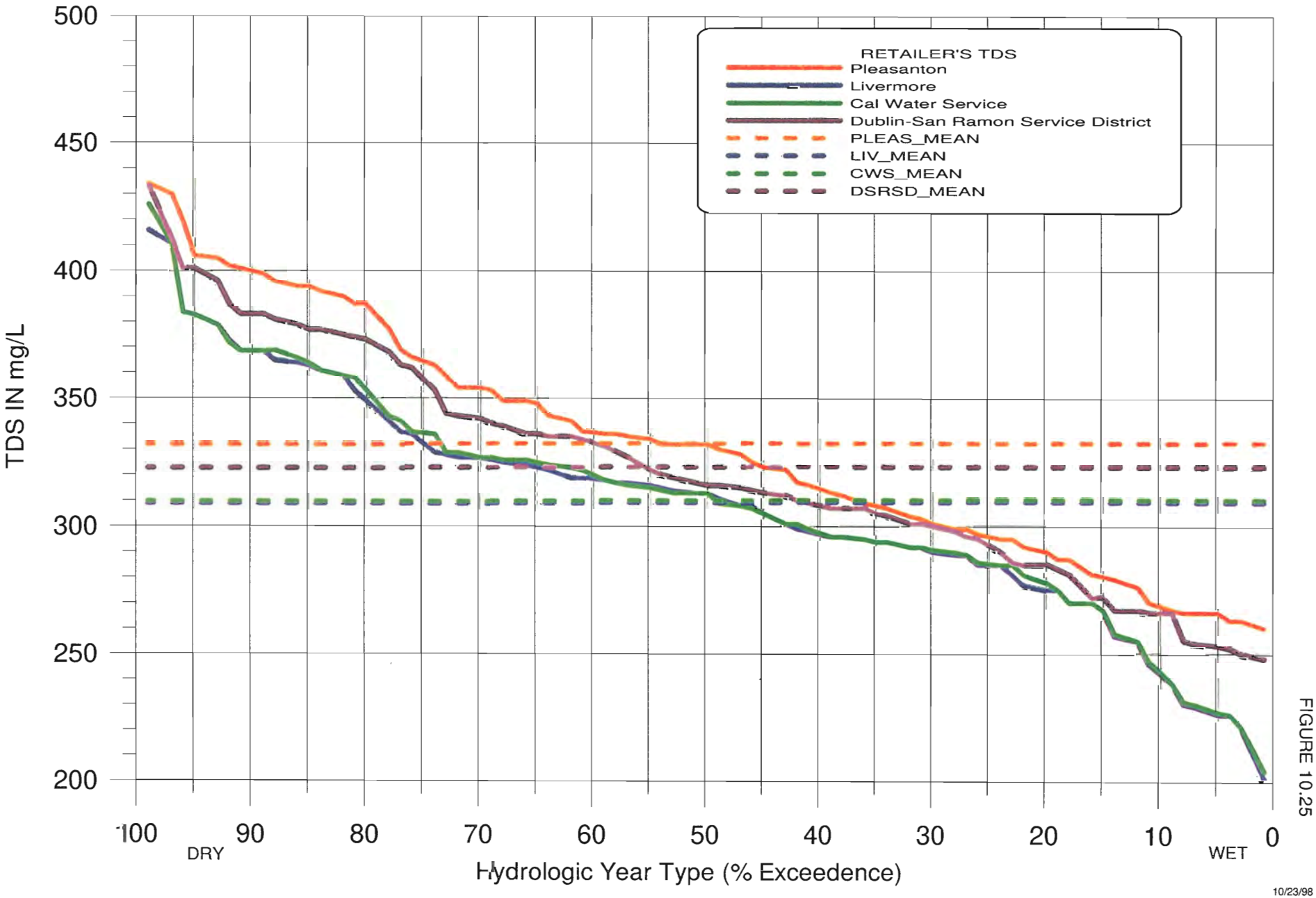


FIGURE 10.25

10/23/98

Table 10.8
Projected Annual Average TDS Delivered To Retailers Under Strategy 11B
and Net Change from Strategy 1

	Annual Average TDS and Net Change (mg/L)					
	Dry Year (90%)	Change	Average Year (50%)	Change	Wet Year (10%)	Change
Livermore	370	(0)	310	(0)	240	(0)
CWS	370	(-10)	310	(0)	240	(0)
Pleasanton	400	(-40)	330	(-30)	270	(-30)
DSRSD	380	(-40)	320	(-10)	270	(0)

Livermore and CWS would continue to receive approximately the same quality and the lowest TDS deliveries, varying from 370 mg/L in dry years to 240 mg/L in wet years. In critically dry years (99%) the average would be as high as 420 mg/L and in very wet years (1%) as low as 200 mg/L (Fig 10.25).

Pleasanton and DSRSD would receive better quality but still higher TDS deliveries than Livermore and CWS, varying from 400 mg/L in dry years to 270 mg/L in wet years. In critically dry years (99%) the average would be as high as 430 mg/L and in very wet years (1%) as low as 260 mg/L (Fig 10.25). Delivered water quality under Strategy 11B becomes much more similar for both east and west portions of the system.

10.4.3 Water System Operations Model Results for Strategy 15

The main features of Strategy 15 are increased conjunctive use (8.5 TAF/year) and increased demineralization of high TDS groundwater pumpage (5 TAF/year). Section 10.2 describes Strategy 15 in more detail. The range of modeled water quality variability in the Zone 7 system for Strategy 15 under various hydrologic conditions is shown in Figure 10.26.

ZONE 7 WATER AGENCY
WATER RESOURCES ENGINEERING

AVERAGE ANNUAL ZONE 7 TDS DELIVERED TO RETAILERS
UNDER 2010 DEMANDS - SMP STUDY 15

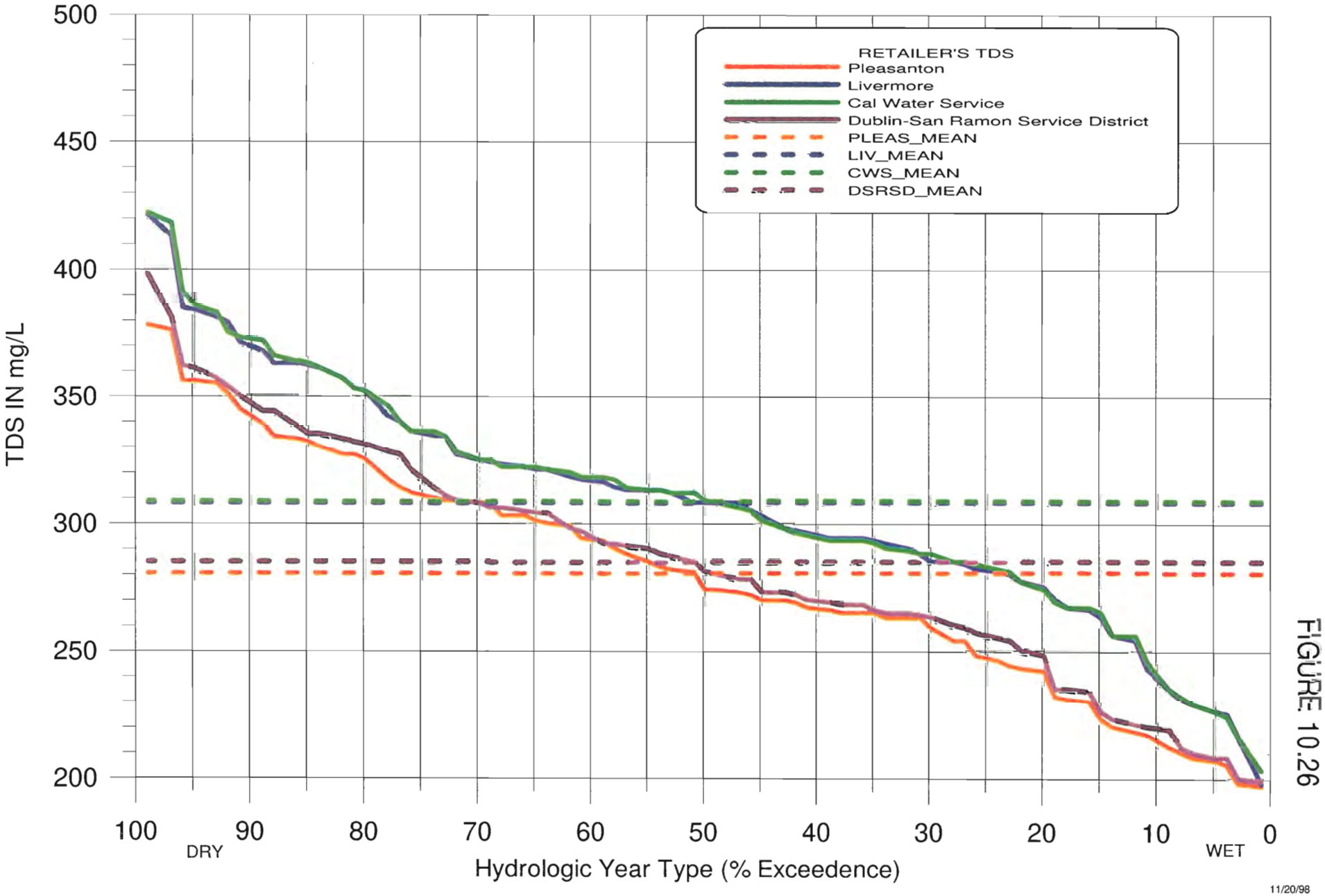


FIGURE 10.26

11/20/98

Table 10.9
Projected Annual Average TDS Delivered To Retailers Under Strategy 15
and Net Change from Strategy 1

	Annual Average TDS and Net Change (mg/L)					
	Dry Year (90%)	Change	Average Year (50%)	Change	Wet Year (10%)	Change
Livermore	370	(0)	320	(10)	240	(0)
CWS	370	(-10)	320	(10)	240	(0)
Pleasanton	340	(-100)	300	(-60)	220	(-80)
DSRSD	350	(-70)	300	(-30)	220	(-50)

Table 10.9 data, extracted from Figure 10.26, summarize Zone 7 delivered water quality for each retailer under dry, average and wet hydrologic conditions for Strategy 15.

Livermore and CWS would continue to receive essentially the same TDS deliveries (which would now be slightly higher than DSRSD and Pleasanton deliveries), varying from 370 mg/L in dry years to 240 mg/L in wet years. In critically dry years (99%) the average would be as high as 420 mg/L and in very wet years (1%) as low as 200 mg/L.

Pleasanton and DSRSD would receive the lowest TDS deliveries under Strategy 15, varying from 350 mg/L in dry years to 220 mg/L in wet years. In critically dry years (99%) the average would be as high as 380 mg/L and in very wet years (1%) as low as 200 mg/L (Fig 10.26).

10.5 Modeling Results Comparison of Key Strategies

10.5.1 Groundwater Model Results Comparison of Strategies 1A, 1, 11B and 15

Each strategy would have a different groundwater quality impact at a given well location. Figures 10.27 through 10.30 show the groundwater quality changes in the deep aquifer under the key strategies at Stoneridge well, Hopyard 4 well, Pleasanton 8 well and the future Bernal Property well field (GWP Castlewood) locations.

As shown in Figure 10.27, the groundwater TDS at the Stoneridge well location would increase significantly in the beginning under all proposed strategies. This is due to the fact that after the gravel mining operation stops in the vicinity of Stoneridge well (Kaiser operation), the upper aquifer high TDS groundwater (currently pumped by Kaiser) would start moving into the deep aquifer. The groundwater TDS under Strategies 1A and 15 at this location would be about the same and would stabilize at about 575 mg/L after 25

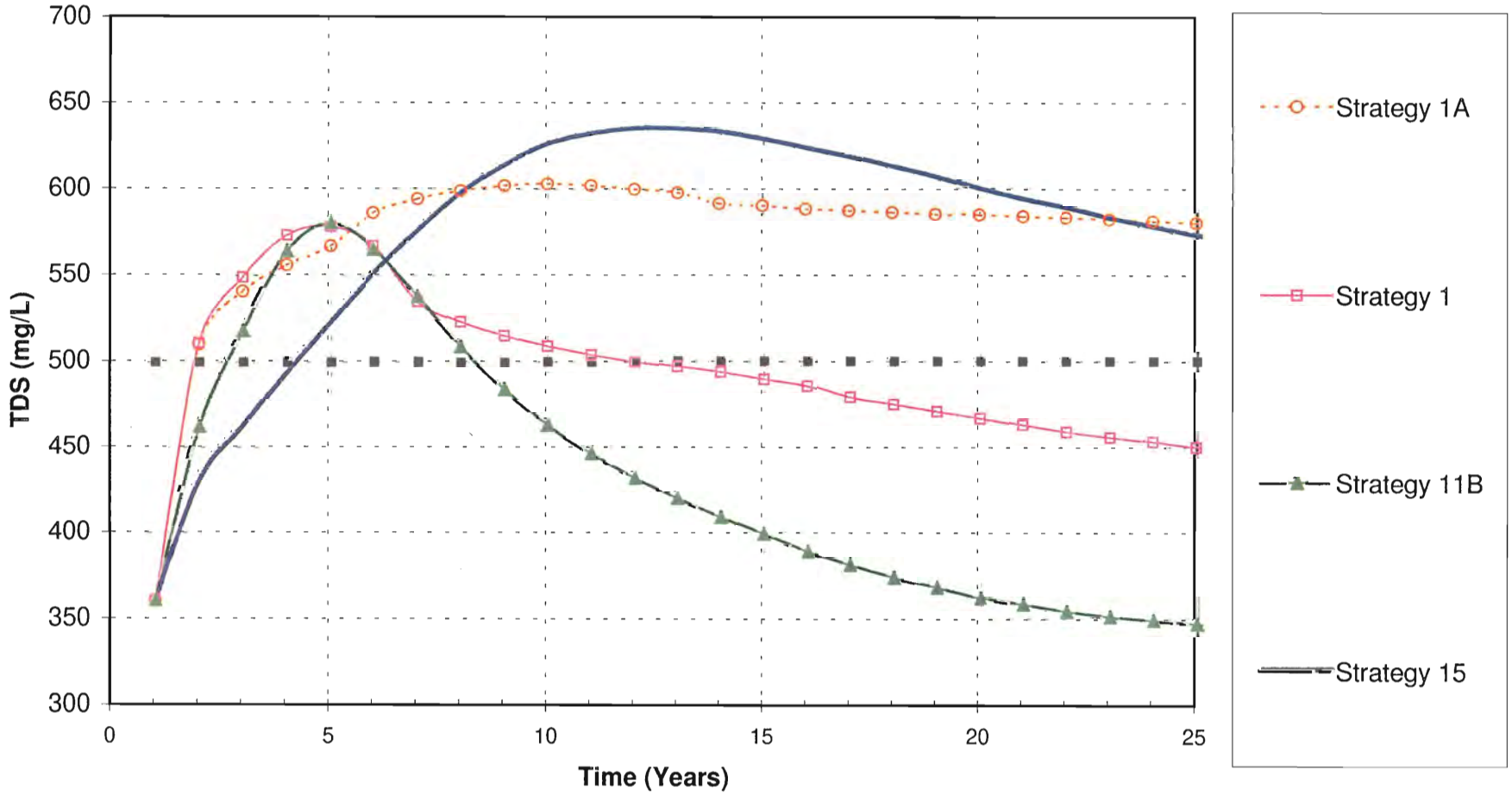


Figure 10.27
Stoneridge Well

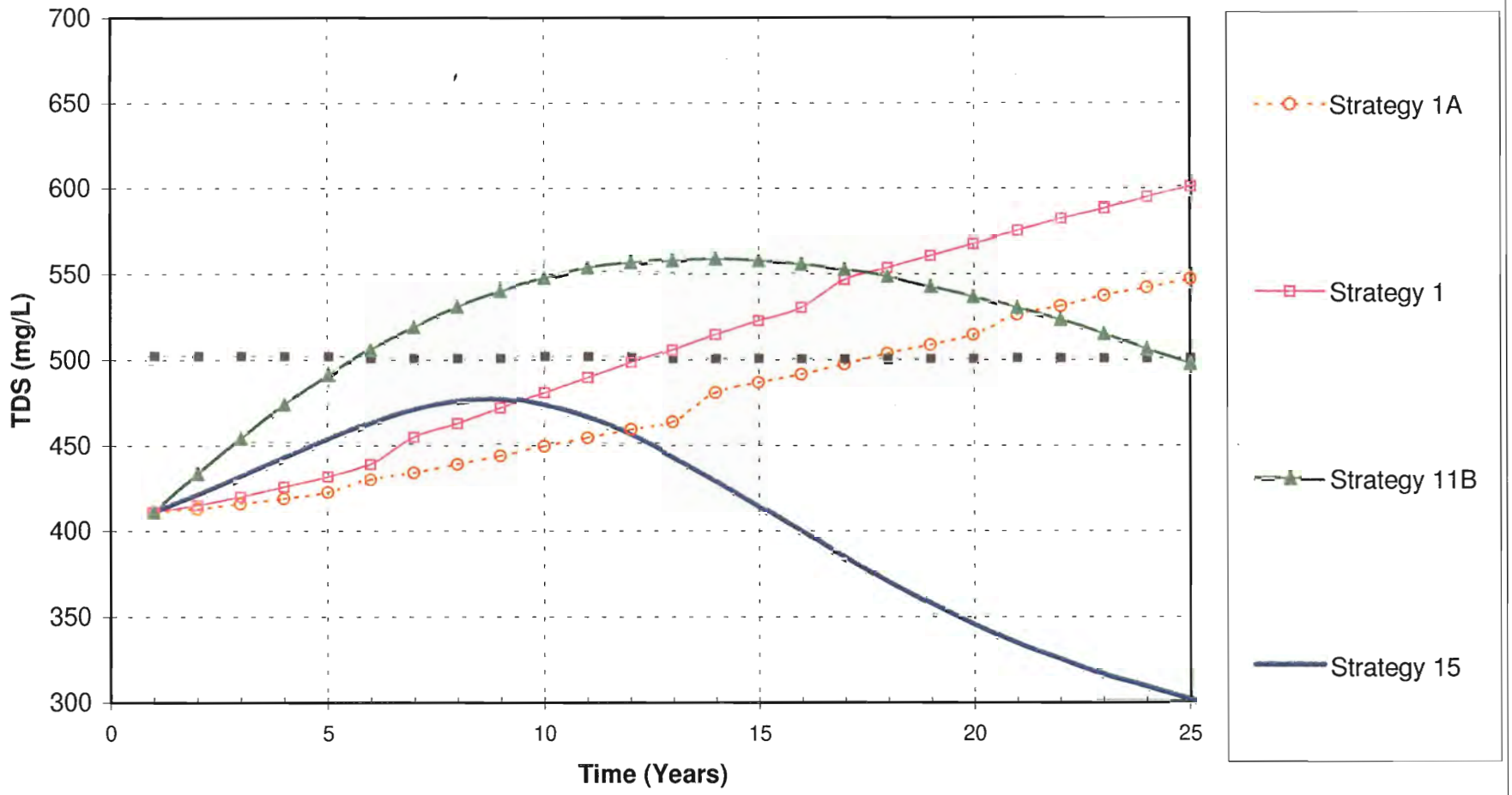


Figure 10.28
Hopyard #4 Well

years. Under strategies 1 and 11B (due to low TDS water injection), the groundwater TDS would start improving after about five years and would be significantly better than under strategies 1A and 15. The groundwater TDS after 25 years would be at about 450 mg/L and 350 mg/L under strategies 1 and 11B, respectively.

The Hopyard well field (Figure 10.28) groundwater TDS under Strategy 15 would be significantly lower than under strategies 1A, 1 or 11B. The groundwater TDS after 25 years under Strategy 15 would be 300 mg/L as compared to 500 mg/L for Strategy 11B and over 550 mg/L for strategies 1A and 1. This is due to the increased ASR injection and pumpage, and the pumpage and demineralization of shallow groundwater that would otherwise degrade the lower aquifer.

The groundwater TDS at the Pleasanton #8 well location responds similarly under all proposed strategies. TDS initially increases then drops to the 400 mg/L range under strategies 1,11B and 15 (Figure 10.29). Even under Strategy 1A (Status Quo), this location's groundwater TDS would stabilize at less than 450 mg/L after 25 years. This location receives a large contribution of low TDS Arroyo Valle recharge which has a primary influence in this area.

The future Bernal Property wellfield location (GWP Castlewood) groundwater TDS would improve significantly under Strategy 15 versus strategies 1A and 1 (Figure 10.30). Under strategies 1A and 1, the groundwater TDS would increase from 550 mg/L to 650 mg/L after 25 years. Under Strategy 11B
the groundwater would stay at about current TDS levels and under Strategy 15 the groundwater TDS would be trending down after 10 years to about 510 mg/L by the 25th year.

10.5.2 Water System Operations Model (WRMI) Results Comparison of Strategies 1, 11B and 15

Water quality in the Zone 7 distribution system varies with hydrologic conditions and with location in the distribution system. Water quality can also vary significantly due solely to seasonal water quality changes in the SWP's Delta pumping.

TDS reached higher levels in dry years as compared to average or wet years for two primary two reasons: 1) The TDS of surface water supplies is generally higher in dry years and 2) Total groundwater pumpage is higher due to deficiency in surface water supplies.

Summary Figure 10.31 and selected results shown in Table 10.10 below present how the overall average TDS of Zone 7 deliveries would compare for the three key strategies under dry (90%), average (50%) and wet (10%) conditions. In a dry year, the annual average of Zone 7 deliveries under Strategy 1 would be 400 mg/L, versus 380 mg/L for Strategy 11B and 350 mg/L for Strategy 15. Similarly, the overall average TDS of Zone 7 deliveries in

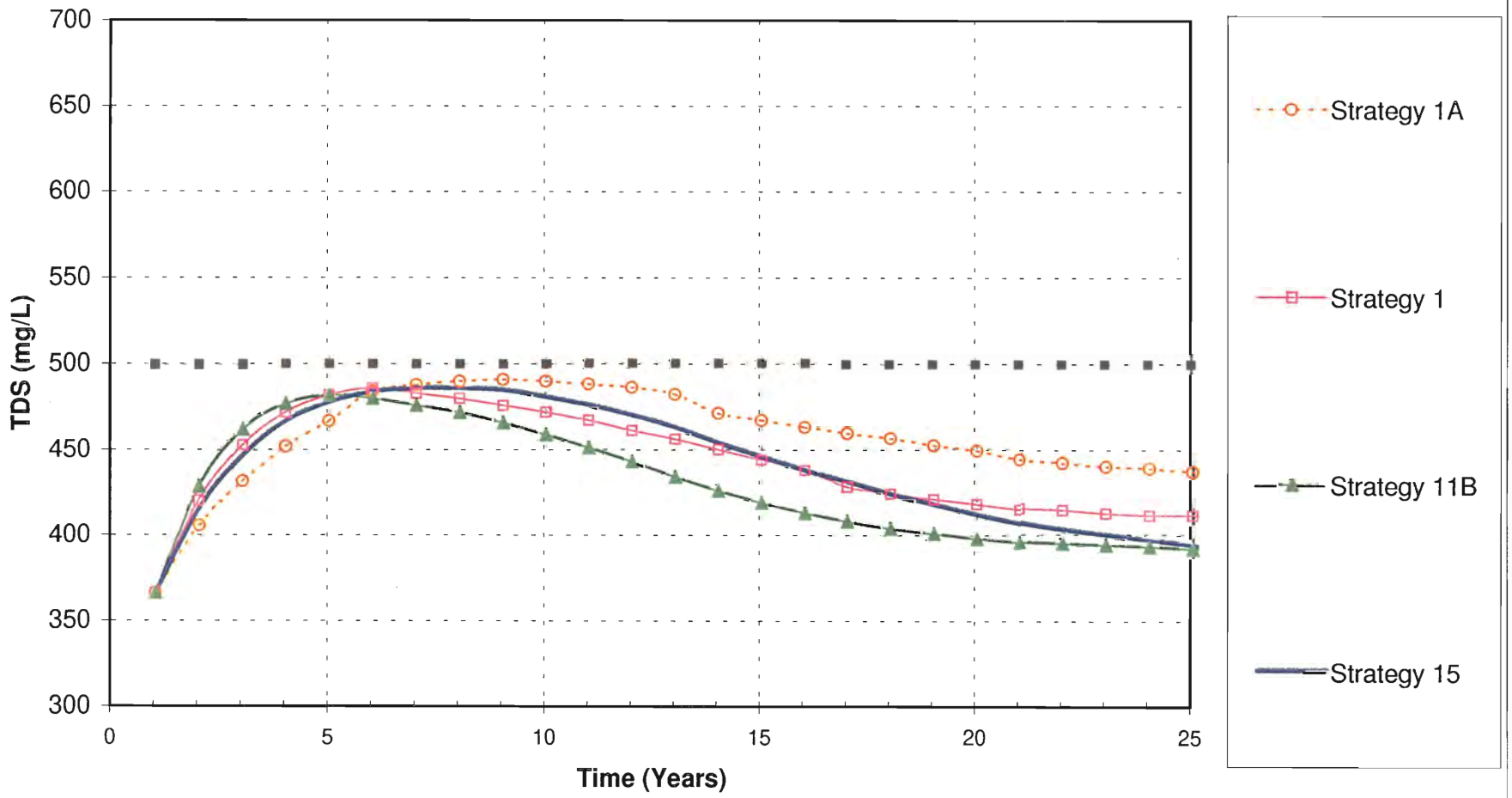


Figure 10.29
Pleasanton #8 Well

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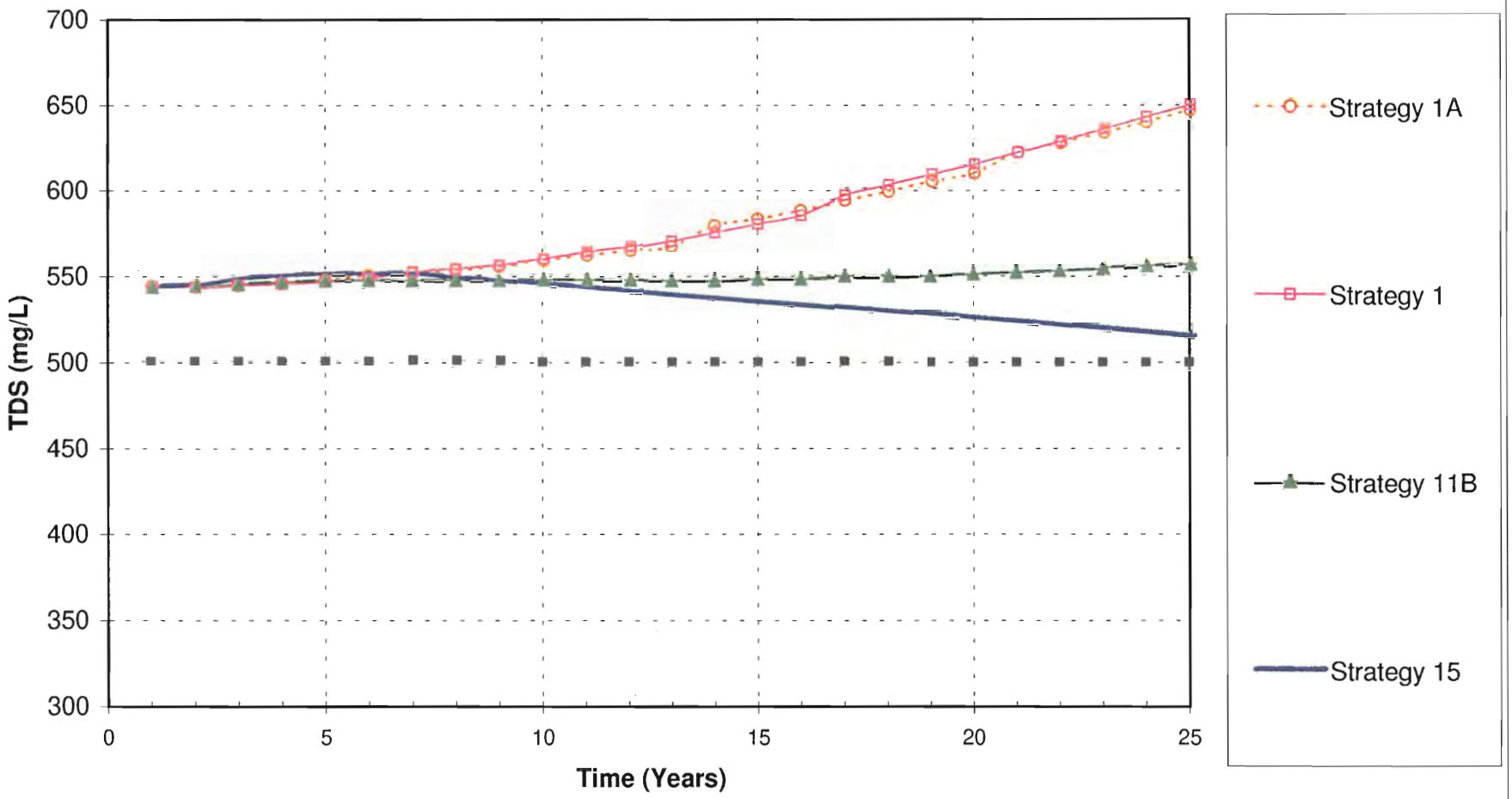


Figure 10.30
GWP Castlewood (SFWD)

average and wet years would improve by 10 and 40 mg/L under strategies 11B and 15, respectively versus under Strategy 1.

The differences are due to the differing amounts of demineralization (3 TAF/year under 11B versus 5 TAF/year under 15) and to the improvement in overall groundwater TDS under strategies 11B and 15. The long-term average of Zone 7 deliveries would also improve slightly from 335 mg/L for Strategy 1 to 320 for Strategy 11B and 290 mg/L for Strategy 15 (Figure 10.31 and Table 10.10).

Table 10.10
Overall Average Zone 7 Delivered Water Quality Variability with with Hydrologic Conditions under Strategy 1, 11B and 15

	Zone 7 Annual Average TDS (mg/L)		
SMP Strategies	Dry Year (90%)	Average Year (50%)	Wet Year (10%)
Strategy 1	400	330	270
Strategy 11b	380	320	260
Strategy 15	350	290	230

Table 10.11 presents the long-term average TDS of Zone 7 deliveries to individual retailers to illustrate the TDS variability under each strategy. Under Strategy 1, the long-term average TDS of Pleasanton's deliveries would be 370 mg/L (highest overall) as compared to 310 mg/L for Livermore (lowest). Under Strategy 11B, the respective long-term average TDS difference is reduced with Pleasanton deliveries of 330 mg/L as compared to 310 mg/L for Livermore. Under Strategy 15, the long-term average TDS of Pleasanton and Livermore deliveries would be equal at 310 mg/L.

Although there is only a 10% overall improvement (330mg/L to 300mg/L) in long-term average water TDS of Zone 7 deliveries between strategies 1 and 15, there is a more significant improvement in the equalization of delivered water TDS to the retailers. Equalizing delivered water TDS is one of the goals of the Salt Management Plan. To reiterate, the main reasons for this east-west variability improvement are the demineralization of groundwater pumpage and improved groundwater quality under strategies 11B and 15.

ZONE 7 WATER AGENCY
WATER RESOURCES ENGINEERING

COMPARISON OF SMP STUDY 1, STUDY 11B, AND STUDY 15
AVERAGE ANNUAL ZONE 7 DELIVERED WATER TDS

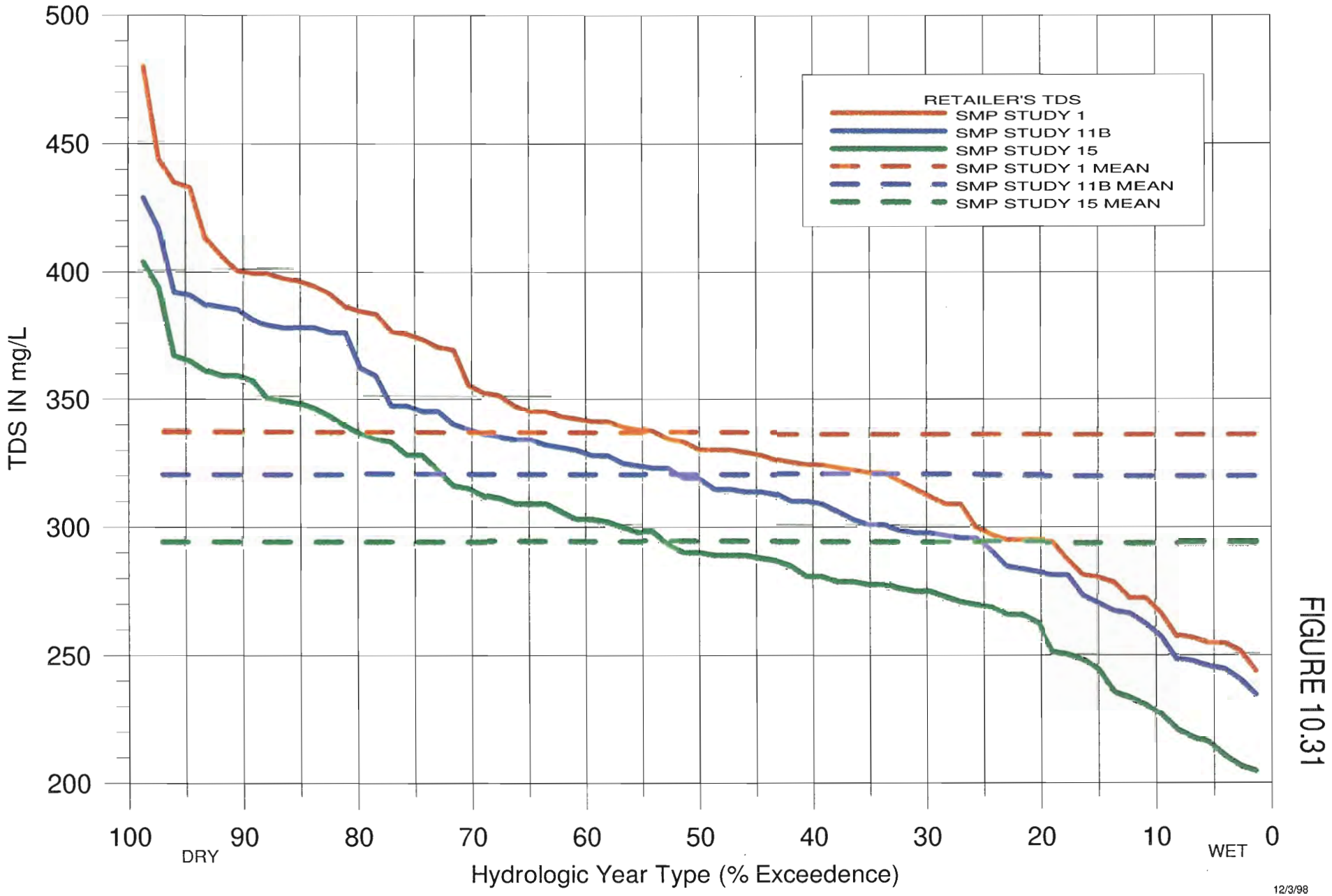


FIGURE 10.31

12/3/98

Table 10.11
Comparing Variability among Retailers under Strategy 1, 11B and 15.

	Long Term Average TDS (mg/L)		
	Strategy 1	Strategy 11b	Strategy 15
Livermore	310	310	310
CWS	320	310	310
Pleasanton	370	330	310
DSRSD	340	320	290
Zone7 Average	330	320	300

Pleasanton and DSRSD receive most of Zone 7's groundwater pumpage. Since the groundwater demineralization facilities are assumed to be connected into the water distribution system near the Hopyard wellfield and Camp Parks wellfield, Pleasanton and DSRSD would benefit the most due to the demineralization of groundwater pumpage under strategies 11B and 15.

Livermore and CWS delivered water quality would not change appreciably since both would continue to receive predominantly treated surface water from Zone 7 under all proposed strategies.

10.6 Apparent Best Year 2010 Strategy

These groundwater and WRMI system modeling results confirm the earlier feasibility screening of studies performed in Section 9.8 that Strategy 15 appears to be the best currently acceptable strategy to eliminate the basin net salt loading. Following is a brief summary of the benefits of Strategy 15 versus other key strategies:

- Lowered groundwater TDS in the upper aquifer in the western part of the Amador and the central part of the Bernal sub-basins. This improvement is due to the shallow groundwater pumpage for demineralization (5 TAF/year) under this strategy. This pumpage would intercept the high TDS subsurface inflow from the Dublin sub-basin and high TDS recharge from urban irrigation. The low TDS recharge from Arroyo Valle and from Lake I would move further into the Bernal sub-basin and help lower the groundwater TDS (Figure 10.22).

- Figures 10.32 and 10.33 map the modeled groundwater TDS for the lower aquifer after 10 and 25 years for Strategy 1A and figures 10.34 and 10.35 do the same

under Strategy 15. When comparing these figures, it is clear that the area of the basin with groundwater TDS below 500 mg/L (blue color) would be significantly larger for Strategy 15 even during earlier time periods (versus the 50-year maps presented earlier in this chapter). The Bernal sub-basin lower aquifer and western portion of the Amador aquifer would benefit most under Strategy 15. Most of the main basin lower aquifer would stabilize around or below 500 mg/L.

- GW TDS at all the municipal well locations under Strategy 15 would be equal to or better than under the other strategies except at Stoneridge well (Figures 10.27-10.30). The Stoneridge well area location TDS could also be improved by increasing local area conjunctive use (beyond that assumed for Strategy 15) while injecting low TDS SWP water into the Stoneridge well or any other nearby future well.

- Zone 7 average delivered water TDS would be lower and more equivalent under Strategy 15 (tables 10.10 and 10.11).

- Strategy 15 would not require any additional facilities other than those already included in the Capital Improvement Program. The incremental O&M cost would add about $50/AF to the Zone 7 treated water rate. Assuming that average annual water use per house is one half acre-foot per year, this would increase the treated water cost by $25 per year per household.

- Strategy 15 doesn't preclude use of any other strategies as they become available in the future (such as groundwater export, RO recycled water injection, etc.). It would facilitate future lower cost seasonal groundwater export since facilities could be readily included to allow pumpage to be diverted to an arroyo, instead of to the demineralization facility, when environmental and institutional conditions permit.

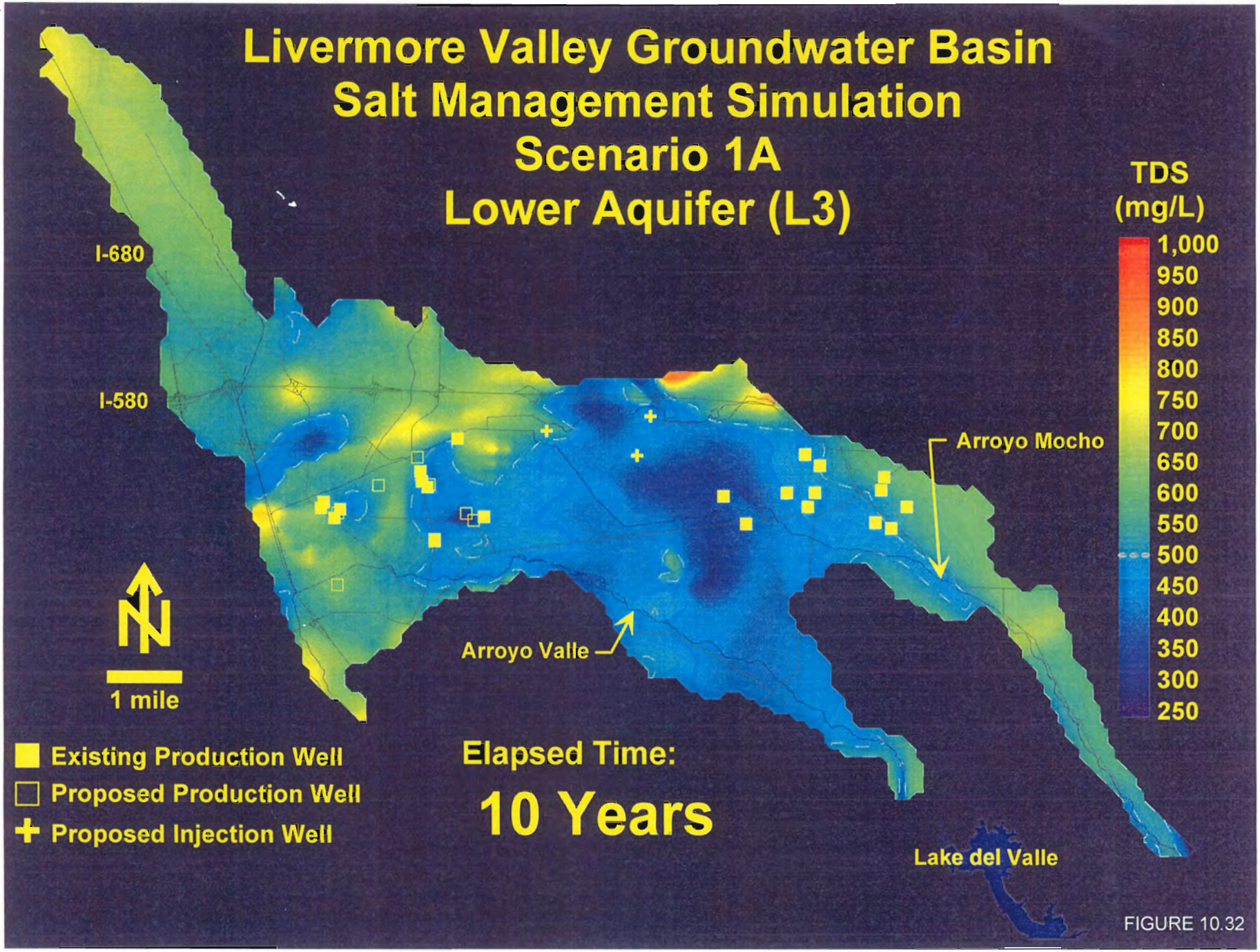

Livermore Valley Groundwater Basin
Salt Management Simulation
Scenario 1A
Lower Aquifer (L3)
TDS
(mg/L)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
I-680
I-580
Arroyo Mocho
Arroyo Valle
Lake del Valle
1 mile
Existing Production Well
Proposed Production Well
Proposed Injection Well
Elapsed Time:
10 Years

FIGURE 10.32

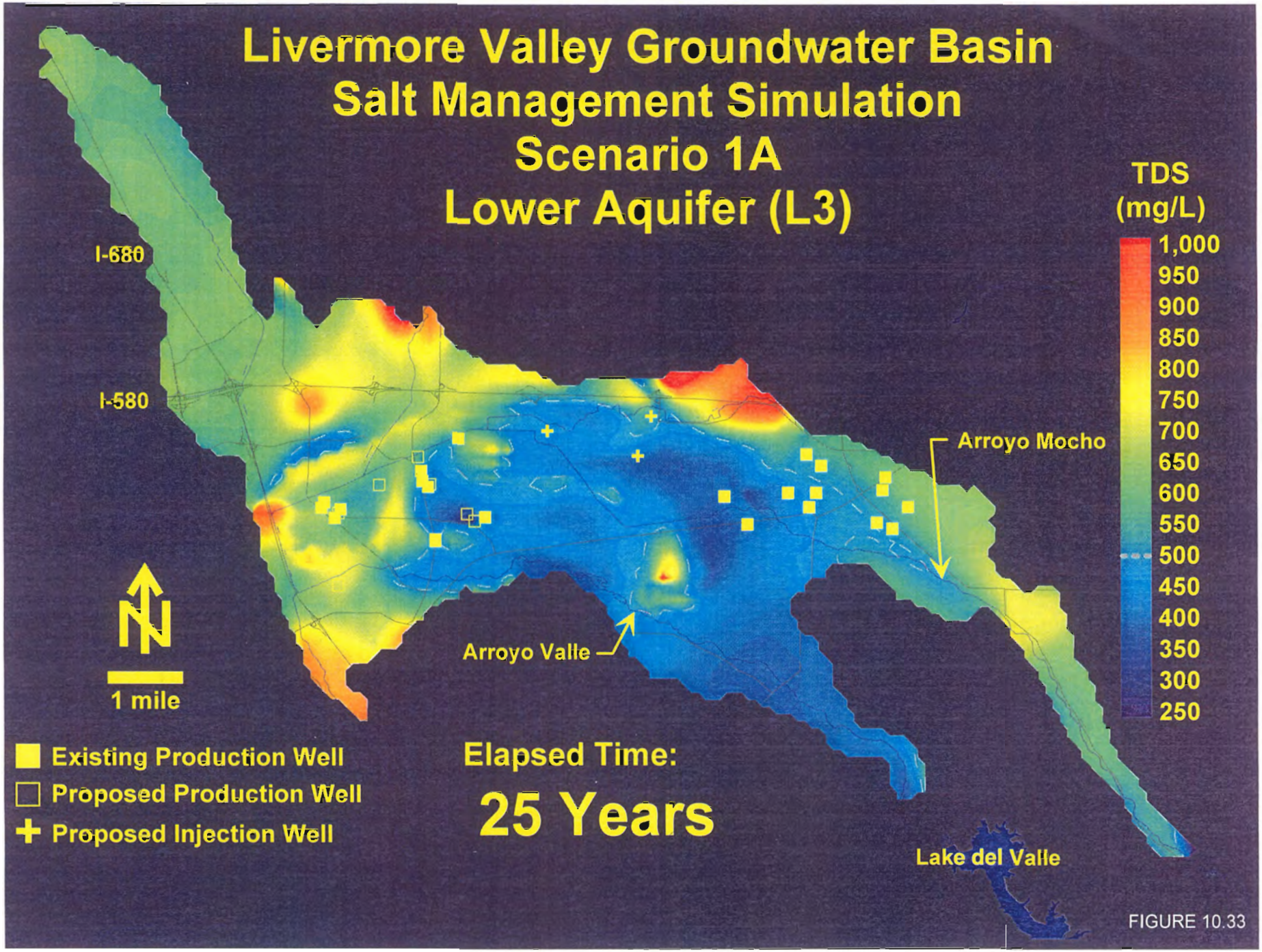

Livermore Valley Groundwater Basin
Salt Management Simulation
Scenario 1A
Lower Aquifer (L3)
TDS
(mg/L)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
I-680
I-580
Arroyo Mocho
Arroyo Valle
Lake del Valle
N
1 mile
Existing Production Well
Proposed Production Well
Proposed Injection Well
Elapsed Time:
25 Years

FIGURE 10.33

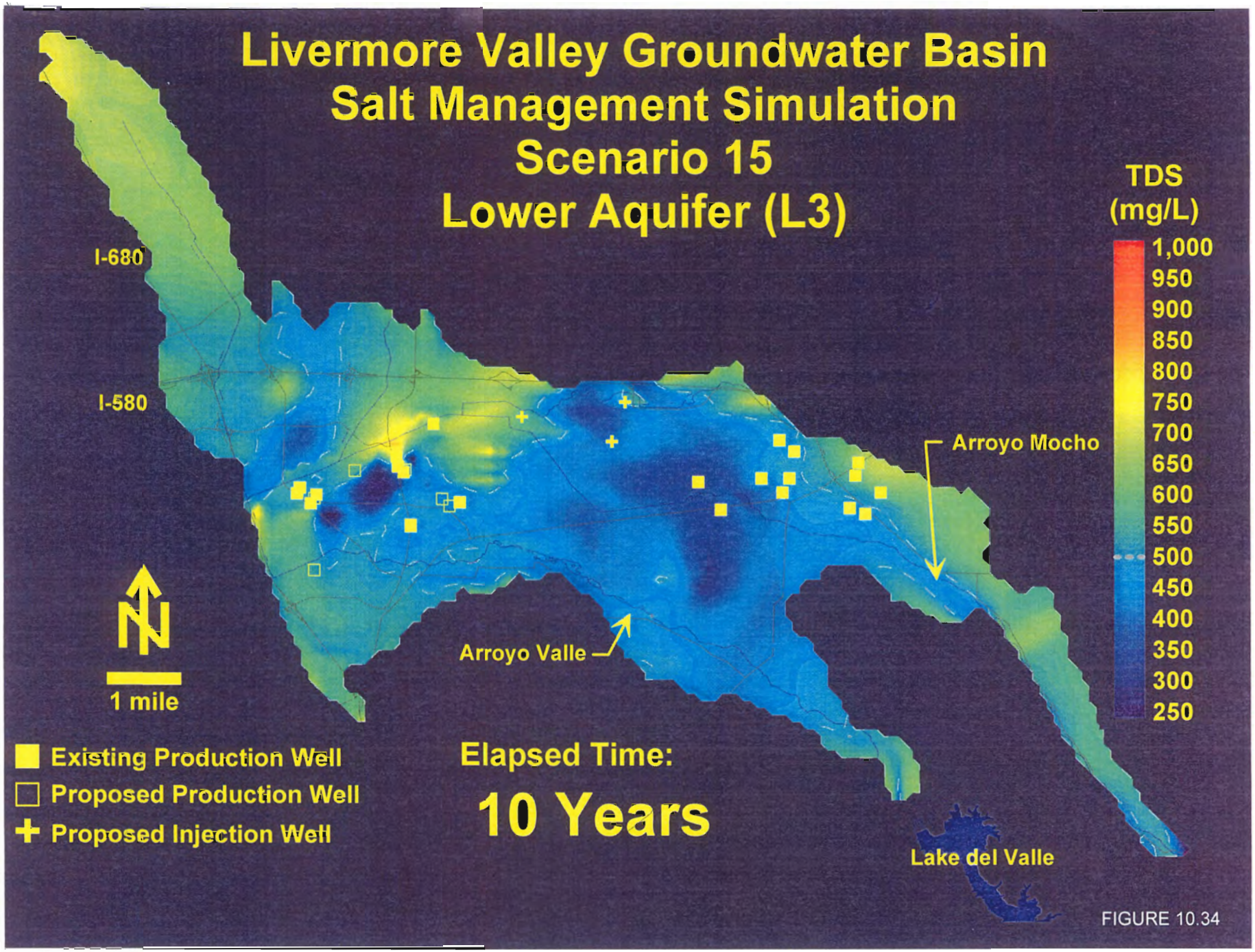

Livermore Valley Groundwater Basin
Salt Management Simulation
Scenario 15
Lower Aquifer (L3)
TDS
(mg/L)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
I-680
I-580
Arroyo Mocho
Arroyo Valle
N
1 mile
Existing Production Well
Proposed Production Well
Proposed Injection Well
Elapsed Time:
10 Years
Lake del Valle

FIGURE 10.34

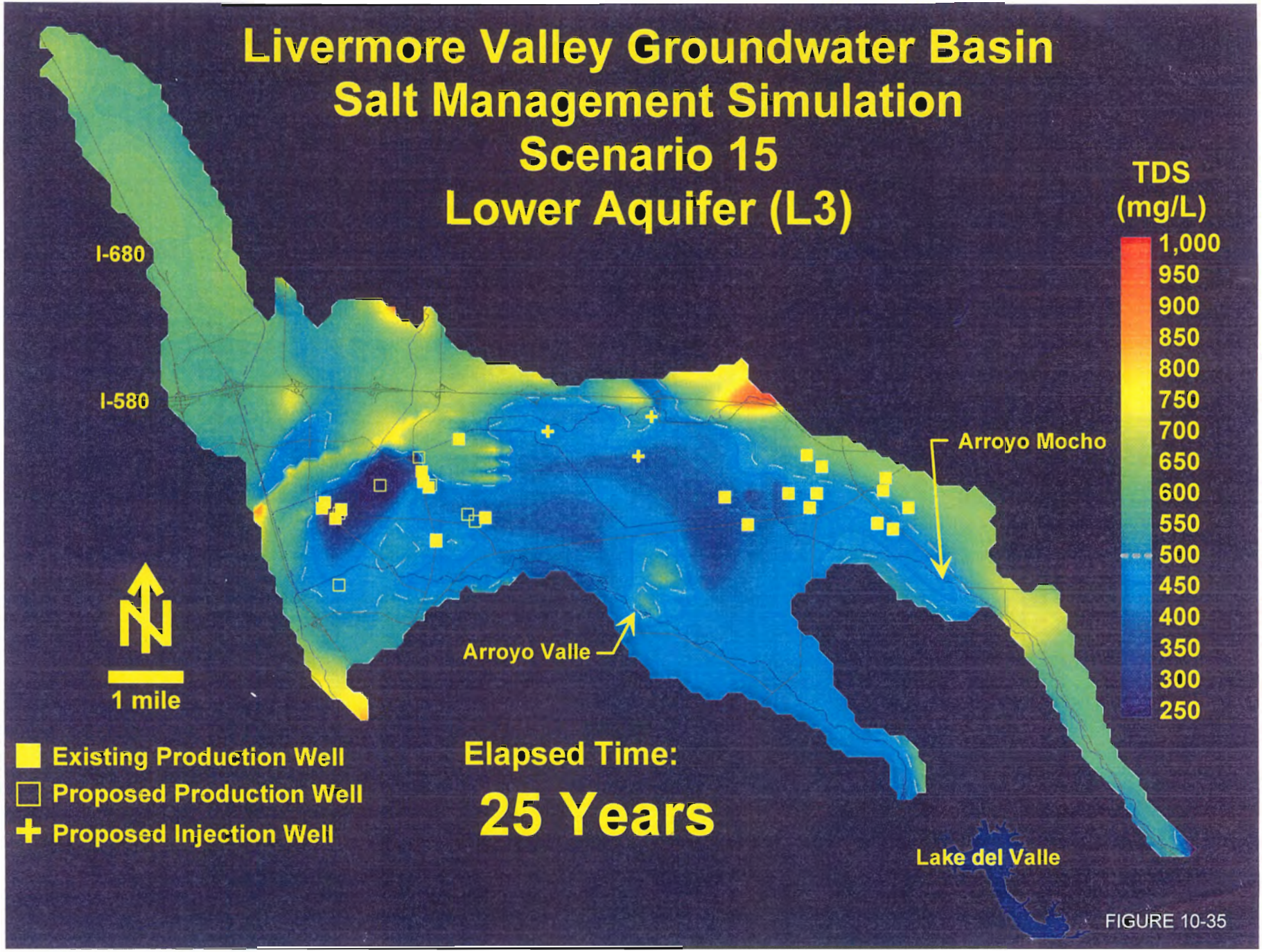

Livermore Valley Groundwater Basin
Salt Management Simulation
Scenario 15
Lower Aquifer (L3)
TDS
(mg/L)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
I-680
I-580
Arroyo Mocho
Arroyo Valle
N
1 mile
Existing Production Well
Proposed Production Well
Proposed Injection Well
Elapsed Time:
25 Years
Lake del Valle

FIGURE 10-35

Chapter 11

Salt Management Cost Allocation

Chapter 11

Salt Management Cost Allocation

11.1 Introduction

Prior chapters of this SMP described individual and composite salt management strategies (referred as "studies" in Chapter 9) and their associated costs (tables 9.1 and 9.2). Strategy 15, a composite of increased conjunctive use and wellhead demineralization, was the only strategy that passed all the screening criteria (section 9.6). More detailed modeling (Chapter 10) confirmed that Strategy 15 would meet the proposed SMP policy goals of fully offsetting year 2010 salt loading while maintaining (and in certain geographic areas improving) delivered water quality. Strategy 15 operational costs to offset the projected 5,400 tons/year of salt loading in the year 2010 were estimated at $2.6 million/year.

This chapter describes options and a recommended approach for allocating salt management costs. The recommendations were developed in large part based on input from the Technical Advisory Group (TAG) and the Groundwater Management Advisory Group (GMAC). The focus of the evaluation is primarily on near-term cost allocation measures to offset the current 2,200 tons/year salt load (Section 11.3). The options evaluated were limited to those consistent with Zone 7's existing approach for allocating capital and operations and maintenance costs (i.e., via connection fees and water rates, respectively). These options generally assumed that a centralized approach would be adopted by the Zone 7 Board (such as Strategy 15) where the overall basin-wide salt loading would be offset via Zone 7 directed basin management actions and facilities.

This chapter also includes the results of discussions with the TAG and GMAC regarding potential cost allocation options for facilities needed to offset future salt loads resulting from new urban and agricultural development, and from recycled water irrigation (sections 11.4 – 11.6). Additional work and negotiations beyond the scope of this report will be required to determine the most equitable and appropriate approach(es) for allocating these future salt management capital and O&M costs. In the interim, staff recommends that impacts of new projects be evaluated and addressed on a case-by-case basis.

An approach for calculating salt removal costs or salt credits on a project-by-project basis was also developed in cooperation with the TAG (Section 11.7). This approach addresses the situation where individuals would seek to develop their own salt management measures for a given project independent of Zone 7.

11.2 Livermore Valley Land Use and Salt Impact Zones

The annual salt loading calculations prepared by Zone 7 (Chapter 5) require in part an estimate of the pounds of salt applied via irrigation in a given area that will impact the main basin. In these calculations, 100% of the applied salt in areas directly above the main basin is assumed to reach the main basin (see Section 3.6). Future salt loading is projected to increase from the current 2,200 tons/year to an estimated 5,400 tons/year by the year 2010 due primarily to reductions in gravel mining pumpage exports and due to increased irrigation associated with new urban and agricultural development.

Most new development will be occurring in areas outside of the main basin. In these fringe areas, local geologic conditions influence the relative percent of applied salt that will reach the main basin. The following describes the methodology used for dividing the valley into four relative salt impact zones.

Annually Zone 7 prepares a hydrologic land use study and map (Figure 11.1) of the Livermore-Amador Valley (see Reference P for the complete Land Use Memorandum Report). Land use changes are used in the computation of rainfall recharge, applied water recharge, mining area evaporative losses, and unmetered agricultural groundwater pumpage. Land is subdivided into four main categories: urban, irrigated agriculture, mining area, and unclassified. Areas are further classified by the primary irrigation source, surface water or groundwater. Current and potential recycled water irrigation sites are also tracked (see discussion and map in section 6.6).

Annual changes in these various land uses affect the amount and salt content of water recharging the groundwater basin. This information is used in updating the annual salt balance calculations and in refining the Salt Management Monitoring Program (SMMP – see Chapter 6).

The runoff characteristics and hydrogeologic information about the valley (see Chapter 2) was used to prepare a map (Figure 11.2) that divided the valley into four general salt loading impact zones: 100%, 67%, 33%, and 0%. This was done to provide a reasonable method for estimating future salt impacts to main basin groundwater quality from irrigation with different quality water supplies. Following is a brief description of the various impact zones and their locations. More detailed information on individual areas on a drainage basin basis is contained in Reference G.

100% Impact Zones

Land area in the 100% impact zone (shown in white in Figure 11.2) is that located directly above the main groundwater basin. It is assumed that all the salt in recharge water due to water applied for irrigation onto this land would migrate vertically and that 100% of the associated salts would impact the main basin.

Figure 11.1

EXPLANATION

NODE NUMBER 46 · NODE BOUNDARY · MAIN BASIN / NODE BOUNDARY · 47 MAIN BASIN NODE NUMBER

LAND USE CATEGORIES

- **URBAN**
- URBAN RECLAIMED WATER
- GOLF COURSE GROUNDWATER
- GOLF COURSE SURFACE WATER
- GOLF COURSE RECLAIMED WATER
- **IRRIGATED AGRICULTURE** (BY PRIMARY IRRIGATION SOURCE)
- GROUNDWATER
- SURFACE WATER
- **MINING AREA**
- LAKES
- WET CLAY
- RECLAIMED URBAN

N

0' 3000' 6000'

SCALE

ZONE 7 WATER AGENCY

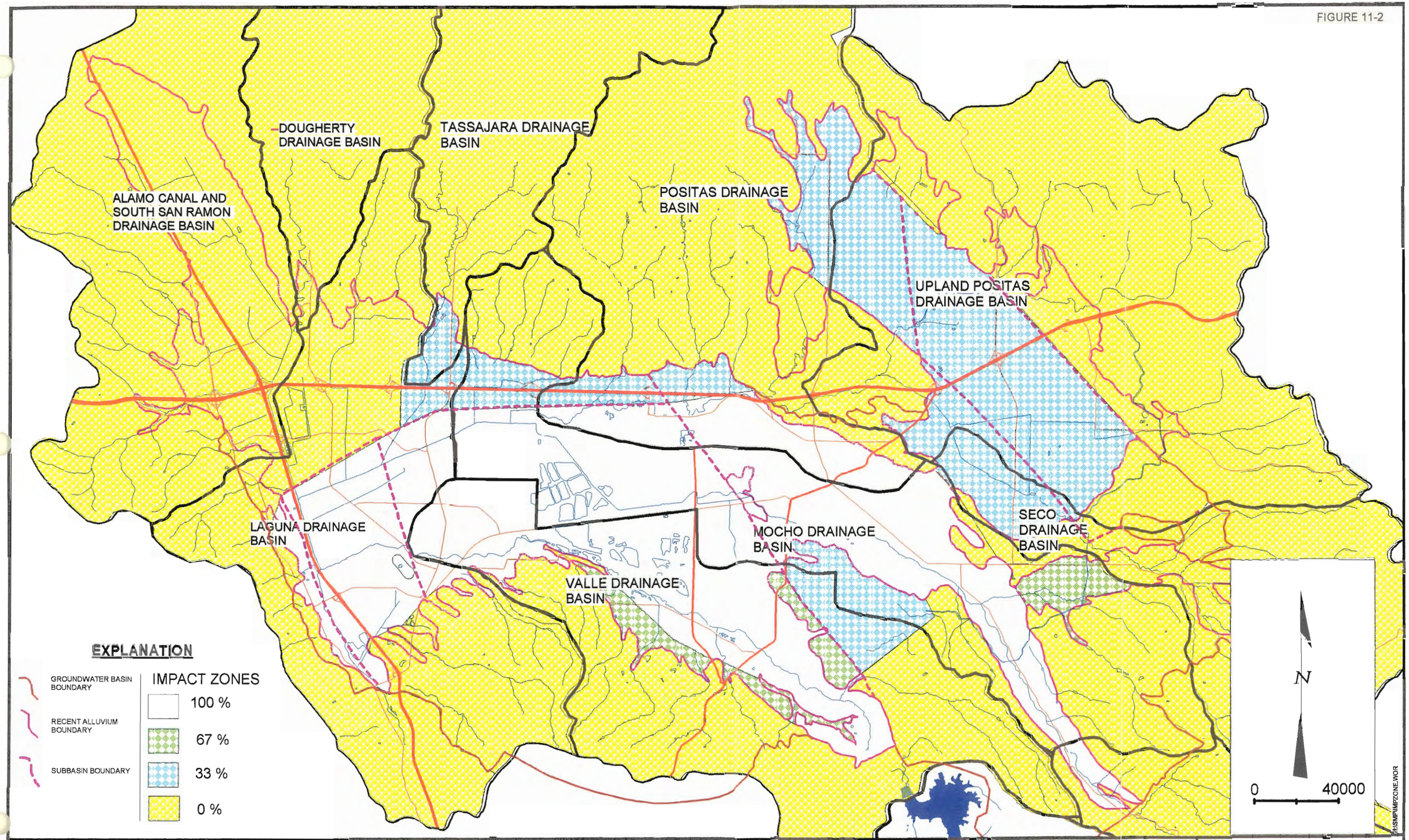
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	TODD WENDLER
DESIGNED	JEFF TANG
CHECKED	JARNAIL CHAHAL
APPROVED	

WATER RESOURCES ENGINEERING
LIVERMORE VALLEY LANDUSE 1997 WATER YEAR

SCALE	1" = 6000'
DATE	10 October 1997
FILE NO.	B-128 | LU_S97.WOR

FIGURE 11-2



ZONE 7 WATER AGENCY 5997 PARKSIDE DR, PLEASANTON, CA.	DRAWN BY: GERALD GATES DESIGNED BY: GERALD GATES CHECKED BY: APPROVED BY:	WATER RESOURCES ENGINEERING LIVERMORE VALLEY SALT IMPACT ZONES	SCALE: 1" = 7000' DATE: 2 JULY 1998 FILE NO: H:\SMP\IMPZONE.WOR

0% Impact Zones

Land area in the 0% impact zone (shown in yellow in Figure 11.2) is located outside of the main basin. In addition, there are physical geologic boundaries separating these land areas from the main basin. These geologic features generally prevent water from flowing from 0% impact zones into the main basin. These areas are also in watersheds from which runoff does not generally have pathway back into the main basin. Therefore, it can be assumed that none (or a negligible portion) of the salts applied to land areas in the 0% impact zones would impact the main basin.

33% Impact Zones

Springtown Area—This area is located generally northeast of downtown Livermore and straddling I-580 (33% impact zones are shown as light blue in Figure 11.2). It is above portions of the May, Spring, and Mocho I groundwater subbasins. Geologically, this area is separated from the main basin, so that there is effectively no subsurface groundwater inflow to the main basin. However, groundwater from this area may rise into the Arroyo Las Positas. A portion of this rising groundwater would recharge into the main basin during periods of low Arroyo flow (i.e., when there is excess recharge capacity available—see Chapter 3). Zone 7 estimated that during 1998 approximately 1,750 tons of salt was brought into the main basin via natural recharge from the Arroyo Las Positas. Springtown is considered a 33% impact zone due to the limited excess capacity in the Arroyo Las Positas for recharging rising groundwater from new urban or agricultural irrigation.

Arroyo Valle 33% Zone—This area in south Livermore is for the most part separated from the main basin geologically. However, some subsurface inflow to the main basin may occur. Additional monitoring wells have been proposed as part of the SMMP (Chapter 6) to further investigate the extent, if any, of subsurface inflow from this area. Increased recharge in this area may cause groundwater to rise into creeks. During periods of high flow, this rising groundwater would flow out of the watershed for the most part through the Arroyo Valle to the Arroyo de la Laguna. Given the possibility of some subsurface inflow occurring and some rising groundwater recharging in the Arroyo Valle during low flow periods, this area is considered a 33% impact zone.

North of Central Main Basin 33% Zone—This area is located straddling I-580 between East Dublin and Livermore. It is above most of the Camp sub-basin and the northwestern tip of the Mocho II sub-basin. Similar to the Arroyo Valle 33% zone described directly above, this area is generally separated geologically from the main basin with the exception of a small amount of subsurface inflow. The geologic barrier separating this area from the main basin is the Parks fault. The small amount of subsurface inflow that occurs from this area has a significant (>50 year) lag time. If there is an increase in irrigation and associated recharge in this area, the groundwater may rise into the creeks. The rising groundwater would flow out during high natural runoff periods. Given the small amount of subsurface

inflow and rising groundwater that may recharge in the Arroyo Las Positas during low flow periods, this area is considered a 33% impact zone.

67% Impact Zones

Southeastern Arroyo Mocho 67% Zone—This area is located southeast of Livermore and lies above the Mocho I sub-basin (67% impact zones are shown in light green on Figure 11.2). This area generally recharges the main basin through subsurface inflow. Most of this subsurface inflow rises up into the Arroyo Mocho. During periods of high flow, some of the rising groundwater into the Arroyo Mocho flows out of the watershed, eventually reaching the Arroyo de la Laguna and the Niles Cone. Under high flow conditions (in excess of stream recharge capacity), the main groundwater basin is impacted less from salts from this land area than during other times of the year. Given the subsurface inflow and natural stream recharge that does occur and that most of the applied water does impact the main basin, this area is considered a 67% impact zone.

Southern Arroyo Valle 67% Zone—This area is located in the south central portion of the Arroyo Valle watershed, downstream from Lake del Valle. Groundwater from this area generally flows into the Arroyo Valle as subsurface inflow or rises into storm drains that flow into the Arroyo Valle. During periods of high flow, a significant portion of the rising groundwater flows through the watershed to the Arroyo de la Laguna and exits through the Niles Cone. During low flow periods, this rising groundwater recharges back into the basin in the lower reaches of the Arroyo Valle. Given the amount of rising groundwater from this area recharging in the lower reaches of the Arroyo Valle and that most of the applied water from this area indirectly impacts the main basin, this area is considered a 67% impact zone.

11.3 Current 2,200 Tons/Year Salt Management Cost Allocation

This section briefly summarizes how Zone 7 currently allocates costs for other water related facilities and then presents three options for allocating costs for facilities (such as a scaled down Strategy 15) needed to offset the current 2,200 tons/year of net salt loading.

Connection Fees

Since 1972, Zone 7 has been charging fees for new connections to its water supply system. These connection fees are used to fund expansion of and improvements to the water treatment and delivery system needed to serve new development. The program for collecting these fees was established by an ordinance, which was adopted pursuant to the District Act. The ordinance includes a schedule of charges based on the size of the connecting meter. Prior to 1994, the amount of the connection charge was based on a

system whereby the new connector bought into the existing system by paying a proportionate share of the value of the existing system less accumulated depreciation.

Water supply planning reports prepared by the Zone and its consultants in 1992 through 1994 identified the need to obtain additional water supplies to meet future demands. To finance the projects needed to procure, convey, treat, and distribute these new water supplies, Zone 7 increased its water connection fees from $830 to $3,050 in 1994, to $3,250 and then again to $3,595 in 1997, to $4,915 in 1998, to $8,900 in 2000 and to $9250 in 2001. The connection fee program is reviewed annually and the fee adjusted as needed. The fee increases are calculated based on the marginal cost method. Under this method, charges are calculated by apportioning the cost of the expansion projects to the water system among the new users/connections. This method is in accordance with the Zone 7 Board policy that the burden of cost of future water supplies and associated facilities not be placed on existing water users.

To protect against future uncertainties affecting any one water source, Zone 7 has pursued a number of sources while continuing to seek sources with the highest reliability and the lowest cost. Previously identified capital projects required to meet future needs include new water treatment facilities, new wellhead demineralization facilities, new water transmission pipelines, additional injection/extraction wells and recharge facilities. Zone 7 is currently completing several studies (see Chapter 2), including a Water Facilities Master Plan and Well Master Plan to update plans and funding requirements for new water supply, treatment, distribution, storage, and water quality management facilities. These facilities are intended to maintain at least the current level of reliability and peaking ability, as well as maintain the quality of water delivered to Zone 7 customers.

As discussed in Chapter 8, the salt management alternatives considered for this SMP were primarily developed assuming use of capital facilities and/or operational strategies already included in Zone 7's Capital Improvement Program (CIP) or under evaluation in the Facilities Master Plan and Well Master Plan. A fundamental cost allocation assumption, therefore, was that previously collected connected fees were allocated and available for funding the capital facilities necessary to offset the current 2,200 tons/year salt loading.

Water Rates

The Zone 7 treated water rates are reviewed and adjusted as needed annually. Rates are set to cover system operations and maintenance (O&M) costs including such items as labor, utilities, chemicals, and repair and replacement capital costs.. The Zone7 cost of water management and water quality monitoring is generally split between treated and untreated water rates with the majority of funding from treated water rates. Table 11.1 lists the treated (Potable) and untreated (non-potable) water rates for 1998-2003.

Table 11.1

Year	Treated water rate, $/AF	Untreated Water Rate, $/AF
1998	$508	$50
1999	$528	$52
2000	$539	$52
2001	$539	$64
2002	$548	$86
2003	$562	$72

Cost Allocation Options

Various options were analyzed and presented to the GMAC and TAG groups to determine how to most equitably distribute the cost of mitigating the existing 2,200 tons/year salt loading. Initial discussions explored the feasibility and practicality of allocating costs based on each water retailer's relative percent contribution of salt to the main basin. This approach had a "first blush" appeal, similar to the "polluter-pays-principle." However, as is evident in the salt balance calculations (Table 5.2), there are numerous sources of salt, each of varying degrees of controllability, with many of them "natural" (e.g., subsurface inflow) or a function of managing the main basin water balance (i.e., artificial recharge).

There are also multiple existing salt removal mechanisms such as groundwater pumping and mining export that provide benefits versus impacts to the main basin. Therefore, an equitable pay by relative contribution cost allocation strategy would need some means to account for both impacts from those contributing to the problem and benefits to those contributing to the solution.

Relative Impact Allocation Approach—One highly simplified approach that was briefly explored was to assess the retailers for salt management costs based on the percentage of main basin salt loading occurring within their geographic service areas, assuming that all salt loading was proportional to treated water delivery volumes (which is not the case). This conceptual approach ignores actual salt sources and removal mechanisms and simply assigns responsibility based on the relative amount of water delivered, irrigated area, and the acres of different percent salt impact zones in each service area.

Table 11.2 presents the conceptual salt load impact distribution calculated in this manner by the purveyor. The 1997 land use map was used to calculate the urbanized area within each service area. The percentage of irrigated area within the urbanized areas and the TDS of the irrigation water was assumed to be the same in all four service areas.

The impact zone map (Figure 11.2) was then used to determine the percent of the total urban acreage in each service area that was in each of the percent impact zones. The overall average percent impact for each service area was then calculated based on the

Table 11.2
Existing Salt Loading Distribution
Urban Applied Salt Loading by Water Purveyor

	1997 Urban Service Area Impact Zones by Percent of Acres [1]				1997 Average Impact	1997 Zone 7 Deliveries AF	Adjusted 100% Impact Deliveries AF	Salt Load Impacting Main Basin by Purveyor	
	0%	33%	67%	100%				tons [2]	% of total [4]
Pleasanton	36%	4%	2%	59%	61%	13550	8246	1170	53%
CWS	20%	1%	7%	72%	77%	7400	5710	810	36%
Livermore	18%	68%	0%	13%	36%	4900	1758	250	11%
DSRSD	100%	0%	0%	0%	0%	4600	0	0	0%
Total (Acres)	7023	2299	482	8634	53%	30450	15715	2230 [3]	100%

1. Based on "Salt Impact Zone" map (Figure 11.2)
2. Estimated tons of salt from each purveyor impacting main basin assuming that demand is similar for all urban service areas
3. Total Salt loading to main basin from urban deliveries based on 1997 Main Groundwater Basin Salt Balance calcuations
4. Percent of total salt impacting main basin that each purveyor is responsible for

Note: Over time as development occurs, the percent of each purveyor's service area that is in each of the impact zones may change. As this occurs, the percent of salt that each purveyor contributes toward the total salt load impact on the main basin may also change. The values shown in this table, should be considered rough estimates for the 1997 water year.

relative number of acres overlying the four percent impact zones. Pleasanton and Cal Water show the highest average impacts (61%, 77%) since much of their service area is over the 100% impact zone (i.e., over the main basin).

The average impact percent was then multiplied by the Zone 7 deliveries to each purveyor to obtain the actual volume of water impacting the main basin in each service each. These volumes, expressed as a percentage of the total 15,715 AF calculated to be impacting the main basin, are then assumed to reflect the relative percent of the total 2230 tons of salt contributed by each purveyor.

Under this string of assumptions, Pleasanton would be viewed as responsible for the greatest proportion of existing salt loading (53% or 1170 tons). This is due to the city's 61% average impact zone acreage and to the fact that Pleasanton also delivers the most water (nearly twice that of the next largest purveyor, CWS). At the other end of the spectrum, DSRSD's deliveries would be considered as having 0% impact since all of the DSRSD service area is within the zero impact zone.

There are numerous limitations to using an approach such as this as the basis for allocating costs. As noted above, this approach does not have a linkage to the complex real world conceptual model of salt loading sources and removal mechanisms. It does not assess responsibility for "natural" salt sources. If one were to use this percent impact zone approach, should, for example, DSRSD be assessed for subsurface inflow impacts from the Dublin sub-basin since the Dublin sub-basin is in its service area? Should the mining companies be given salt credits for the salt in the mining pumpage that is exported out of the valley?

A more sophisticated geographically-based salt loading allocation approach could certainly be developed than the simple example presented here. Taken to the extreme, such an approach would require tracking loading and allocating costs on a parcel-by-parcel basis. Since land use changes every year and the above calculations would be very complex to complete more comprehensively and accurately, it would require a significant effort every year to estimate costs to allocate. This effort would add to the actual salt management cost. The TAG generally agreed that this approach to cost allocation would not only be burdensome to administer but that it would be difficult to equitably balance costs and benefits.

The Zone 7 Board Groundwater Committee indicated that they were not in favor of a cost allocation approach where water bills would become as complicated as phone bills. Allocating costs differently to different retailers would also be contrary to historic Zone 7 practices of melding most other costs and having one treated water rate for all customers.

Another limitation of this approach is that it does not reflect the fact that all parties benefit from use of the groundwater basin (particularly during drought). Thus there is value and, therefore, should be some dollar amount worth paying by all users to ensure that acceptable groundwater quality is maintained.

This approach also does not reflect the benefits to near-term delivered water quality that would result from implementation of salt management strategies such as Strategy 15 that includes wellhead demineralization (see sections 10.4 and 10.5). The candidate wellhead demineralization facilities are proposed to be located in the western portion of the valley where they would primarily benefit Pleasanton and DSRSD. Under the above cost allocation approach, DSRSD would not accrue costs, but would receive a high proportion of the near-term benefits through lower TDS delivered water quality. CWS would accrue the second highest costs (based on Zone 7 water purchases) but receive minimal benefits from the demineralization facilities. Chapter 10 presents in more detail the relative delivered water TDS impacts to each retailer under dry, average and wet year conditions assuming Strategy 15 with wellhead demineralization were to be implemented.

Melded Cost Allocation Approach—A simpler, and arguably more equitable cost allocation approach, would be to simply meld salt management O&M costs into the treated water rates. Table 11.3 and Figure 11.3 show (as an example) the components of 1998/99 treated water rates modified as if they were to include salt management as a cost component. This example assumed that a combination of increased conjunctive use and shallow groundwater wellhead demineralization would be used (similar to Strategy 15A) to offset the current 2,200 TPY salt loading. This example also assumes that costs for operating these facilities would be allocated solely to salt management (although costs could be allocated at least in part to normal operations for the lower TDS water quality benefits that would be provided). This example assumes that annual chemical, power, and labor costs would increase by $1,000,000, equivalent to about $29/AF treated water produced and a 5.7% rate increase.

Actual salt management costs would depend on annual decisions about how to operate most cost effectively to achieve the SMP goals in a given year (per the adaptive management approach described in Section 12.5).

The existing salt loading can be offset by operating the already planned and funded Zone 7 conjunctive use and demineralization facilities. Since 1994, connection fees collected by Zone 7 included monies for 18 to 20 new wells and a 3 million gallon per day wellhead demineralization facility. To ensure a high quality water supply, a groundwater demineralization project was first approved by the Zone 7 Board as part of the Water Supply and Water Quality Improvements in 1987.

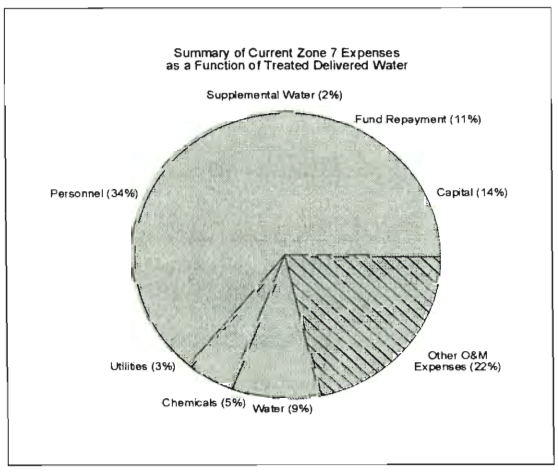
This decision was based on the knowledge that as water demands increased over time, groundwater pumpage would need to be increased, thereby reducing the ratio of surface water to groundwater and increasing the TDS in the delivered water. The demineralization facility would serve to help maintain delivered water quality and help equalize the quality of water delivered between the east and west sides of the Livermore-Amador Valley. The conjunctive use and demineralization capital facilities are planned to be constructed over the next several years as part of the Zone 7 capital improvement/expansion program.

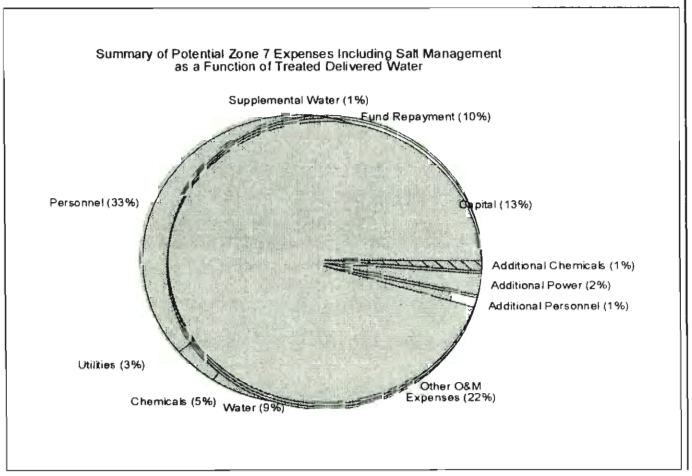
Table 11.3
Summary of Zone 7 Expenses as a
Function of Treated Delivered Water Rate

	FY98/99		
	Estimated Costs		
Expense	Millions $	$/AF Treated Water	% Treated Water Rate
Capital Projects	2.2	70	14%
Fund Repayments	1.75	56	11%
Supplemental Water	0.25	8	2%
Operating Expenses			
Personnel	5.5	175	34%
Maintenance	1	32	6%
Utilities	0.5	16	3%
Chemicals	0.8	25	5%
Water	1.5	48	9%
Professional Services	0.95	30	6%
Other Services	1	32	6%
Bonds	0.5	16	3%
Subtotal	15.95	508	100%
Salt Management[1]	1.01	29	5.7%
Total	16.96	537	

1. Example Potential Cost

Figure 11.3





GMAC and TAG Recommendations—Both the GMAC and TAG agreed that the existing 2,200 ton per year salt load could and should be handled by using currently planned and funded Zone 7 capital facilities. They also recommended that the annual operations and maintenance costs be melded into the treated water rates. The TAG supported equal instead of stratified cost increases and gradual (i.e., 1-2%/year) increases instead of a 5-7% increase in one year. Toward that end the TAG supported increasing water rates sooner rather than later, as long as the funds were dedicated to future salt management costs.

11.4 New Urban Development (M&I) Salt Loading

As discussed in Chapter 7, the recommended fundamental salt management strategy is that there be no net increase in salt loading to the main basin. This policy implies that new development will be required to fully offset any resulting salt impacts. To maintain no net increase in salt loading to the Main Basin, it is projected that approximately 3,200 tons per year of additional salts must be offset by 2010, possibly sooner. The currently planned capital facilities have some excess capacity and can be operated to mitigate some of the new development induced increase in salt loading beyond the existing 2,200 tons per year. While there would not be any additional capital costs required for this, there would be an increase in the annual operations and maintenance costs.

When the salt loading exceeds the capacity of the facilities Zone 7 is already planning to construct, additional facilities will need to be available. For example, by the time the mining companies cease operations, an estimated additional 2 mgd of demineralization capacity would need to be available to offset the increased salt loading due to the loss of the mining pumpage export of salts.

Capital facilities are funded through the connection fee program. Connection fees can be adjusted as needed, and it is assumed that they will continue to be collected to construct the required facilities. This is consistent with Zone 7 Board policy to revisit the connection fee program in accordance with new planning studies. Any new charges determined to be necessary to maintain delivered water quality beyond those currently being collected would presumably be charged based upon apportioning the cost of the expansion projects among new users. This method would be consistent with the Zone 7 Board's historic policy of not burdening existing water users with the cost of future water supplies.

Annual operations and maintenance (O&M) costs associated with future M&I salt loading were assumed to be melded into the treated water rates and paid by all treated water users. Annual wellhead demineralization costs would be primarily a function of the volume of groundwater that needs to be demineralized to meet delivered water quality and salt loading goals. During wet years the facilities may only need to be operated for limited periods, for example during groundwater pumping to meet peak summer demands. During dry years, and in future years as mining exports decrease, the facilities would need to be operated for longer periods of time and/or at higher rates. Such changes in O&M

costs were assumed to be incorporated as appropriate as part of Zone 7's annual review and adjustment of water rates.

TAG Recommendations—The TAG supported funding capital and O&M costs for facilities to offset future M&I usage derived salt loading in the same manner as funding facilities to offset existing salt loading (i.e., via connection fees and water rates, respectively). As an alternative funding mechanism, the TAG recommended considering capitalizing 10-20 years of operations and maintenance costs onto connection fees. Some members of the TAG also recommended that consideration be given to a fee structure that would ensure that connection fees and annual O&M costs be assigned equitably to all (both treated and untreated water) customers relative to their contributions to the salt loading.

11.5 New Agricultural Development (Untreated Water) Salt Loading

Limited discussions were held with the TAG regarding alternative measures to allocate capital and O&M costs associated with salt loading from potential new agricultural development. The TAG felt that Zone 7 needed to first finish its investigations into how to best meet, and the facilities needed to accommodate, future untreated water demands. However, since agricultural irrigation does contribute a (small) percentage to the existing salt loading, the TAG did recommend melding a proportionate cost (to be determined) onto the untreated water rates. Until some of these other decisions are made, the salt loading impacts of new agricultural irrigation projects will continue to be evaluated and addressed on a case-by-case basis.

11.6 Recycled Water Irrigation Salt Loading

Numerous studies of potential recycled water irrigation projects in the valley have been conduced over the years. As discussed in Section 6.6, there is a large potential demand for recycled water. However to date, very few projects have been implemented, due in part to concerns about managing the resultant salt loading. Three options were developed and reviewed with the TAG for allocating costs of managing salt loading from recycled water irrigation projects.

Option 1—The first option was based on the philosophy that "water is water and salt is salt" and, therefore, recycled water salt loading should be treated the same as M&I salt loading. Under this approach, recycled water would be viewed simply as another source of supply and used to accommodate future demand either directly or by freeing up treated water. Consistent with M&I salt management, capital and O&M costs for facilities to offset future recycled water salt loading would be funded via connection fees and treated water rates, respectively. This first approach offers some potential for economies of scale to the extent that larger centralized facilities (e.g., demineralization) could be used, assuming that Zone 7 would be responsible for all salt management activities. This

approach would likely be simpler to administer with only one entity responsible for tracking and managing salt loading.

Given that wellhead demineralization is being proposed to provide the majority of salt management in this SMP, option 1 may result in better delivered water quality to the extent other approaches to salt management were implemented by others. For example, irrigation with demineralized recycled water would provide net salt removal benefits (see Section 11.7) but would not provide delivered water quality benefits. Reductions in delivered water TDS from wellhead demineralization will also result in lower recycled water TDS and resultant salt loading.

Option 2—A second option would be for the irrigation recycled water purveyors (who may be the same as the retail potable water purveyors) to pay to offset salt loading above a specified delivered water quality baseline. For example, if Zone 7 treated water has 325 mg/L TDS and recycled water has 750 mg/L TDS, then salt loading impacts from 325 mg/L treated water TDS would be assigned to the potable water purveyor while the salt loading impacts from the additional 425 mg/L TDS in the recycled water would be assigned to the recycled water purveyor.

This second option would be consistent with existing agreements between DERWA and ACWD for salt mitigation. It allocates the incremental salt loading costs to recycled water users/purveyors rather than spreading them across all treated water users as under the first option. From one standpoint this approach could be perceived as more equitable. However, that same logic could lead to the implication that Zone 7 should have different rate structures for users depending on TDS content of its other sources of supply. This would be a more administratively complex option to implement.

Option 3—A third option would be for the irrigation recycled water purveyors to pay for mitigating the full salt loading impacts (750 mg/L in the above example) of their recycled water usage. Potential demineralized recycled water injection projects would generate salt credits (see below) given that they would produce and recharge water with a TDS less than (typically in the 100 mg/L range) the treated water baseline of 325 mg/L.

Option 3 would increase the cost of non-demineralized recycled water irrigation projects and as such be a disincentive to greater recycled water use. Salt management costs would be borne by wastewater ratepayers, not all of who would necessarily be receiving the salt management program benefit of stabilized/improved groundwater quality.

Given the high costs (both actual and administrative) of offsetting salt loading on a project by project basis (see Section 11.7 below), protracted discussions could ensue on each project regarding the salt loading assumptions and calculations, the amount of salt reaching the main basin that needs to be offset, how the offset would be accomplished and tracked, and when the offset would be required to be in place. One potential positive impact of Option 3 would be that it would tend to encourage recycled water purveyors to pursue wastewater TDS reduction measures (e.g., public education about the negative

impacts of regenerative water softeners) to reduce recycled water TDS levels and thus salt loading offset costs.

TAG Recommendations—The TAG opinion of recycled water salt management evolved as additional information was developed during preparation of this SMP. Initially some concerns were raised about equity and whether by melding costs into the Zone 7 water rates (Option 1) those irrigating over the fringe basins and not impacting the main basin would be subsidizing others. A counterpoint raised was that not all purveyors use or benefit from all of Zone 7's existing infrastructure. It would be a significant change in policy and administratively complex to institute a system where capital and operational costs of new facilities would be allocated on the basis of their use by, or benefit to, an individual purveyor.

Most TAG members agreed with the general principal that customers that do not share in salt management costs should not share in the benefits of the groundwater basin. Some differences remained given the precedent of the DERWA/ACWD agreement (Option 2) and the desire for flexibility and independence from Zone 7 (Option 3). There was general agreement that Option 1 would be appropriate at such time as Livermore, Pleasanton, and DSRSD were distributing similar amounts of recycled water (with similar impacts on the main basin).

The general consensus reached by the TAG was to proceed with an approach resembling a combination of Options 1 and 2. Under this scenario, Zone 7 would nominally be responsible for managing recycled water salt loading, but recycled water purveyors would have the option of opting out and implementing their own offsetting salt management measures on a project-by-project basis.

Section 11.7 below presents the conceptual approach developed with the TAG for assessing project-by-project salt loading and salt credits. This approach is based on the net difference in TDS concentration in the applied or injected water that a project causes. Any excess salt credits generated by individual projects would be available to be used/traded to offset other costs or other project's salt loading.

For non-Zone 7 sponsored salt management projects it was proposed that Zone 7 would provide a rebate/credit for tons of salt removed based on either 1) Zone 7's long-term average melded salt management costs ($/ton removed), or 2) Zone 7's annual projected salt management O&M costs (i.e., recalculated each year based on combination of available salt management strategies used).

Table 11.4 presents a summary of the proposed salt management cost allocation approach by the source water responsible for the salt loading (existing M&I, future M&I, untreated, and recycled). Additional commentary on cost allocation and related issues was provided at the September 3, 1998 workshop SMP briefing by the DSRSD, Pleasanton, Livermore, and Cal Water senior water/wastewater and public works managers. Table 12.4 summarizes the highlights from that meeting. Detailed meeting notes are included in Reference Q.

Table 11.4
FUNDING STRATEGY
FOR ZONE 7 SALT MANAGEMENT PROJECTS
BY SOURCE OF SALT LOADING

Funding Source	Existing M&I Water		New M&I Water		Untreated (non-potable) Water		Recycled Water	
	Capital Facilities	*Annual O&M*	*Capital Facilities*	*Annual O&M*	*Capital Facilities*	*Annual O&M*	*Capital Facilities*	*Annual O&M*
Treated (potable) Water Connection & Replacement Fees	X		X		X		X	
Treated (potable) Water Rates		X		X		X		X
Untreated (non-potable) Water Connection Fee					Option [1]			
Untreated (Non-Potable) Water Rates						Option [1]		
Recycled Water Purveyor Rates							Option [2]	Option [2]

1) Zone 7 has the discretion to assess.

2) Recycled Water Purveyors have the option to implement their own salt loading offset measures.

11.7 Future Individual Project Salt Loading Impact and Cost Calculation Method

This section presents an approach for assessing the salt loading and salt credits from future individual projects. The fundamental assumption underlying this approach is that existing and future salt impacts are to be fully mitigated so that there is no net increase in salt loading to the Main Basin (Fundamental Salt Management Policy Option 3 from Figure 7.1).

Method for Assessment of Salt Loading

There are four steps to assessing the salt impacts of a project:

Step 1—Identify the project type and "netting" equation. As shown in Table 11.5, there are three general project categories. The first category includes existing potable irrigation sites that would be retrofitted to use recycled water or changed over from treated water to groundwater. The second category includes new municipal or agricultural development projects that are not currently irrigated and would be irrigated with either potable, untreated, or recycled water, or possibly a combination. The third category of projects includes all salt management projects. These projects generate salt credits by operating in a manner that results in a net removal of salts from the basin.

Step 2—Determine the change in TDS concentration ("netting equation") resulting from the project. An existing irrigation site being changed from treated water (325 mg/L) to recycled water (750 mg/L) would result in a net increase in TDS of 425 mg/L. A new development irrigated with recycled water would represent a net increase of 750 mg/L since the site wasn't irrigated previously.

A shallow groundwater wellhead demineralization project would provide a net TDS decrease and salt credits of 900 mg/L since the 1,000 mg/L shallow groundwater would be demineralized to 100 mg/L. A groundwater export project pumping 1,000 mg/L TDS water from the upper aquifer of the main basin would provided 750 mg/L credits since that water has to be replaced with 250 mg/L surface water. A groundwater export project pumping 1,000 mg/L TDS water from a fringe basin that doesn't otherwise reach the main basin would provide 1,000 mg/L fringe basin credits since that water does not have to be replaced with 250 mg/L surface water. Note that this fringe basin credit cannot be used directly to offset main basin loading.

Based on the net change in TDS concentrations as shown in Table 11.5, one can calculate the concentration based gross salt loading or salt credits. These should be considered typical concentrations to be used for comparative purposes. Actual net TDS concentrations would be determined on a project-by-project basis.

Step 3—Determine the percent of salt loading from the project that impacts the Main Basin. Figure 11.1 shows the 0, 33, 67, and 100 percent impact zones mapped based on current basin knowledge. Figure 11.1 can be used to determine the appropriate factor to apply to the calculated gross salt load (from Step 2) to estimate the net salt load to the Main Basin.

Step 4—Calculate the tons of net salt loading. For irrigation projects, multiply the net concentration based impact (from Step 3) by the project irrigated acreage and estimated unit irrigation rate in AF/acre/year and appropriate conversion factors to obtain the tons/year of net salt loading (or credit). For salt credit projects such as wellhead demineralization, the net concentration based impact would be multiplied by the volume produced and conversion factors (0.00138) to obtain the tons/year of salt credit.

Table 11.5 Future Individual Project Salt Loading Impact and Cost Calculation Method

Project Type	Project Description	Source Water TDS (mg/L) Original Quality	Final Quality	Net Change
Existing Irrigation & Retrofit RW Projects	Treated to Recycled Water	325	750	425
	Groundwater to Recycled	450	750	300
	Treated to Groundwater	325	450	125
Future Irrigation Projects	New Recycled Water	0	750	750
	New Groundwater	0	450	450
	New Treated Water	0	325	325
	New Untreated Water	0	250	250
Salt Credit Projects	Wellhead Demineralization (lower aquifer)	450	100	-350
	Wellhead Demineralization (upper aquifer)	1000	100	-900
	Conjunctive Use (stream recharge)	450	250	-200
	Conjunctive Use (injection well)	250	250	0
	GW Export (upper aquifer)	1000	NA	-750
	GW Export (fringe basin)	1000	NA	-1000
	RO Recycled Water Injection	450	100	-350

Assumptions:
TW: Zone 7 treated water, 325 mg/L TDS
Untreated: SBA untreated water, 250 mg/L TDS
GW: Groundwater, 450 mg/L TDS
RW: Recycled water, 750 mg/L TDS
RO Recycled Water Injection water, 100 mg/L TDS
Wellhead Demineralization water, 100 mg/L TDS

Example Project Salt Loading Calculations—Table 11.6 below shows examples of how these four steps would be followed to assess individual irrigation project's salt loading to the Main Basin.

Table 11.6
Example Main Basin Salt Loading Assessment Calculations

A. Pleasanton Sports Park or Robertson Park

1. Convert from Zone 7 treated water to recycled water;
2. Gross 425 mg/L increase (750 - 325 mg/L);
3. 100% impacts main basin;100% x 425 mg/L=425 mg/L net impact;
4. 100 acres x 2 AF/ac/yr = 200 AFY x 425 mg/L = 120 tons/yr

B. Triad Business Park or New East Dublin Park

1. New development recycled water use site;
2. Gross 750 mg/L increase (750 - 0 mg/L);
3. 33% impacts main basin;33% x 750 mg/L = 250 mg/L net impact;
4. 100 acres x 2 AF/ac/yr = 200 AFY x 250 mg/L = 70 tons/yr

C. Dublin Sports Park

1. Convert from Zone 7 treated water to recycled water;
2. Gross 425 mg/L increase (750 - 325 mg/L);
3. 0% impacts main basin;0% x 425 mg/L = 0 mg/L net impact

D. New Residential Irrigation above Main Basin

1. New development treated water irrigation;
2. Gross 325 mg/L increase (325 - 0 mg/L);
3. 100% impacts main basin; 100% x 325 mg/L = 325 mg/L net impact;
4. 100 acres x 2 AF/ac/yr = 200 AFY x 325 mg/L = 90 tons/yr

Example Individual Project Salt Management Cost Calculation—Chapter 8 reviewed the range of salt management strategies available including conjunctive use, wellhead demineralization, and seasonal groundwater export. Table 8.14 presented the unit salt removal O&M costs for each strategy ($/ton removed). Here, once the tons of net salt loading from an individual project have been calculated and a salt management strategy selected, the cost of the offset can be determined. In example D above, the net salt loading resulting from a new residential development with 100 irrigated acres located above the Main Basin was estimated to be 90 tons per year. If wellhead demineralization of shallow wells was selected as the salt management strategy, the offset cost would be 90 tons/yr x $350/ton = $31,500/yr. If wellhead demineralization of deep wells were selected instead, the unit cost would increase to $910/ton, for an offset cost of $81,900/yr.

Chapter 12

Near-Term Salt Management Strategies and Implementation Plan

Chapter 12

Near-Term Salt Management Strategies and Implementation Plan

12.1 Introduction

Chapter 9 presented 15 salt management strategies designed for year 2010 conditions based on several criteria including the ability to fully offset year 2010 projected salt loading of 5,400 tons/year. Of all the strategies only Strategy 15, a combination of conjunctive use and 5,000 AF of high TDS shallow groundwater wellhead demineralization (WHD), successfully passed all the feasibility screening criteria (Section 9.6). More detailed modeling analysis (Chapter 10) confirmed that Strategy 15 would provide the projected benefits to groundwater and delivered water quality.

Zone 7 staff, in consultation with the GAMC and TAG, decided in early 1999 to develop a revised set of salt management strategies that could be implemented near-term (defined as year 2000-2002) versus in 2010. These near-term strategies were based on those previously identified and screened as feasible for 2010 conditions (Section 9.6) but were scaled down for current 2,200 tons/year loading conditions. Letter suffixes (e.g., 15A) are used to differentiate variations on the same basic strategy.

Several additional 2010 strategies had also passed all the feasibility screens (technical, timing and water quality) except for public and institutional acceptability. If varying degrees of regulatory and/or perception barriers could be overcome, at least some of these strategies could also potentially be implemented sooner than 2010. A selected group of what appeared to be the more promising of these strategies were also scaled down to current 2,200 tons/year loading conditions and called potential near-term strategies (Section 12.3).

The unit O&M costs and salt removal capability assumptions used to develop these near-term strategies were the same as described in detail in Section 8.14. Table 12.1 and Figure 12.1 (as first presented in Chapter 8) are reproduced here for reference when reviewing the near-term and potential near-term strategies presented in this chapter.

From the set of near-term strategies, Zone 7 staff, in consultation with the TAG and GMAC, developed a recommended near-term implementation plan (Section 12.4). That plan included recommended policy goals and a three-year phased implementation of increased conjunctive use, wellhead demineralization, and potential demonstration scale

Table 12.1

INDIVIDUAL SALT MANAGEMENT STRATEGIES
UNIT O&M COSTS AND REMOVALS PER 1,000 AF

Salt Management Strategy	O&M Costs to Implement 1,000 AF	Unit O&M Cost Components (*)	Gross Salt Removed (tons/TAF)	Net Salt Removed (tons/TAF)	Net Salt Removal Cost ($/ton)
I. Conjunctive Use (450 mg/L pumpage)					
A. Stream recharge (250 mg/L untreated)	$40,000	(1-2)	270	200	$200
B. Well recharge (250 mg/L treated)	$60,000	(1)	270	200	$300
II. RO Recycled water (to 100 mg/L)					
A. RO Stream recharge or Injection	$60,000	(1)	480	410	$146
III. Wellhead Demineralization					
A. Shallow wells (1,000 to 100 mg/L)	$444,000	(3+4+6)	1220	1000	$444
B. Deep wells (450 to 100 mg/L)	$444,000	(3+4+6)	470	250	$1,776
IV. Seasonal Groundwater Export to Creeks					
A. Army wells (1,000 mg/L)	$110,000	(5+6)	1360	1020	$108
B. Bernal (800 mg/L)	$110,000	(5+6)	1090	750	$147
C. Dublin (1,000 mg/L)	$110,000	(5+6)	1360	1020	$108
D. Excess mining pumpage (600 mg/L)	$110,000	(5+6)	820	470	$234
E. Basin outflow (700 mg/L)	$70,000	(6)	950	610	$115
v. Continuous Groundwater export on arroyos by Zone 7					
A. Zone 7 export on AV (500 mg/L)* * *	$290,000	(1.5(1)+7))	680	340	$853
B. Zone 7 export on AM (500 mg/L)* * *	$260,000	(1+7)	680	340	$765

AF = Acre-feet
GW = Groundwater
SW = Surface water
TAF = Thousand AF
O&M = Operations & Maintenance
RO = Reverse Osmosis

(*)

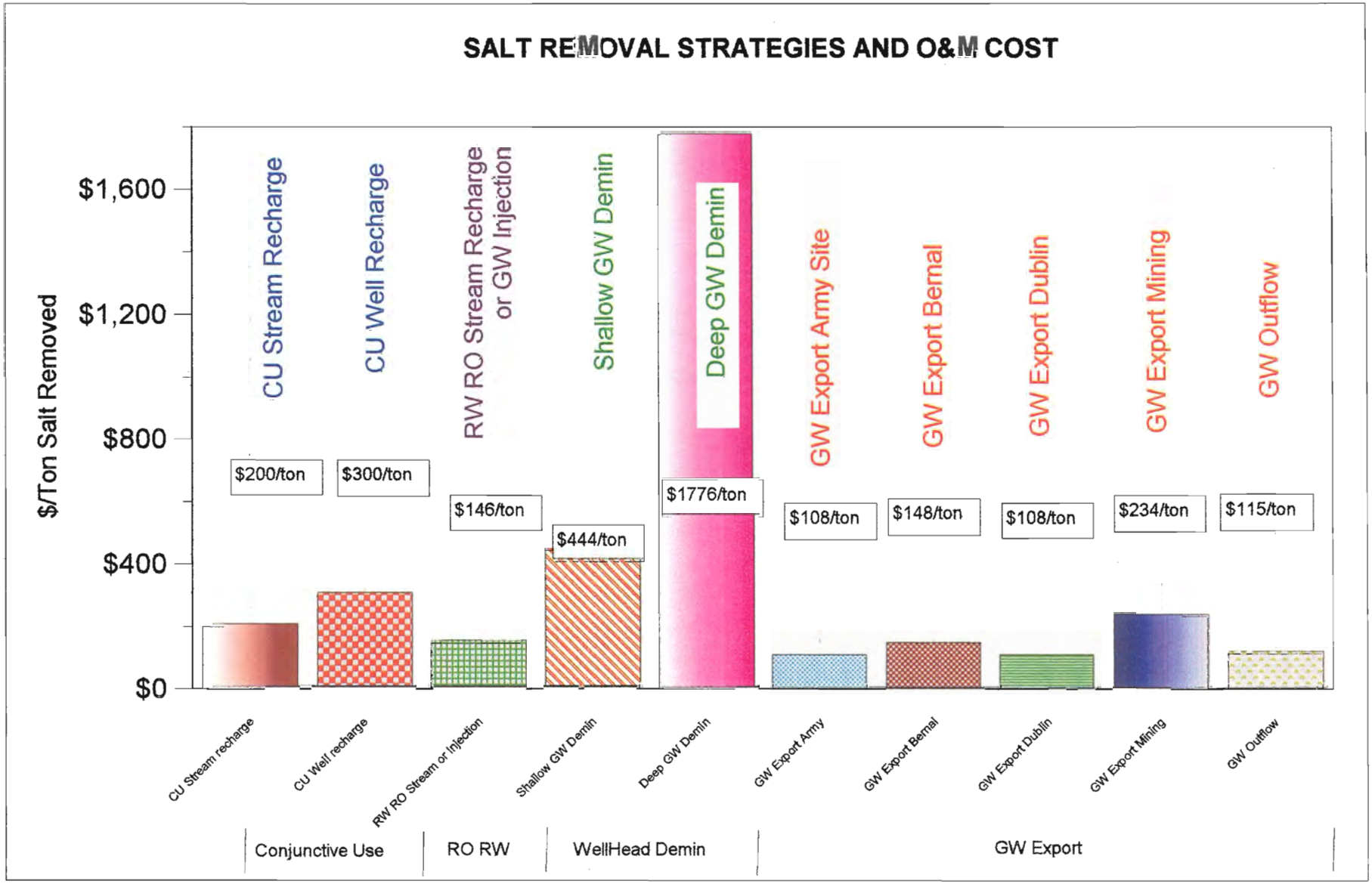
Unit O&M Costs	
Description	$/AF
1. GW Pumping	$60
2. SW Treatment Plant	$20
3. Reverse Osmosis	$400
4. Brine Disposal Cost	$30 (**)
5. Shallow GW Pumping	$40
6. Replacement Water	$70
7.Estimated Annual Entitlement paymen	$200

(**) $150/AF LAVWMA pumping cost & 0.2 AF brine production and 0.2 AF replacement water per 1 AF demin.

(***) The cost does not include the conveyance capacity cost and entitlement purchase cost.

Net removal reflects replacement water TDS and pumpage/ salts reapplied over main basin.

FIGURE 12.1



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RO recycled water stream recharge. The plan also identified how annual salt management decisions would be made via an adaptive management process and integrated into Zone 7's existing Annual Operations Plans.

This chapter concludes (Section 12.5) with a discussion of recommended next steps towards selecting strategies and cost allocation measures to address future salt loading, and towards facilitating implementation of potential near-term strategies such as seasonal groundwater export.

12.2 Near-Term Salt Management Strategies

From the 2010 strategies (Chapter 9), Zone 7 staff developed seven near-term salt management strategies that were believed feasible to begin to implement during the 2000-2002 time period (Table 12.2). Values in Table 12.2 were calculated as if the strategies were to be implemented under projected year 2000 loadings, treated water deliveries, and costs (see Table 12.2 footnotes).

For example, Strategy 5A in Table 12.2 is a scaled down version of Strategy 5 listed in Table 9.1 for 2010 conditions. Strategy 15A for year 2000 is derived from Strategy 15 for 2010 conditions. Therefore, most of the assumptions applicable to strategies 5 and 15 are also applicable to strategies 5A and 15A. None of the strategies presented in Table 12.2 for the 2000-2002 period include any demineralized recycled water injection.

These seven individual and composite year 2000 strategies are compared in figures 12.2 and 12.3. Figure 12.2 presents four parallel series of bar charts. The first (uppermost) bar chart series presents the surface water to groundwater volume ratio of Zone 7 deliveries under each of the seven strategies. The second graph presents each strategy's resultant minimum and maximum monthly average TDS (of the 12 monthly averages), and the overall annual average TDS of Zone 7 deliveries (i.e., three bars per strategy). The third graph presents the annual average salt loading (in tons) remaining after implementation of each strategy. The fourth (bottom) graph presents the incremental O&M cost per acre-foot of Zone 7 deliveries (i.e., increase in treated water rates attributable to salt management).

One of the recommended salt management goals from Chapter 7 was to equalize delivered water quality to all retailers to the greatest extent practicable. Figure 12.3 compares the annual average TDS of Zone 7 deliveries to individual retailers under Status Quo operations (Strategy 1A) versus under two recommended composite strategies. Each near-term strategy shown in Figures 12.2 and 12.3 is described below.

Table 12.2
NEAR TERM SALT MANAGEMENT STRATEGIES

			Long - Term Average						
			NET	NET	Projected	TDS OF	ZONE 7 INCREMENTAL OPERATIONAL COSTS		
STRATEGY NO.	NAME	POLICY OPTION	SALT LOADING TONS/YR	INCREASE IN GW TDS mg/l/year	GW TDS after 10 yrs mg/l	ZONE 7 DELIVERIES mg/l	PER YEAR	PER ACRE-FOOT OF TW DELIVERY	% Rate Increase
Status Quo 1A	Year 2000 Status Quo (no demineralized RW injection)	I	2200	7	520	300	$0	$0	0.0%
Conj. Use 5A	Minimum Conjuctive Use 3000 AF (Stoneridge well - no GW demin)	II	1600	5	500	310	$120,000	$4	0.8%
6A	Major Conjuctive Use 11,000 AF (zero out salt balance)	III	0	0	450	350	$680,000	$20	3.8%
Wellhead Demin 15A	2200 AF Demin GW Pumpage (1000 mg/L to 100 mg/L)	III	0	0	450	280	$976,800	$29	5.5%
COMPOSITE OF 5A AND 15A	Minimum Conjuctive Use (3000 AF/Y) and 1500 AF/Y Demin GW PUMPAGE	III	0	0	450	300	$786,000	$23	4.4%
COMPOSITE OF 5A, 15 A AND 17A (17A Ref. Table 12.2)	Minimum Conjuctive Use (3000 AF/Y) and 1300 AF/Y Demin GW PUMPAGE 840 AF (Livermore) RW RO Stream Recharge	II	0	0	450	300	$714,000	$21	4.0%
6A PLUS 15A	Major Conjuctive Use (11000 AF/Y) and 2200 AF/Y Demin GW PUMPAGE	IV	-2100	-7	380	330	$1,656,800	$49	9.3%

Assumptions:

1) *Zone 7 TW delivery of 33,500 AF and UTW of 7300 AF (Year 2000)*
2) *Base TW rate of $528 / AF for year 1999.*
3) *Incremental cost spread only to Zone 7 Treated water deliveries.*
4) *GW TDS of 450 mg/l and SW TDS 270 mg/l (Historic average at PPWTP)*
5) *GW Demin capacity at 2200 AF/Y (180 af/ month for 12 months)*

Status Quo (Strategy 1A)

The first (left most) bar shown on each of the series of graphs in figures 12.2 and 12.3 represents the Status Quo strategy, defined as continuing with historic basin management operational criteria. Under this strategy, Zone 7's annual average deliveries would be a blend of about 85% surface water and 15% groundwater. The annual average TDS of Zone 7's blended deliveries would be about 300 mg/l. The annual average salt loading to the main basin would remain at about 2,200 tons. Since it does not require any changes in operations, there would be no incremental costs.

Net Result: This strategy minimizes operational costs but it fails to achieve the other salt management plan goals.

Minimum Conjunctive Use (Strategy 5A)

The second bar from the left shown on Figure 12.2 represents the minimum conjunctive use with no wellhead demineralization strategy (5A in Table 12.2). Under this strategy the annual average groundwater pumpage volume would be 3,000 AF more than under the Status Quo and Zone 7's annual average deliveries would be a blend of about 75% surface

water and 25% groundwater. The annual average TDS of Zone 7's blended deliveries would be about 10 mg/l higher than under the Status Quo. The annual average salt loading to the main basin would be reduced to about 1,500 tons. The incremental operational cost would be about $4/AF of Zone 7's treated water deliveries or $2/household/year (assuming 0.5 AF/household/year usage).

Net Result: This strategy reduces the salt loading by about 700 tons/year (31%) but it increases the annual average TDS of Zone 7 deliveries by about 3%. The 0.8% incremental operational cost is minimal relative to the 1999 treated water rate of $528/AF.

Major Conjunctive Use (Strategy 6A)

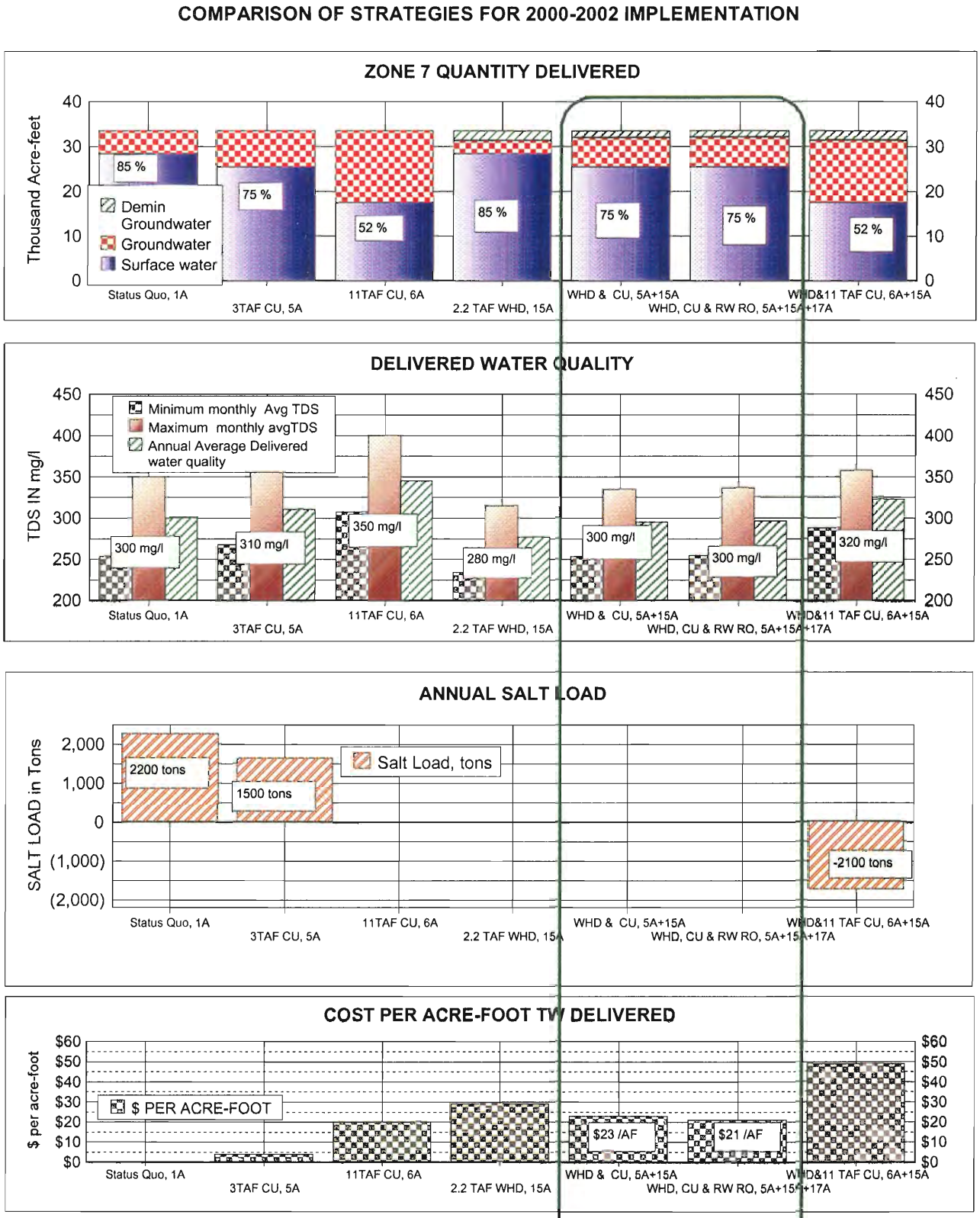
The third bar from the left shown on Figure 12.2 represents the major conjunctive use with no wellhead demineralization strategy (6A in Table 12.2). Under this strategy the annual average groundwater pumpage volume would be 11,000 AF more than under the Status Quo and Zone 7's annual average deliveries would be a blend of about 52% surface water and 48% groundwater. The annual average TDS of Zone 7's blended deliveries would be about 50 mg/l higher than under the Status Quo. Net annual average salt loading to the main basin would be essentially eliminated. The incremental annual operational cost would be about $20/AF of Zone 7's treated water deliveries or $10/household/year. This strategy achieves the salt neutral, zero net loading goal (Fundamental Policy III in Chapter 7), but does not meet the goals of maintaining/improving and equalizing east/west delivered water quality.

Net Result: This is the minimum cost strategy that is salt neutral. It would significantly increase the TDS of Zone 7 deliveries, particularly to the west side of the valley contrary to other salt management goals.

Wellhead Demineralization (Strategy 15A)

The fourth bar from the left shown on Figure 12.2 represents the high TDS shallow groundwater wellhead demineralization (wellhead RO) strategy (15A in Table 12.2). Under this salt neutral strategy the annual average groundwater pumpage volume would be the same as under the Status Quo and Zone 7's annual average deliveries would remain a blend of about 85% surface water and 15% groundwater. About 2,200 AF/year of groundwater would be pumped from new high TDS shallow wells and demineralized from the ambient level of about 1,000 mg/L to 100 mg/L. The low TDS demineralized water would be delivered to the distribution system near the Mocho and/or Hopyard well fields and blended in-line with other higher TDS groundwater to chemically neutralize the low TDS/alkalinity water and yield a TDS equivalent to that provided elsewhere in the Zone 7 distribution system.

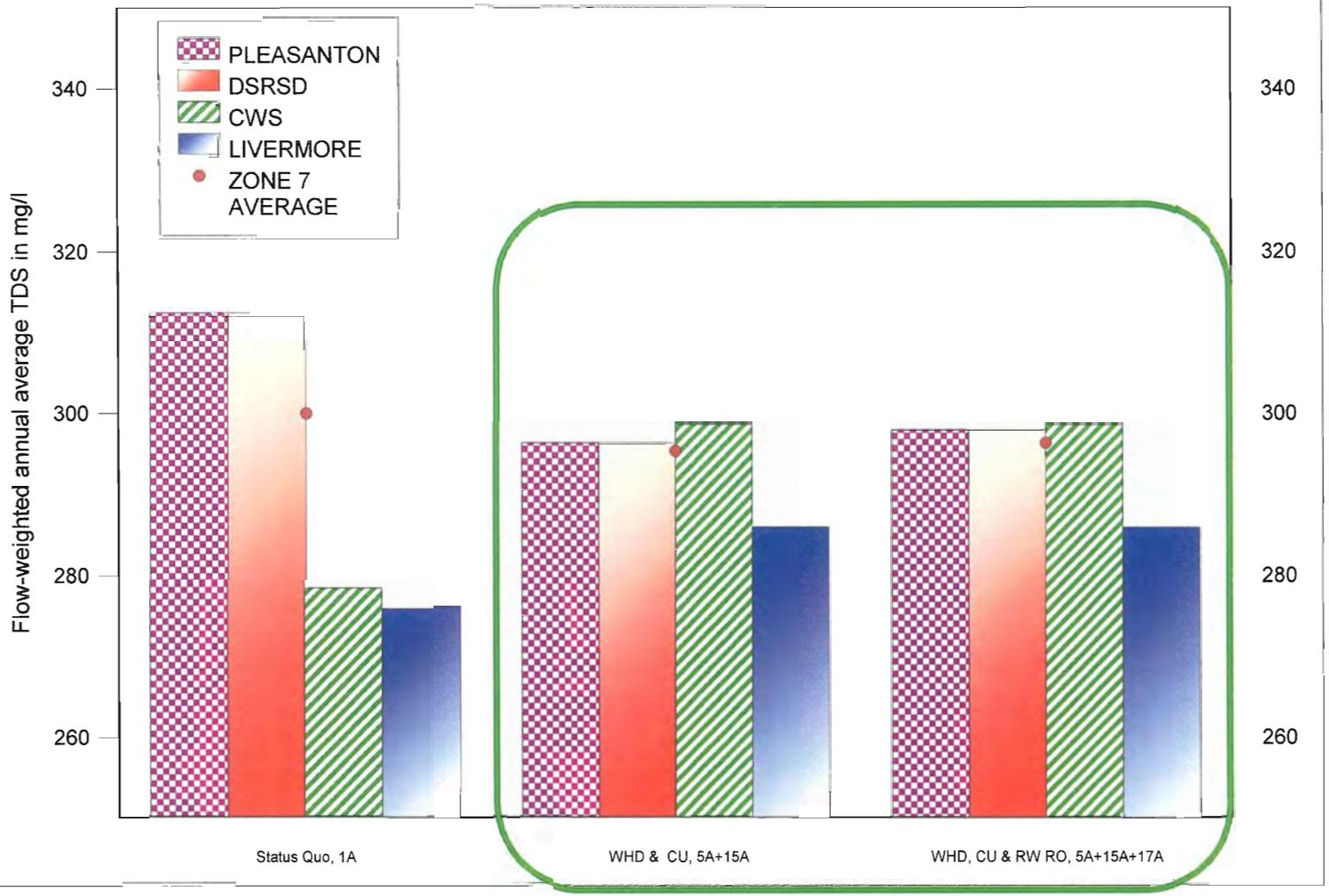
Figure 12.2



CU = CONJUNCTIVE USE, WHD= WELL HEAD DEMINERALIZATION
RW RO= RECYCLED WASTE WATER RO, PENDING PUBLIC ACCEPTANCE
AF= ACRE-FEET, TAF=THOUSAND ACRE-FEET

Figure 12.3

Annual Average TDS Delivered to Retailers
Under Historic and Proposed 2000-2002 Operating Conditions



NOTE:

1) Assuming that 75% of the time the Stoneridge pumpage will be diverted to East (to CWS & Livermore) by closing rate control valve in X-valley pipeline.

2) Assuming that all the other GW pumpage (GW, WHD & ASR) is delivered to Pleasanton and DSRSD (prorated by delivery amount) .

3) Assumes Stoneridge pumpage at 400 mg/l and all other Zone 7 pumpage at 450 mg/l, Well Head Demineralization to 100 mg/l.

Figure 12.3

As described in Chapter 8, for this strategy to be viable, it has been assumed that institutional arrangements could be worked out whereby concentrated brine would be exported to the Bay via the LAVWMA/EBDA pipelines and outfall. The annual average TDS of Zone 7's blended deliveries under Strategy 15A would be about 20 mg/l lower than under the Status Quo. The incremental operational cost would be about $29/AF of Zone 7's treated water deliveries or $14.50/household/year.

Net Result: This is a salt neutral strategy that would also decrease the TDS of blended Zone 7 deliveries particularly to the western side of the valley. It is the highest cost of the near-term salt neutral strategies.

Composite of Minimum Conjunctive Use and Wellhead Demineralization (Composite of Strategies 5A and 15A)

The fifth bar from the left shown on Figure 12.2 and the middle bar cluster shown on Figure 12.3 represent the composite strategy of 3,000 AF/year conjunctive use and 1,500 AF/year shallow groundwater wellhead demineralization (wellhead RO). Under this strategy the annual average groundwater pumpage volume is 3,000 AF higher than under the Status Quo and Zone 7's annual average deliveries would be a blend of about 75% surface water and 25% groundwater. About 1,500 AF (versus 2,200 AF for Strategy 15A alone) of new shallow groundwater pumpage would be demineralized from 1,000 mg/l to 100 mg/l, blended in-line and delivered to customers as under Strategy 15A. Concentrated brine is similarly assumed to be exported via LAVWMA.

The incremental annual operational cost would be about $23/AF of Zone 7's treated water deliveries or about $11.50/household/year. Under this salt neutral strategy the annual average TDS of Zone 7's blended deliveries would be about the same as under the Status Quo. However, it would moderately decrease the TDS of deliveries to the west side of the valley and thereby help equalize the TDS of deliveries to retailers (Figure 12.3). It does not require any significant additional facilities other than those previously planned and budgeted for in the Zone 7 capital improvement program. This composite strategy approach does not preclude the use of other more cost-effective strategies if they become available (e.g., seasonal groundwater export). Other strategies could be incorporated by reducing the volume of groundwater demineralized. This issue is addressed in more detail in the Section 12.5 discussion of SMP adaptive management.

Net Result: This is the most economical near-term strategy that satisfies all the salt management criteria.

Composite of Minimum Conjunctive Use, Wellhead Demineralization and RO Recycled Water Stream Recharge (Composite of Strategies 5A, 15A and 17A)

The sixth bar from the left on Figure 12.2 and the third cluster from the left on Figure 12.3 represent the composite strategy of 3,000 AF of conjunctive use, 1,300 AF of wellhead demineralization and 840 AF/year of Livermore RO recycled water stream recharge (during summer months only) in the Arroyo Mocho near Isabel Avenue. The 840 AF/year represents the maximum production of the existing Livermore 0.75 mgd RO facility. Recharge of this full amount assumes temporary winter storage of about half this volume (e.g., in Chain of Lakes Lake G).

This salt neutral composite strategy is similar to the previous one (5A plus 15A) except that about 300 tons/year of salt removal would be provided by the RO recycled water stream recharge (Strategy 17A), replacing 200 AF/year of the higher unit cost wellhead demineralization. Costs would therefore be slightly less, about $21/AF versus $23/AF of Zone 7's treated water deliveries.

In September 1998, the Zone 7 Board passed a resolution regarding DSRSD's CWR project requiring demonstrated public acceptance prior to supporting any RO recycled water injection projects. Following this resolution, staff from Zone 7, DSRSD and Livermore started investigating alternative strategies to make use of demineralized recycled water. One of the several alternatives investigated was to augment the existing artificial stream recharge on the Arroyo Mocho with demineralized recycled water produced by the Livermore and/or DSRSD RO plants. (This RO stream recharge strategy and its potential riparian corridor environmental enhancement benefits plus a "phased injection" alternative are described in more detail in SMP Section 8.9).

Strategy 17A is presented as a standalone "potential near-term" project in Section 12.3 and Table 12.4. It is included here as part of this near-term composite strategy since RO recycled water stream recharge was perceived to be potentially more acceptable to the public than direct injection into the basin. Some of the perceived positive attributes include the additional treatment "barrier" provided by streambed percolation, the potential environmental enhancement benefits resulting from the release to the Arroyo, the demonstration scale size of the project, and the availability of an existing recycled water pipeline extending from the Livermore facility south along Isabel Avenue to the Arroyo Mocho.

Net Result: This strategy could satisfy all the salt management criteria and would be slightly less expensive compared to the previous composite strategy (5A and 15A). If the RO recycled water stream recharge component did not occur or were delayed, the amount of wellhead demineralization included would need to be increased 200 AF/year and this strategy would effectively become the same as the prior strategy.

Composite of Major Conjunctive Use and Wellhead Demineralization (Composite of 6A and 15A)

The seventh bar from the left shown on Figure 12.2 represents the composite strategy of 11,000 AF/year of conjunctive use plus 2,200 AF/year of wellhead demineralization. This strategy was included since it uses the estimated maximum available stream recharge capacity and the maximum estimated wellhead demineralization facility design capacity. Under this strategy the annual average groundwater pumpage volume is 11,000 AF higher than under the Status Quo and Zone 7's annual average deliveries would be a blend of about 52% surface water and 48% groundwater. About 2,200 AF of shallow groundwater pumpage would be demineralized, blended in-line, and delivered primarily to customers in the western portion of the valley. The demineralization brine is assumed to be exported via LAVWMA.

This strategy would reverse the annual average salt loading to the main basin to about 2,100 tons. However, the annual average TDS of Zone 7's blended deliveries would be about 330 mg/L or 30 mg/l higher than under the Status Quo. The incremental operational cost would be about $49/AF of Zone 7's treated water deliveries or $24.50/household/year.

Net Result: Groundwater quality would improve most rapidly under this strategy but delivered water quality would degrade. This was the highest cost near-term strategy evaluated.

12.3 Potential Near-Term Strategies

Several year 2010 strategies passed all the feasibility screens (technical, timing and water quality) except for public and institutional acceptability. If various non-technical barriers could be overcome, at least some of these could potentially be implemented near-term (see screening discussion in Section 9.6). A selected group of these 2010 strategies, scaled down for current 2,200 tons/year loading conditions, are presented here as "potential" near-term strategies. Some of the individual strategies have limited salt removal capabilities and would need to be used in conjunction with other strategies to fully offset existing salt loading (i.e., a composite strategy).

Table 12.3 summarizes the key statistics for 11 potential near-term salt management strategies based on: a CalFed Delta Fix, RO recycled water injection, seasonal groundwater export, Lake G recycled water storage and irrigation, and RO recycled water stream recharge. The relative performance of seven selected individual and composite potential near-term strategies are compared in four parallel series of comparative bar charts (Figure 12.4).

As described above and similar to Figure 12.2, the first bar chart presents the surface water to groundwater ratio of Zone 7 deliveries. The second graph presents each strategy's resultant average monthly minimum, maximum and annual average Zone 7 delivered

water TDS in mg/L. The third graph presents the annual average salt loading in tons after implementation of each strategy. The fourth graph presents the incremental O&M cost per acre-foot of Zone 7 deliveries (i.e., increase in treated water rates attributable to salt management).

Table 12.3
POTENTIAL NEAR-TERM SALT MANAGEMENT STRATEGIES

			Long - Term Average						
STRATEGY NO.	NAME	POLICY OPTION	NET SALT LOADING TONS/YR	NET INCREASE IN GW TDS mg/l/year	Projected GW TDS after 10 yrs mg/l	TDS OF ZONE 7 DELIVERIES mg/l	ZONE 7 INCREMENTAL OPERATIONAL COSTS PER YEAR	PER ACRE-FOOT OF TW DELIVERY	% Rate Increase
2	DELTA FIX 100 mg/l SBA water quality	III	0	0	450	160	$0	$0	0.0%
RO RW INJECTION 11D	3640 AF RO RW Injection & 500 AF RO GW Pumpage (1000 mg/L to 100 mg/L)	III	0	0	450	310	$440,400	$13	2.5%
GW Export 13B	2000 GPM GW Pumpage (1000 mg/L) to Creek when Laguna flow > 100 cfs (250 AF/Y Long Term Average, 30days@2000gpm)	II	1950	7	520	310	$27,500	$1	0.2%
13C	2000 GPM GW Pumpage (1000 mg/L) to Creek when Laguna flow > 50 cfs (400 AF/Y Long Term Average, 45days@2000gpm)	II	1800	6	510	310	$44,000	$1	0.2%
13D	2000 GPM GW Pumpage (1000 mg/L) to Creek when Laguna flow > 25 cfs (700 AF/Y Long Term Average, 80days@2000gpm)	II	1500	5	500	310	$77,000	$2	0.4%
Lake G RW 16A	Lake G Wet Weather RW Storage of 1800 af, Ag/Fringe Basin Irrigation or LAVWMA Export	I	2200	7	520	305	$0	$0	0.0%
16B	Lake G Wet Weather RW Storage of 1800 af, for Urban/Main Basin Irrigation	II	1700	6	510	305	$0	$0	0.0%
16C	Strategy 16A plus 2200 AF Demin GW Pumpage (1000 to 100 mg/L)	III	0	0	450	280	$976,800	$29	5.5%
16D	Strategy 16B plus 1700 af Demin GW Pumpage (1000 to 100 mg/L)	III	0	0	450	285	$754,800	$23	4.4%
RW RO Conj. Use 17A	840 AF (Livermore) RO RW Summer Stream Recharge on Arroyo Mocho (Lake G Winter Storage)	II	1900	6	510	305	$50,400	$2	0.4%
17B	3640 AF (Liv & DSRSD)) RO RW Summer Stream Recharge on Arroyo Mocho (Lake G Winter Storage)	II	700	2	470	315	$218,400	$7	1.3%

Assumptions:

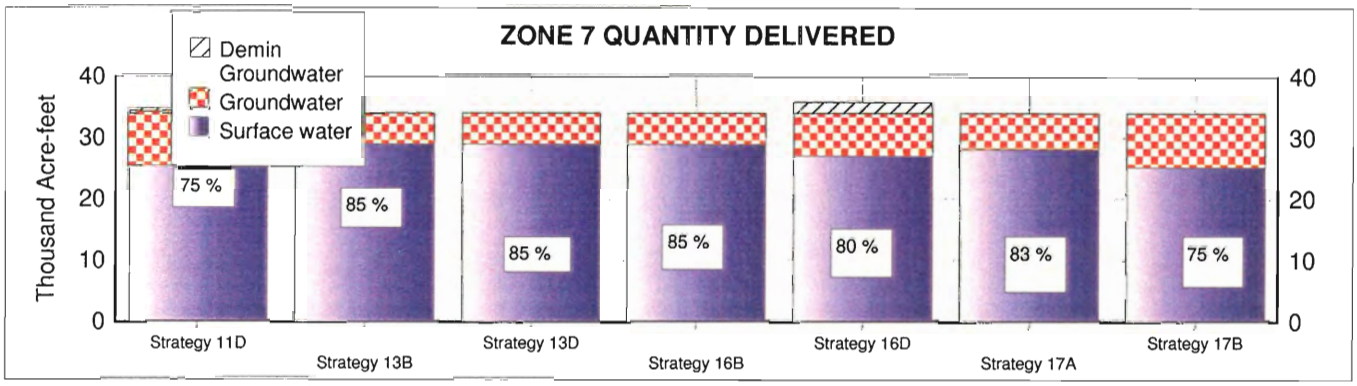
1) Zone 7 TW delivery of 33,500 AF and UTW of 7300 AF (Year 2000)
2) Base TW rate of $528 / AF for year 1999.
3) Incremental cost spread only to Zone 7 Treated water deliveries.
4) GW TDS of 450 mg/l and SW TDS 270 mg/l (Historic average at PPWTP)
5) GW Demin capacity at 2200 AF/Y (180 af/ month for 12 months)

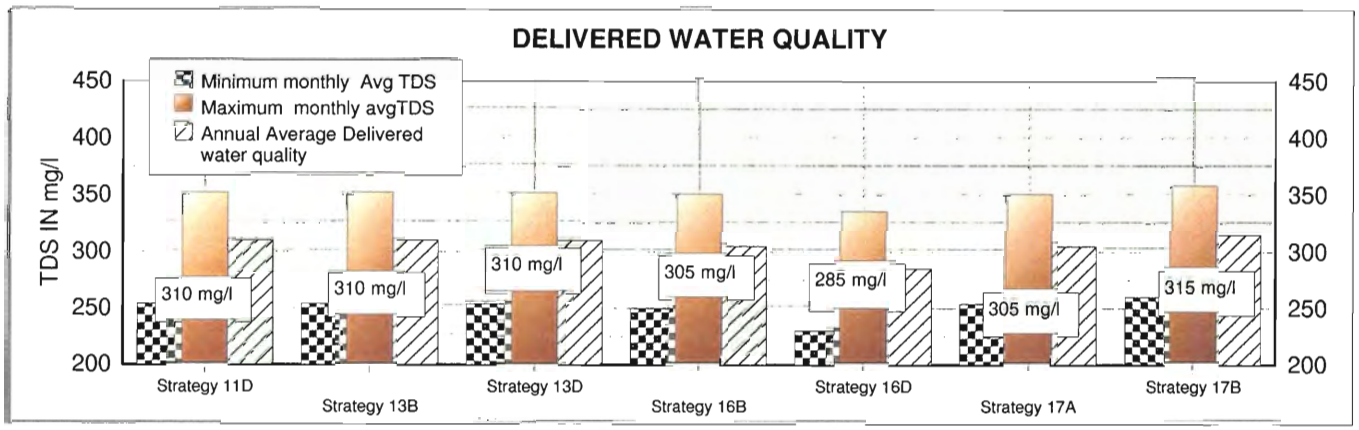
Delta Fix (Strategy 2)

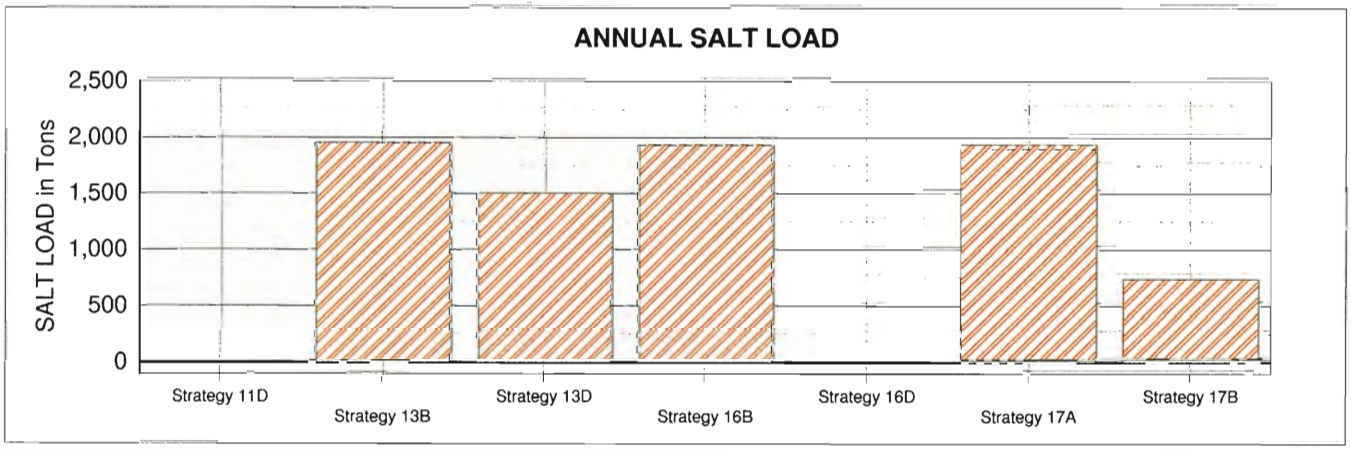
The "Delta fix" near-term strategy (described in Section 8.12) assumes that political will, public support, and funding would come together to support improvements to State Water Project facilities and operations regarding release and conveyance of water through the Delta. Under some of the improved conveyance alternatives the TDS of deliveries from

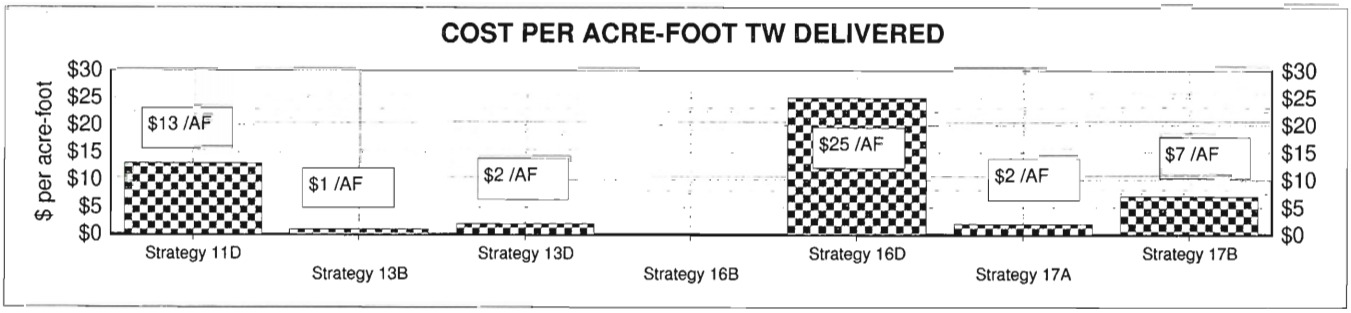
Figure 12.4

POTENTIAL NEAR-TERM SALT MANAGEMENT STRATEGIES









the State Water Project could decrease to about 100 mg/L. This strategy is also included here since it would be representative of conditions that may exist absent a "Delta fix" but resulting from a series of wet years. Given that imported surface water (270 mg/L long-term average TDS) has historically represented 85% of Zone 7 deliveries, this "Delta fix" would significantly decrease salt loading from irrigation and artificial recharge. This strategy would not require any Zone 7 operational changes over the Status Quo (Strategy 1A in Table 12.2).

Under this strategy Zone 7's annual average deliveries would be a blend of 85% surface water and 15% groundwater. The annual average TDS of Zone 7's blended deliveries would be about 160 mg/L (140 mg/l lower than under the Status Quo). The annual average salt loading to the main basin would be eliminated. There would be no incremental operational cost. The main drawback to this strategy is that it is not under Zone 7 control and therefore the timing and feasibility remain uncertain.

Net Result: This strategy would eliminate the 2,200 tons/year salt loading and decrease the annual average TDS of Zone 7 deliveries by about 50% with no increase in operational costs.

Composite of RO Recycled Water Injection and Wellhead Demineralization (11D)

The year 2010 Strategy 11 series projects (Table 9.1) all included 6,000 AF/year of RO recycled water injection. This potential near-term Strategy 11D (which presumes that public acceptability were attained) would reduce the RO recycled water injection to the 3,640 AF/year combined design capacities of the existing DSRSD Clean Water Revival (CWR) RO project (2,800 AF/year) and the Livermore Advanced Water Reclamation Plant (AWRP) RO project (840 AF/year). Also, included is 500 AF/year of high TDS shallow groundwater pumpage and demineralization since this is needed to fully offset the remainder of the 2,200 tons/year of salt loading not offset by the RO recycled water injection alone. As is common to all the strategies in this SMP using wellhead demineralization, the demineralized groundwater would be blended in-line, and delivered primarily to customers in the western portion of the valley, with the brine assumed to be exported via LAVWMA.

The first (leftmost) bar shown on Figure 12.4 represents the performance of this RO recycled water injection and wellhead demineralization strategy (Strategy 11D in Table 12.2). Zone 7's annual average deliveries would be a blend of about 75% surface water and 25% groundwater. The annual average TDS of Zone 7's blended deliveries would be about 10 mg/l higher than under the Status Quo. Annual average net salt loading to the main basin would be eliminated. The incremental operational cost would be about $13/AF of Zone 7's treated water deliveries or $6.50/household/year.

Net Result: This is a relatively low cost, salt neutral strategy. It would slightly (10 mg/L) increase the TDS of blended deliveries. As noted previously, additional demonstration of public support would be required before this strategy could proceed. Phased injection (Section 8.9) and/or ASR well injection with subsequent extraction for irrigation (see year 2010 strategies 14 and 14A) have been proposed as potential modifications to improve public acceptability. ASR well operation (Section 8.6), with recycled or treated water, provides limited salt removal benefits.

Seasonal Groundwater Export (13B, 13C & 13D)

Under these seasonal groundwater export near-term strategies (13B, 13C, and 13D in Table 12.3) it is assumed that high TDS (1,000 mg/L) shallow groundwater would be pumped into the arroyos in areas where the water would be conveyed out of the valley and not recharge and impact the main basin. As described in Section 8.10, this pumpage would be scheduled to occur only during specified wet weather flow periods and in a manner to minimize potential impacts to ACWD recharge operations. The three strategies each assume pumpage at a rate of 2,000 gpm during days when Arroyo de la Laguna flow rates exceed specified values.

Under Strategy 13B the high TDS groundwater would be pumped only when flow in the Arroyo de la Laguna was over 100 cfs. Based on historic flow records, there would be an average of 30 days/year when flow would be over 100 cfs. These conditions would allow groundwater export of 250 AF/year (30 days, 24 hours/day @ 2,000 gpm). Under Strategy 13C, pumpage would occur when flows exceeded 50 cfs (45 days/year allowing an average groundwater export of 400 AF/year). Under Strategy 13D, pumpage would occur when flows exceeded 25 cfs (80 days/year allowing an average groundwater export of 700 AF/year). The year 2010 strategies 13 and 13A had assumed much greater volumes would be pumped (3.6 and 1.5 TAF/year, respectively.)

TDS measurements in the Arroyo de la Laguna show that background concentrations increase from around 200 mg/L at high flows (~1,000 cfs) to nearly 1,000 mg/L at low (~10 cfs) flows. Figure 12.5 shows the relatively small change in stream TDS that would result from the pumpage of 1,000 mg/L TDS under the above three Strategies. At high streamflow there is considerable dilution and at low flows the background TDS would approach or exceed the pumped groundwater TDS.

These seasonal groundwater strategies would require various yet-to-be negotiated institutional and operational agreements with ACWD. Zone 7 or another responsible party may also be required to obtain an NPDES permit for such pumpage from the RWQCB.

The second and third bars from the left on Figure 12.4 represent the performance of two of the seasonal groundwater export strategies (13B and 13D). Under these two strategies, Zone 7's annual average deliveries would be a blend of about 85% surface water and 15%

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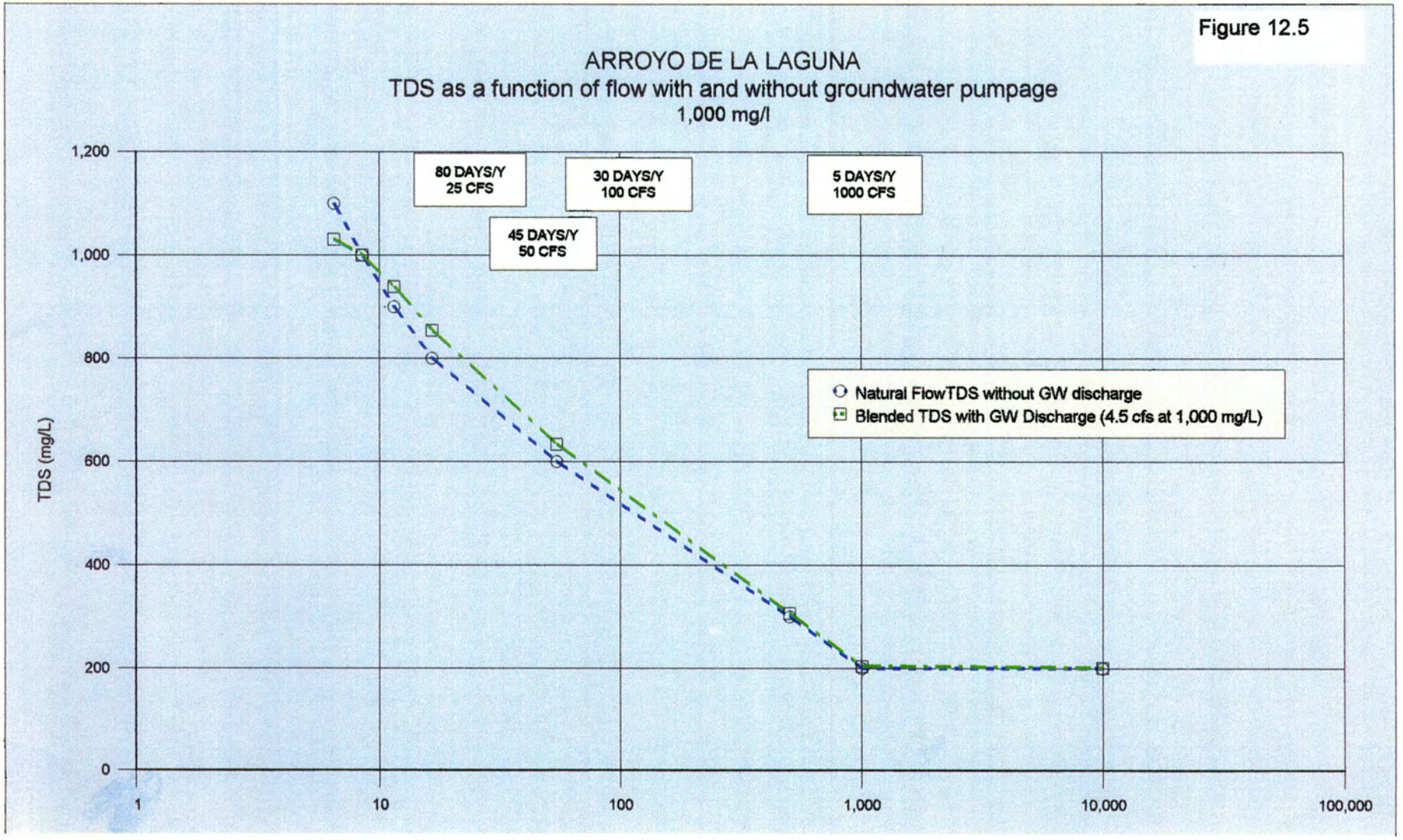
Figure 12.5



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groundwater (the same as under the Status Quo). The annual average TDS of Zone 7's blended deliveries would also be same as the Status Quo.

Annual average net salt loading to the main basin would be reduced by 250, 400 and 700 tons/year for strategies 13B, 13C and 13D, respectively. There would be a small incremental operational cost of $1-$2/AF of Zone 7's treated water deliveries or $0.50-$1.00/household/year.

Net Result: These are low-cost salt removal strategies that would not impact delivered water quality TDS positively or negatively. These strategies would decrease net salt loading but their maximum salt removal capability is limited.

Wet Weather RO Recycled Water Winter Storage and Dry Weather Irrigation Composite Strategy (16A & 16B)

These near-term Strategy 16 series were developed as a potential storage pond based alternative to groundwater injection (Strategy 11 series) or ASR injection and extraction (Strategy 14 series) of RO recycled water. Multiple other variations of these strategies would also be possible depending on future decisions about recycled water demands, uses, storage location and LAVWMA operations. These "16 Series" strategies assume that the DSRSD and Livermore RO recycled water facilities would be operated during six wet weather months (e.g., November through April) at their maximum combined production capacity (3,640 AF/year). This strategy would reduce wet weather demands on the LAVWMA export pipeline system, would provide additional demineralized recycled water for dry weather irrigation (directly or blended with higher TDS water(s)), and would increase salt removal from the basin.

The 1,800 AF of RO recycled water produced during the six wet weather months would be stored in a recycled water (or possibly multi-use untreated water) storage facility. In these "16 Series" examples it has been assumed that Lake G would be available and suitable for this purpose. The same assumptions would apply if another lake were used. It has further been assumed that RO recycled water would be required for this purpose, given the Lake's location above the main basin, even though Lake G is clay lined. Additional hydrogeological investigation and communication with involved agencies would be necessary to determine if the clay liner were adequate so that non-demineralized recycled water could also be stored in Lake G. Storage facilities other than Lake G could also be constructed above or outside the main basin to serve this purpose.

Strategy 16A (Table 12.3) assumes that the 1,800 AF of RO recycled water stored in Lake G would be used for irrigation in fringe basin areas or exported through the LAVWMA pipeline during dry weather months. This strategy would provide no salt removal or Zone 7 delivered water quality benefits since salt loading from irrigation in the fringe basins does not impact (reach) the main basin (with a few minor exceptions—see Section

11.2). However, all these Strategy 16s, through their recycled water use would serve to increase the local water supply by 1,800 AF/year and reduce peak summer demands.

Strategy 16B (shown as the fourth bar from the left on Figure 12.4), assumes that the stored RO recycled water would be used for urban irrigation above the main basin. Under this strategy, main basin salt loading would decrease by almost 500 tons/year due to the assumed irrigation with 100 mg/L TDS RO recycled water instead of 320 mg/L TDS Zone 7 treated water. Zone 7 delivered water quality would remain the same as under the Status Quo. As with all the RO recycled water strategies, is has been assumed that recycled water production and distribution costs would be borne by the recycled water producers so that there would be no incremental operational costs to Zone 7.

Net Result: Strategies 16A and B would allow maximum use of the CWR and Livermore RO facilities by providing winter storage. Strategy 16A would have no impact on salt loading, Zone 7 delivered water quality or Zone 7 incremental operational costs. Strategy 16B would decrease salt loading by about 23% and would not affect Zone 7 delivered water quality or increase operational costs.

Wet Weather RO Recycled Water Winter Storage and Wellhead Demineralization Composite Strategy (16C & 16D)

Strategy 16C was designed to be a salt neutral composite of Strategy 16A plus enough wellhead demineralization to fully offset the remaining salt loading. Since Strategy 16A does not provide any salt removal benefits, 2,200 AF/year groundwater would need to be pumped from new high TDS shallow wells and demineralized from 1,000 mg/L to 100 mg/L to make this a salt neutral strategy (i.e., this effectively becomes the same as Strategy 15A). As is common to all the strategies in this SMP using wellhead demineralization, the demineralized groundwater would be blended in-line, and delivered primarily to customers in the western portion of the valley, with the brine assumed to be exported via LAVWMA.

The annual average TDS of Zone 7's blended deliveries would be about 20 mg/l lower than under the Status Quo. The incremental operational cost would be about $29/AF of Zone 7's treated water deliveries or $14.50/household/year. All the benefits and increase in operational costs in this strategy would be from the wellhead demineralization since Strategy 16C provides no benefits other than winter storage for RO recycled water.

Strategy 16D is a salt neutral composite of Strategy 16B plus 1,700 AF/year of wellhead demineralization to offset the remaining net salt loading. Strategy 16D (fifth bar from the left on Figure 12.4) is similar to 16C except that it requires 500 AF/year less wellhead demineralization and is accordingly less expensive. Under this strategy, Zone 7's annual average deliveries would be a blend of about 80% surface water and 20% groundwater. The annual average TDS of Zone 7's blended deliveries would be about 15 mg/l lower

than under the Status Quo. The incremental operational cost would be about $23/AF of Zone 7's treated water deliveries or $11.50/household/year.

Net Result: Both strategies 16C and 16D are salt neutral strategies that slightly improve the TDS of blended deliveries, particularly that of deliveries to the western side of the valley. Strategy 16D is about 20% less expensive than Strategy 16C due to the zero cost salt removal assumed from irrigation with 100 mg/L TDS RO recycled water.

RO Recycled Water Summer Stream Recharge with Winter Lake G Storage (17A & 17B)

Strategies 17A and 17B both assume full-capacity year-round operation of the two existing RO recycled water facilities with winter storage in Lake G (or an equivalent facility). The same assumptions as to recycled water production and storage for the Strategy 16 series also apply to these Strategy 17 series. The difference is that during summer months the RO recycled water produced, plus that stored in Lake G, would be released into the Arroyo Mocho to recharge the groundwater basin (see Section 8.9 for more details) instead of being used for irrigation.

Under Strategy 17A (Table 12.3), 420 AF/year of RO recycled water from the Livermore RO facility would be stored in Lake G during the six winter months. This water would be pumped from Lake G and recharged on the Arroyo Mocho during summer months along with the 420 AF of summer RO recycled water production. Groundwater pumpage (450 mg/L) by Zone 7 and/or the owner of the recharged RO recycled water would be increased by 840 AF/year above the Status Quo to accommodate the increased stream recharge.

Under Strategy 17A (sixth bar from the left in Figure 12.4), Zone 7's annual average deliveries would be a blend of 83% surface water and 17 % groundwater and blended deliveries would be about 5 mg/L higher than under the Status Quo. The annual average salt loading to the main basin would be reduced to about 1,900 tons. The incremental operational cost would be about $2/AF of Zone 7's treated water deliveries or $1/household/year.

Net Result: This strategy would reduce the salt loading by about 300 tons/year, but increase the annual average TDS of Zone 7 deliveries by about 2%. The incremental operational cost would be minimal (0.4%).

Under Strategy 17B, half the combined maximum annual production (1,820 AF/year) of RO recycled water from the CWR and Livermore RO facilities would be stored in Lake G during the six wet weather months. The RO water would be pumped from Lake G and recharged on the Arroyo Mocho during summer months along with the 1,820 AF of summer RO recycled water production. Zone 7 and/or independent quota groundwater pumpage would be increased by 3,640 AF/year to offset the increased stream recharge.

Under Strategy 17B (seventh bar from the left in Figure 12.4), Zone 7's annual average deliveries would be a blend of 75% surface water and 25 % groundwater. The annual average TDS of Zone 7's blended deliveries would be about 15 mg/l higher than under the Status Quo. The annual average salt loading to the main basin would be reduced to about 700 tons. The incremental operational cost would be about $7/AF of Zone 7's treated water deliveries or $3.50/household/year.

Net Result: This strategy would reduce the salt loading by about 1,500 tons/year, but increase the annual average TDS of Zone 7 deliveries by about 5%. The incremental operational cost would be low (1.3%).

12.4 Adaptive Salt Management Via Annual Operations Plan

Section 2.2 described how Zone 7 manages water deliveries in accordance with its historic water operations planning program that consists of the following three major components:

1. Five-Year Demand Projections and DWR Delivery Schedule
2. Annual Water Supply and Storage Probability Analysis (Water Supply Forecast)
3. Monthly Water Operations Plan (MWOP)

The Water Supply Forecast is prepared in December of each year for the following calendar year. The Water Supply Forecast shows how Zone 7 would operate to make full deliveries under a wide range of hydrologic conditions ranging from critically dry to extremely wet.

The Water Supply Forecast addresses water management decisions on an annual basis. The Monthly Water Operations Plan addresses water management decisions on a monthly basis. Each year in July, Zone 7 prepares preliminary versions of the Monthly Water Operations Plans for the following three years. In September of each year, these three-year Monthly Water Operations Plans are updated to reflect the latest demand requests from Zone 7 contractors and are used for preparing the DWR water delivery schedules. In January of each year, the Monthly Water Operations Plan for the current year is updated with more accurate DWR water supply projections for most probable conditions. In April of each year, after DWR has announced the firm rest-of-year deliveries, Zone 7 develops a Monthly Water Operations Working Plan. This Monthly plan is then updated monthly for the rest of the year with actual year-to-date data and as such reflects adjustments made to meet water operational objectives.

The primary goal of the historic operations plan was to minimize O&M costs by delivering the maximum amount of surface water and pumping groundwater only to supplement surface water supplies during peak demand and drought periods. This historic operations plan successfully provided sustainable water supply at minimum O&M cost but did not address salt loading, groundwater quality, or delivered water quality.

It is proposed that the Water Operations Plan be expanded to incorporate the SMP goals and an adaptive management approach to selecting the combination of salt management strategies to be implemented in a given year. Over time, it is expected that additional strategies may become available (e.g., seasonal groundwater export) and Zone 7 will need to decide what is the optimum combination of strategies to use in a given year. Multiple variables will need to be balanced in making this decision, and the variables will likely change year by year, hence the need for an adaptive management approach.

Adaptive management is "learning by doing." The CALFED Bay Delta Program defined adaptive management as a science-based process whereby the possible solutions to prioritized problems are implemented, monitored, and evaluated and then either are repeated or evolve into the next round of testing.

Figure 12.6 presents the schematic of the proposed adaptive management approach to developing an annual operations plan each year. This approach requires input in four major areas: 1) Policy directives (bottom box), 2) Salt loading tracking (top box), 3) Available salt management strategies (right box) and 4) Available resources and demand (left box).

Policy directives would include items such as Zone 7 Board decisions and guidance that there should not be any long-term average net salt loading to the groundwater basin and to maintain or improve delivered water mineral quality.

Available resources and demand factors include assessing the water supply, demand and groundwater storage conditions at the beginning of each year. This basically represents the information tracked and processed by the historic operations plan.

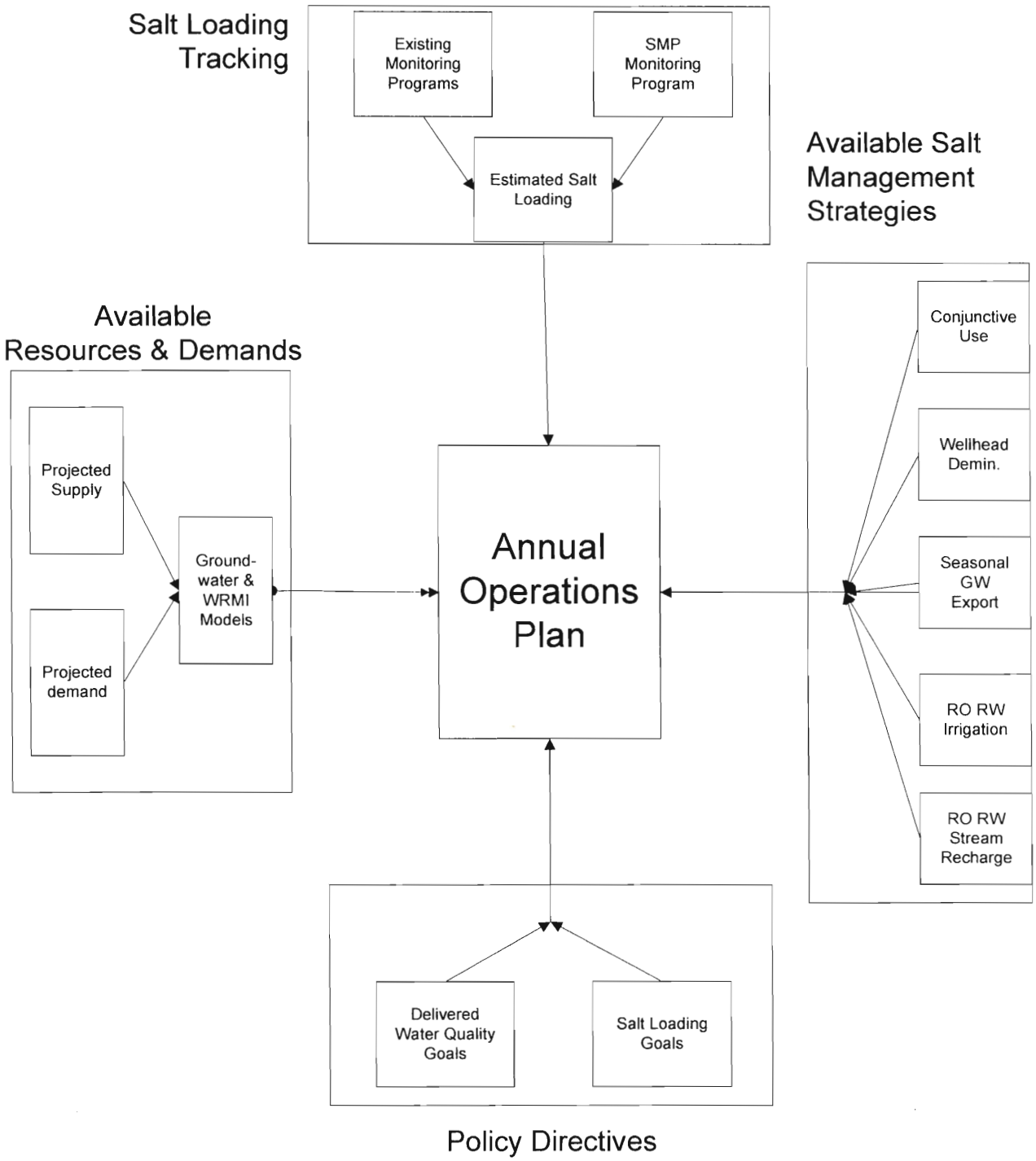
Salt loading tracking factors includes data and information collected from the various monitoring programs. The existing monitoring program is sufficient for tracking salt loading from existing sources and for existing land use conditions. Future land use changes and any increased use of recycled water will require additional monitoring to track the resultant salt loading, as described in chapter 6. The Salt Management Monitoring Program (SMMP) will facilitate tracking salt removal progress and will provide the information needed to calculate the annual salt removal targets for inclusion in the operations plan.

Available salt management strategies represent all the available salt removal tools and their relative removal capacities. The number and type are expected to increase over time (tables 12.2 and 12.3), and the facilities could be owned and operated by Zone 7 or by others.

The various factors such as current and projected salt loading, relative salt removal costs ($/ton removed), impacts on delivered water quality, and water supply conditions would be evaluated together and the best possible solution that would balance the competing salt

Figure 12.6

Schematic of Salt Management Annual Operations Plan



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management goals would be incorporated into the annual operations plan. In some years this decision may require groundwater modeling.

One possible outcome of the adaptive management process may be to decide to not implement any salt removal measures in a given year and to accrue a salt deficit with the intent that it would be offset in future years. This may be the case in the early years of the SMP, when there will be relatively few strategies to select from (e.g., conjunctive use). This outcome could also be the case during droughts when demineralization facilities might not be operated to conserve the water that would otherwise be lost as brine. A similar decision to limit or not operate demineralization facilities might be made during periods of limited power supply and/or high cost power. Conversely, under, for example, very favorable water supply conditions, Zone 7 could choose to implement extra salt removal measures.

Another example of adaptive management decision-making would be whether to operate wellhead demineralization facilities at a constant rate year round (assuming adequate LAVWMA wet weather disposal capacity) or to operate at higher rates, for example, just during the April to October period. The intent of the latter approach would be to produce more low TDS water during the summer months (when more groundwater is pumped) to help reduce both the delivered water TDS and seasonal variability in TDS.

Figure 12.7 shows the impacts on delivered water quality (thick line, bottom graph) under a constant-rate year-round mode of demineralization operation. The groundwater TDS shown is the flow weighted average concentration of the ambient 450 mg/L groundwater pumped and the demineralized groundwater pumped. Figure 12.8 shows the results when demineralization production is limited to April-October and both groundwater pumping and demineralization production is varied to attempt to keep delivered water TDS as constant as possible. Both strategies result in an annual average delivered water blend of 5% demineralized groundwater, 20% non-demineralized groundwater, and 75% surface water.

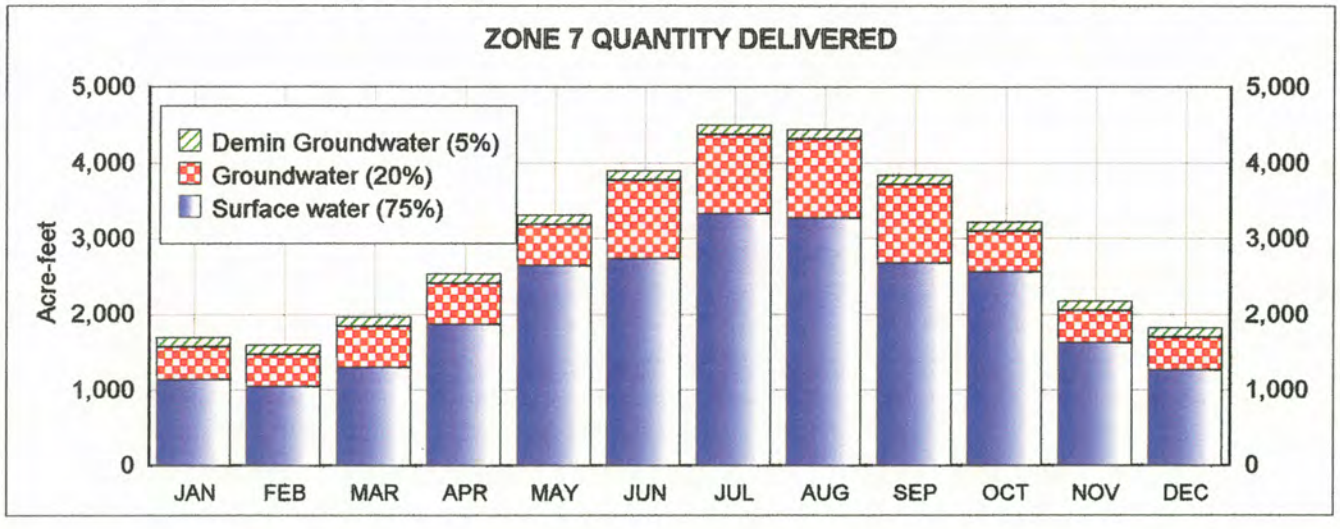
In this example, the resultant annual average delivered water TDS is the same (300 mg/L) under both operation plans, but there is slightly less variation in month-to-month average TDS under the variable operations plan (Figure 12.8). The beneficial impacts on TDS and variability would become more significant if additional demineralization was available and if less groundwater was assumed to be pumped during summer months.

12.5 Phased Near-Term SMP Implementation

During 1998, Zone 7 staff obtained considerable input from the TAG and other interested parties on the SMP. Extensive comments on SMP implementation were provided by the DSRSD, Pleasanton, Livermore, and Cal Water senior water/wastewater and public works managers at an SMP workshop held on September 3, 1998. Table 12.4 summarizes the highlights and recommended actions from that meeting. (Detailed meeting notes are

Figure 12.7

Year 2000 Steady State Salt Loading
WELL HEAD DEMINERALIZATION 1.5 TAF AND CONJUNCTIVE USE 3 TAF
DEMINERALIZATION PRODUCTION EVENLY DISTRIBUTED FOR 12 MONTHS



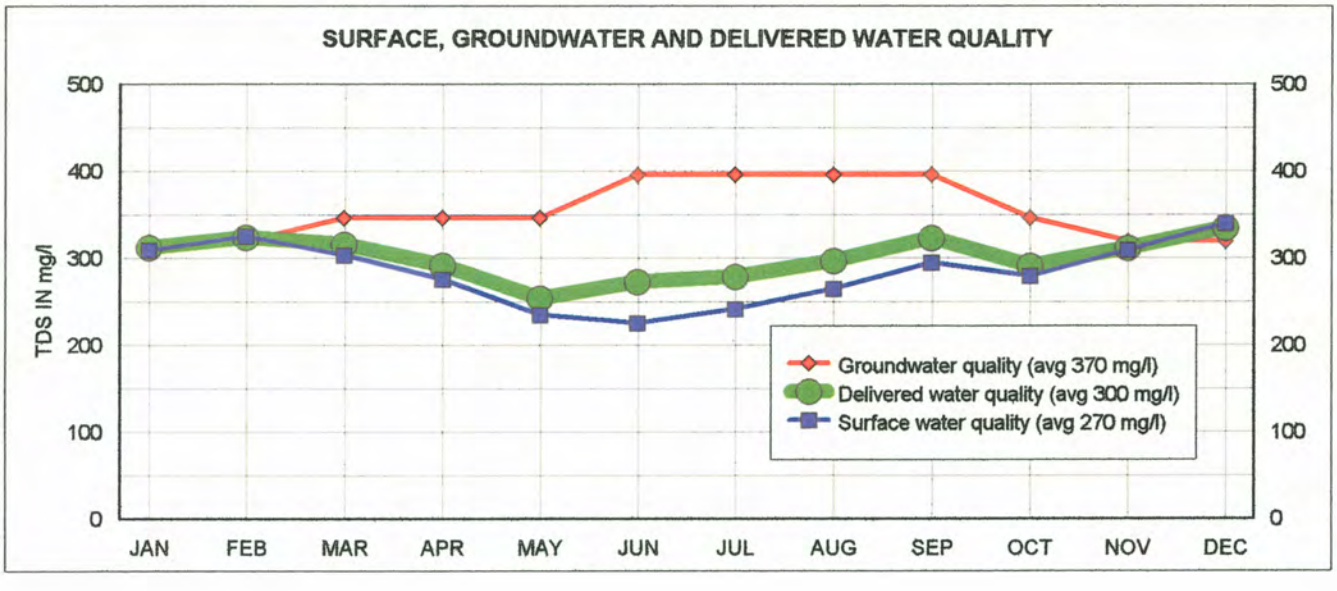
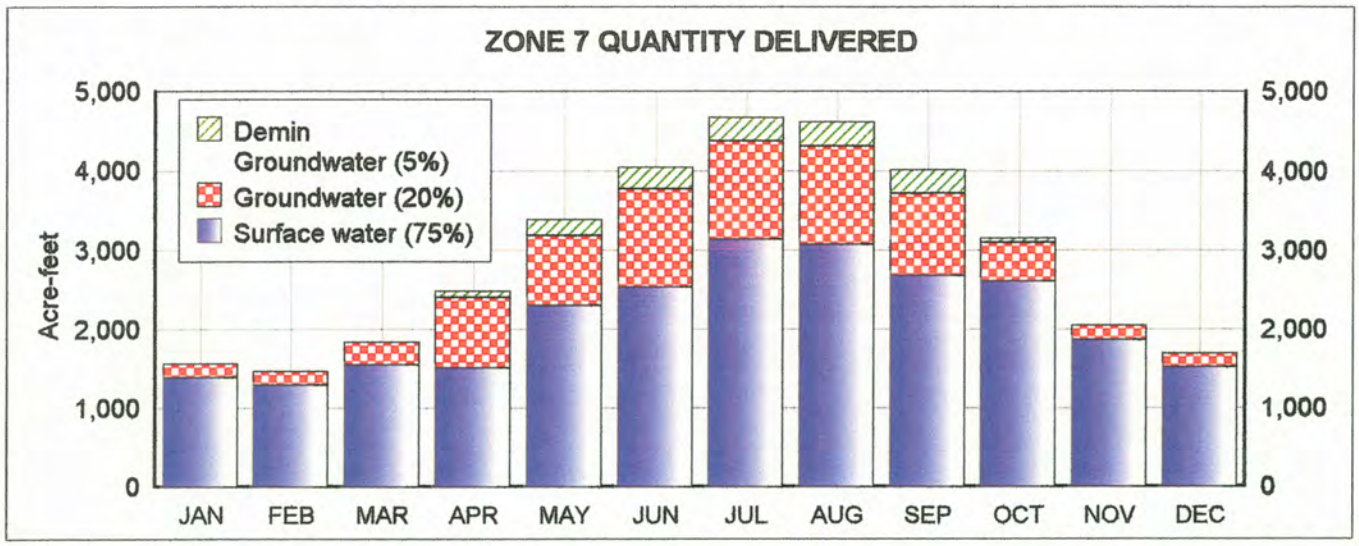


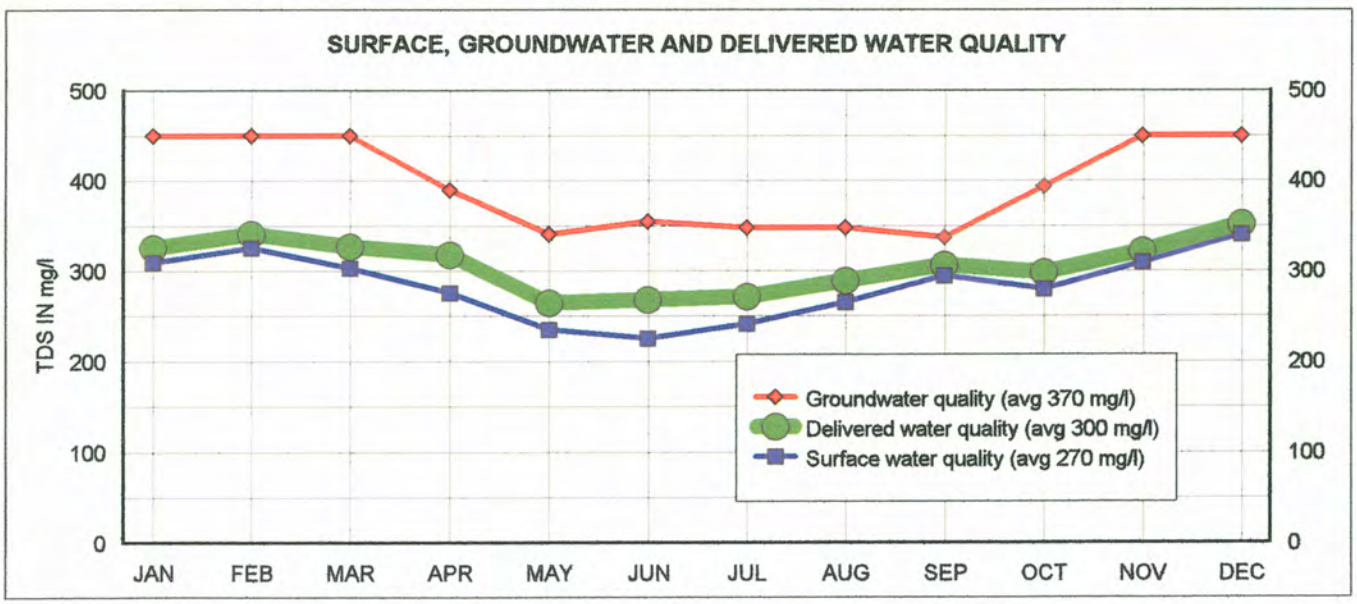
Figure 12.8

Year 2000 Steady State Salt Loading

WELL HEAD DEMINERALIZATION 1.5 TAF AND CONJUNCTIVE USE 3 TAF IN APR-OCT

VARIABLE DEMINERALIZATION PRODUCTION APRIL - OCTOBER





included in Reference Q). The managers supported raising Zone 7 water rates and to begin implementing salt management activities including wellhead demineralization.

During the first half of 1999, Zone 7 staff, in consultation with the TAG and Zone 7 managers, identified a recommended set of Salt Management Plan goals and strategies for inclusion in a phased near-term implementation plan. This plan was intended to serve as a roadmap for how Zone 7 would proceed towards incorporating salt management strategies into routine operations.

SMP Goals

Key SMP policy issues and options were presented in Chapter 7. Based on that information, the following SMP policies (1999) and goals were recommended for Zone 7 adoption and inclusion in the annual operations plan:

- Offset the current (1999) 2,200 tons per year of salt loading plus approximately 50 tons per year of current projected annual increase.
- Maintain or improve groundwater mineral quality.
- Maintain or improve delivered water quality.
- Provide comparable delivered water quality to all retailers.
- Provide a mechanism for full management of all salt loading associated with recycled water use.
- Minimize total operational and maintenance costs through an adaptive management process.

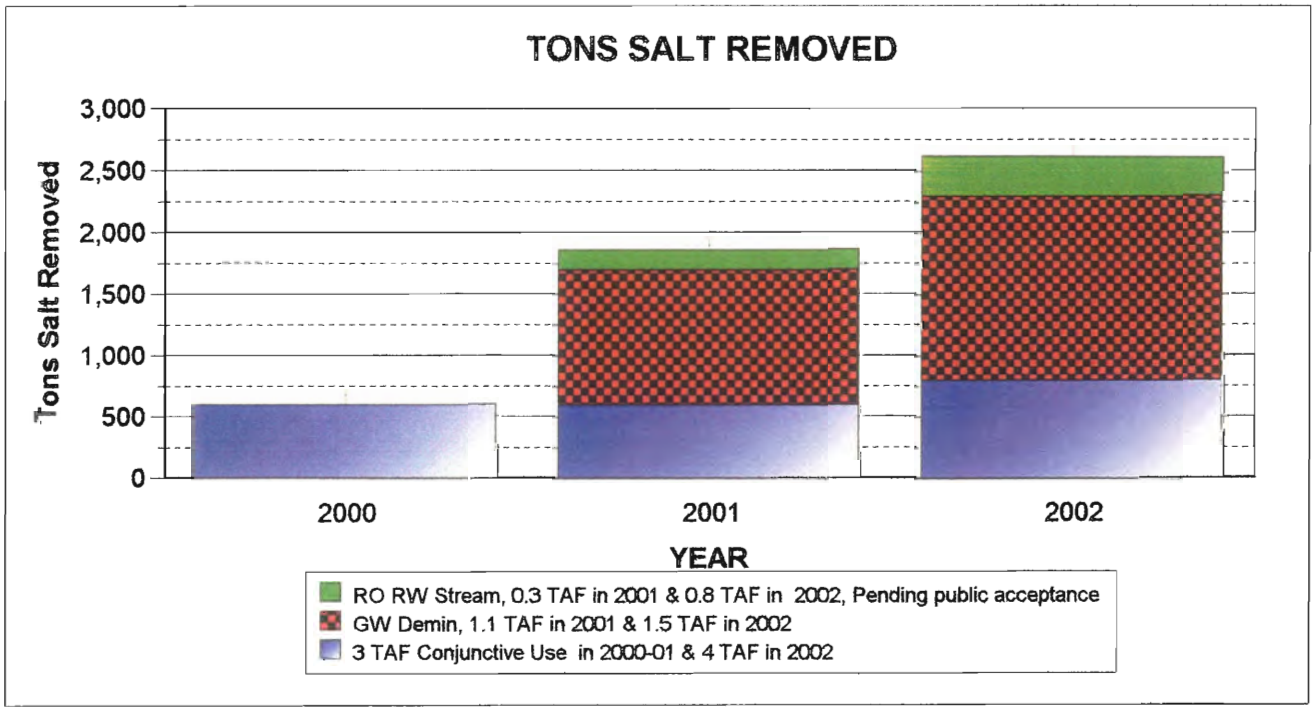
Near-Term Composite Strategy

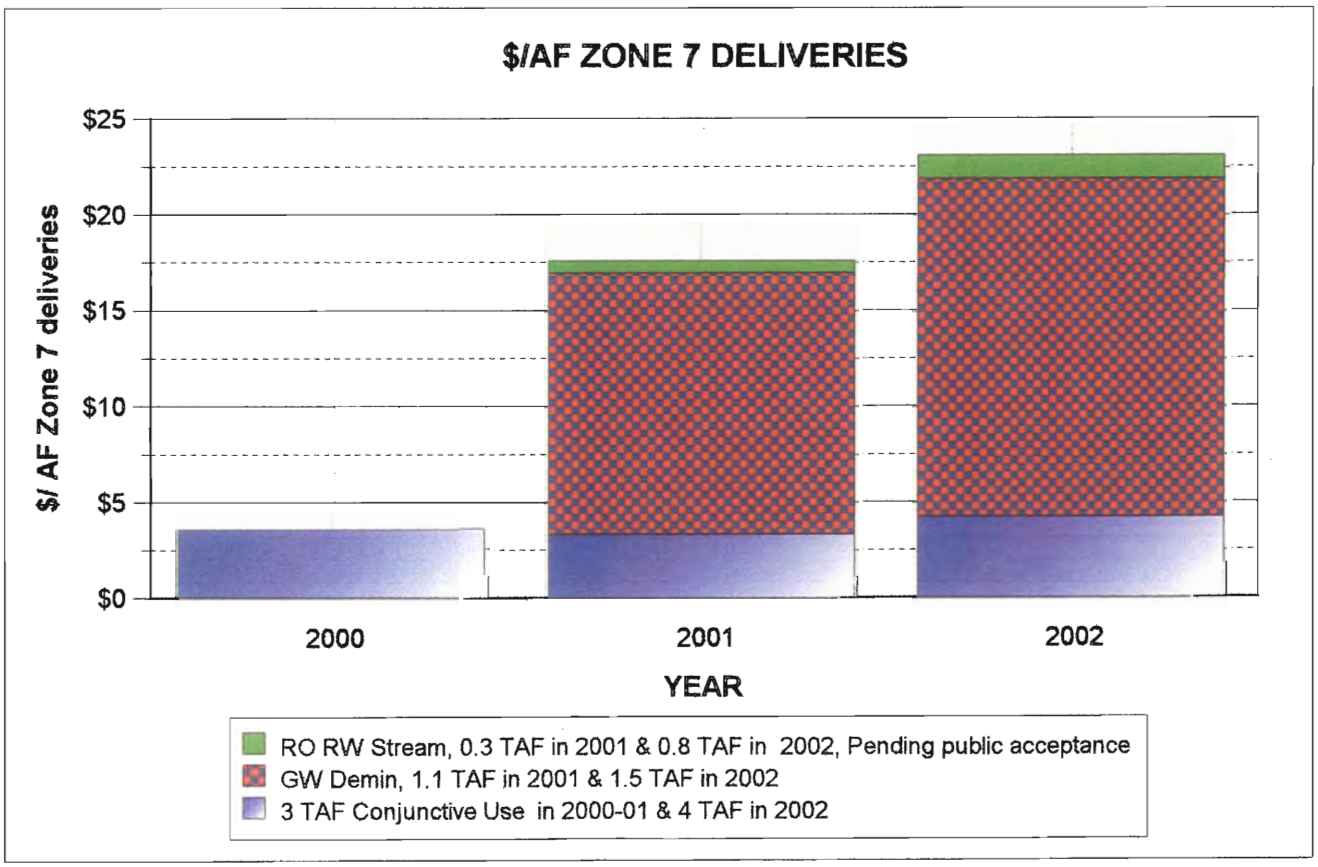
Section 12.2 presented strategies that could be implemented, or begin to be implemented, in the first year of the SMP, which is assumed to be 2000 (as envisioned in early to mid-1999). Based on that information, the apparent best near-term strategy to achieve the multiple SMP goals listed above appeared to be the composite of conjunctive use and wellhead demineralization, with possibly summertime stream recharge of RO recycled water (pending public acceptance). This strategy is represented in the circled fifth and sixth from the left bars on Figure 12.2 and second and third from the left bar clusters on Figure 12.3. These correspond to the two composite strategies 5A plus 15A and 5A plus 15A plus 17a in Table 12.2, respectively.

It is recognized that additional planning, public and agency "buy-in," design, and construction work are required before wellhead demineralization and RO recycled water stream recharge could physically by initiated. Figure 12.9 presents a proposed phased implementation plan for the calendar years 2000-2002. The first bar graph (top) shows tons of salt removed each year and the second bar graph (bottom) show the incremental operational cost per acre-foot of Zone 7's treated water deliveries. The graphs show the

Figure 12.9

PROPOSED SALT MANAGEMENT PLAN FOR 2000-02 AND O&M COST





current loading of 2,200 tons/year in 2000 and the projected 200 tons/year increase to 2,600 tons/year in 2002.

Year 2000—The only SMP action that could be initiated in 2000 would be a limited increase in conjunctive use (i.e., Strategy 5A). Figure 12.9 assumes that in the year 2000 conjunctive use would be increased by more pumping of the Stoneridge well. In a partial response to the goal of providing comparable delivered water quality to all retailers, to the extent possible the groundwater would be delivered to the east side of the Zone 7 distribution system. Pumping 3,000 AF of groundwater in excess of that needed for peaking would remove about 600 tons of salt and would increase treated water costs by about $3/AF.

Year 2001—The middle bar in Figure 12.9 illustrates a situation where by mid-2001 a nominal 3 mgd wellhead demineralization facility would be in operation and Livermore would have obtained the approvals necessary to begin recharging RO recycled water during summer months in the Arroyo Mocho east of Isabel Avenue. Having these facilities operational during the last half of 2001 would allow about 1,100 AF of high TDS groundwater to be demineralized (e.g., at the Camp Parks well site) and blended into the western portion of the distribution system and about 300 AF of RO recycled water to be recharged. These actions plus continuation of the 3,000 AF of conjunctive use pumping begun in 2000 would remove about 1,800 tons of salt and would increase treated water costs by about $17/AF. As of 2004, only the conjunctive use component of the salt management strategies was implemented.

Year 2002—The projected year 2002 strategy shown in the third bar in Figure 12.9 uses the same facilities as in 2001 except that they are assumed to be available for a full 12 months of operation instead of the six months available during 2001. This strategy would pump 4,000 AF of groundwater for conjunctive use, demineralize about 1,500 AF of high TDS groundwater, and recharge about 840 AF of RO recycled water in the Arroyo Mocho during the summer (Livermore RO design capacity with winter storage). This strategy would remove about 2,600 tons of salt and would increase treated water costs by about $23/AF. If RO recycled water stream recharge was not conducted, wellhead demineralization would need to be increased to 1,800 AF/year.

Zone 7 Board Near-Term Implementation Plan Approval

The above phased near-term implementation plan was presented to and approved by the Zone 7 Board of Directors on August 18, 1999 by Resolution No. 99-2068. The tables and figures illustrating the plan contained in this chapter are essentially the same as those presented to the Board. The resolution stated the Board's support for the proposed Salt Management Program Implementation Plan and for inclusion of the above six policy goals in the Zone 7 annual operations plan. The resolution also authorized the Zone 7 General Manager to proceed with the recommended year 2000-2002 Salt Management Implementation Plan.

Interim Implementation Plan Options for 2004-08

During 2000-2003, only the conjunctive use component of the approved implementation plan was implemented. The wellhead demineralization facility that was scheduled to be completed by 2001-2002, has been delayed and it is now projected to be completed by 2008. Zone 7 has the following two options during this interim period:

1) Continue the increased conjunctive use by increasing the annual groundwater to surface water ratio from 15% to about 20%. This will reduce the salt load by about 1,000 tons/year but it will deliver higher mineral content water to all retailers. Pleasanton and DSRSD deliveries would be impacted more than Livermore and CWS. If the retailers were accepting of this option, Zone 7 could continue this partial implementation approach until the wellhead demineralization facilities are completed.

2) Discontinue increased conjunctive use until the wellhead demineralization facility is available (2008). Under this option, groundwater pumpage would be limited to the pumping required to meet peak demands.

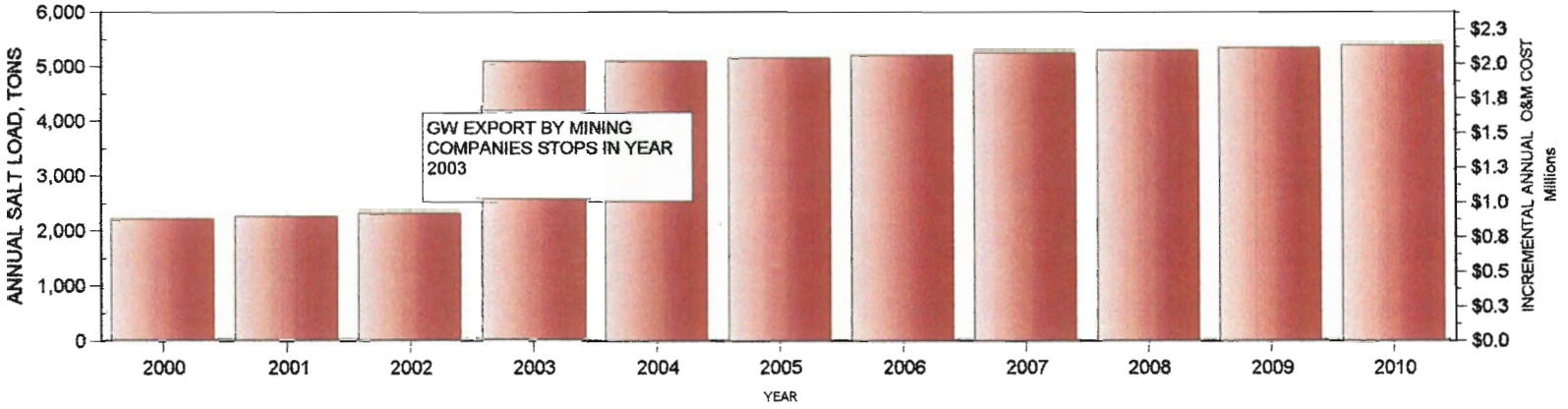
12.6 Future Salt Loading and SMP Next Steps

Main basin salt loading has been projected to increase from the current (1998) 2,200 tons/year to 5,400 tons/year by 2010 or sooner (Section 8.9). The upper graph in Figure 12.10 presents projected future annual salt loading 2000 through 2010. This graph shows salt load in tons on the left y-axis and annual incremental annual O&M cost on the right y-axis. The costs shown are based on one strategy and reflect the potential annual operation and maintenance (O&M) costs to fully offset each year's loading, assuming use of shallow well demineralization (1 to 4 TAF/Y) and conjunctive use (3 to 7 TAF/Y). Under any other strategy or combination strategies, the costs would differ.

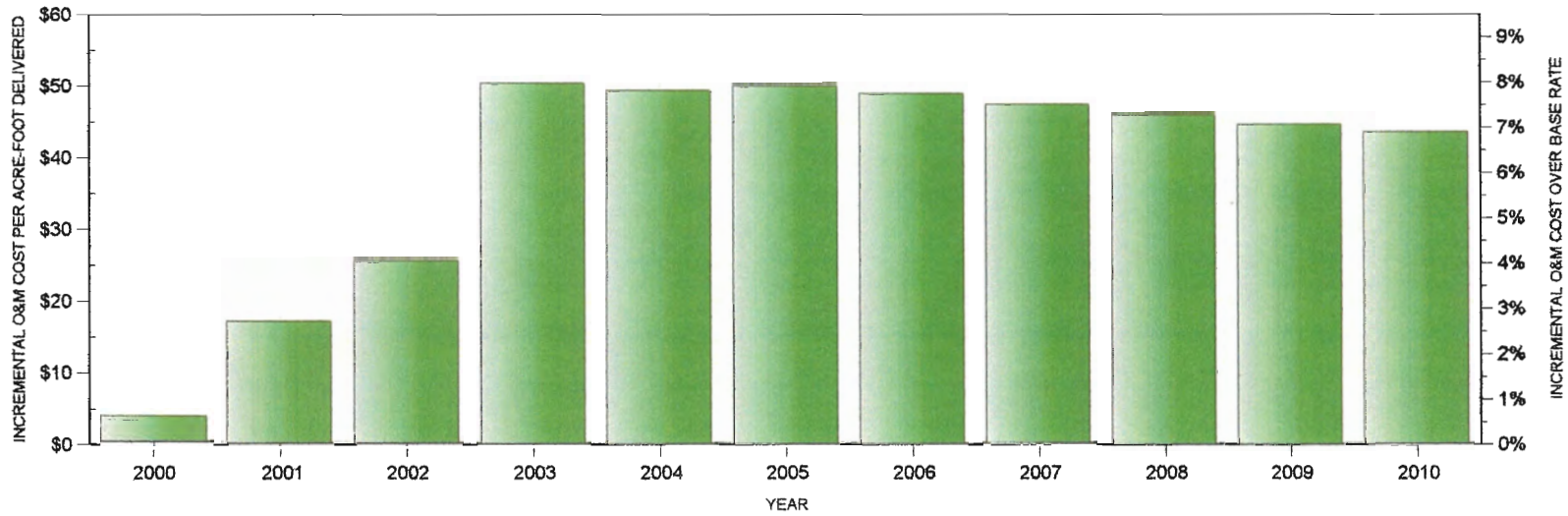
The bottom graph shows the incremental O&M cost per acre-foot of Zone 7 treated water deliveries on the left y-axis. The right y-axis shows this cost as a percentage over the base total treated water rate. For years 2000 - 2002, the incremental cost would increase from about $3/AF/year (first bar on bottom graph of Figure 12.10) or $1.50/houseold/year to about $25/AF/year (left y-axis) or $12.50/houseold/year. That would be an increase of about 5% (right y-axis) over the Zone 7 1998 base treated water rate ($528/AF).

A major change occurred in year 2002 with the cessation of the majority of the water and salt exports by the gravel-mining companies. To remain salt neutral, the salt management plan would need to be expanded to offset the additional 2,800 tons/year. To do so would cause the incremental operational costs to increase by about $50/AF of Zone 7 treated water deliveries over base treated water rates. After 2003, the increase in salt loading is projected to be gradual, about 50 tons/year or 500 tons by 2010 due primarily to increased urban and agricultural development related irrigation.

Figure 12.10
FUTURE ANNUAL SALT LOAD & REMOVAL COST (2)



O&M COST PER ACRE-FEET (normalized for annual Zone 7 treated water deliveries)



NOTE: *1) Salt load calculation does not include:*

a) The impacts of increased future subsurface inflows due to increased agriculture irrigation outside the main basin.

b) The incremental increase in salt loading due to recycled water irrigation over the main basin.

2) Salt removal cost is based upon removal by Shallow Well GW Demin (1 - 4 Taf/y) and Conjunctive use (3 - 7 Taf/y) . For any other tool or the combination of tools, the cost will change.

26-Jun-02

Zone 7 treated water deliveries are projected to increase each year successively at least through 2010, increasing the base volume upon which to distribute the increased O&M costs. Therefore, the incremental operational cost for salt management in 2010 would stabilize at around $45/AF/year (left y-axis). This would represent about 8% of the Zone 7 1998 base treated water rate (right y-axis). If any of the other lower cost salt removal strategies become available in future, they would be integrated into the annual operations plan as part of the SMP adaptive management process and operational costs could be less.

These future salt loading estimates do not include impacts to the main basin of potential increased future subsurface inflow due to increased agriculture irrigation outside the main basin (to be tracked via proposed Salt Management Monitoring Program—see Chapter 6). However, the potential loadings due to increases in such subsurface flow are believed to be minimal due to the various geologic barriers between the fringe and main basin (as described in Chapter 3). The estimates shown in Figure 12.10 also do not include any incremental increase in salt loading due to new or retrofit recycled water irrigation projects impacting the main basin. New and/or expanded salt management strategies and facilities will need to be implemented to offset these future potential salt sources to comply with the SMP goal of fully offsetting net salt loading.

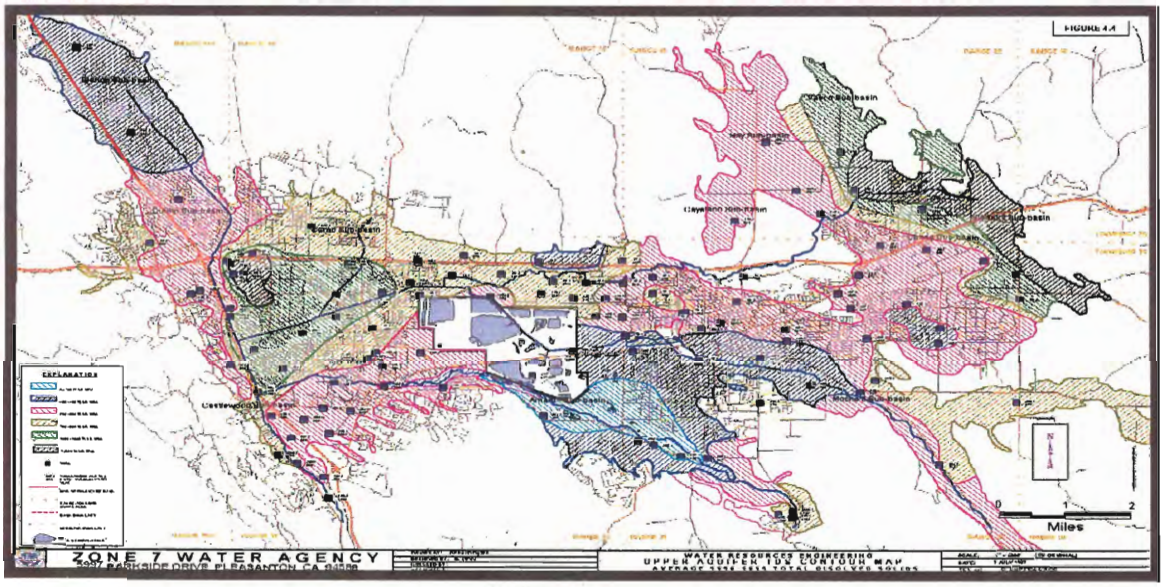
SMP Next Steps

Zone 7 began implementing the SMP in 2000 by increasing conjunctive use (Strategy 5A). Zone 7 has wellhead demineralization facilities scheduled within its Capital Improvement Program (CIP). Further planning studies have been conducted that verified the feasibility of shallow groundwater demineralization as described in this SMP. Those studies also investigated in more detail alternative sites for the demineralization facilities. A well master plan is being conducted that will in part also evaluate in more detail sites for shallow groundwater wells. Negotiations are continuing with DSRSD and Livermore on use of the LAVWMA facilities for brine disposal. Zone 7 has completed a Water Quality Master Plan. The SMP goals and operations have been integrated into and coordinated with the Water Quality Master Plan goals.

Zone 7 is continuing discussions with untreated water and recycled water users and purveyors on equitable ways of offsetting salt loading from those projects. Given enough public support, Zone 7 and Livermore could begin to look in more detail into summertime stream recharge with demineralized recycled water in the Arroyo Mocho near Isabel Avenue (strategies 17A and 17B).

Zone 7 will be continuing discussions with ACWD on possible operational agreements that would identify conditions under which it would be acceptable for Zone 7 to conduct seasonal groundwater export of high TDS groundwater (strategies 13B, 13C, 13D). Zone 7 will contact the RWQCB to determine what type of permit, if any, would be required for this activity.

Following Zone 7 management approval, this SMP will be submitted to the RWQCB staff to document how Zone 7 manages the groundwater basin to maintain sustainable water supply and water quality.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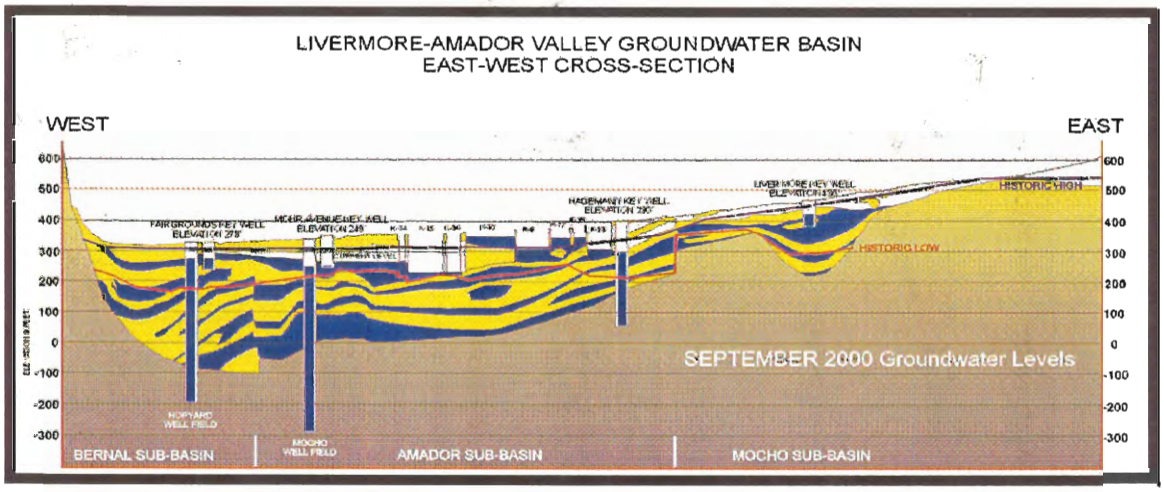
LIVERMORE-AMADOR VALLEY GROUNDWATER BASIN
EAST-WEST CROSS-SECTION
WEST
EAST
HISTORIC HIGH
HISTORIC LOW
SEPTEMBER 2000 Groundwater Levels
BERNAL SUB-BASIN
AMADOR SUB-BASIN
MOCHO SUB-BASIN

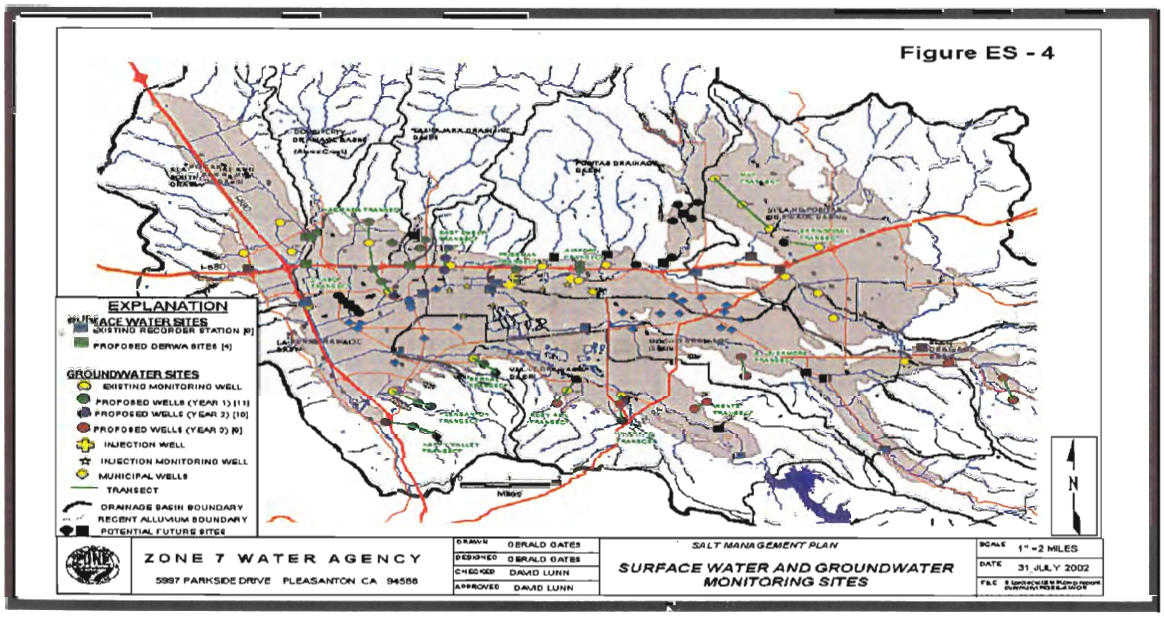
Figure ES - 4
EXPLANATION
GROUNDWATER SITES
ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588
SALT MANAGEMENT PLAN
SURFACE WATER AND GROUNDWATER MONITORING SITES
SCALE 1" = 2 MILES
DATE 31 JULY 2002