Chapter 8

Individual Salt Management Strategies

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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

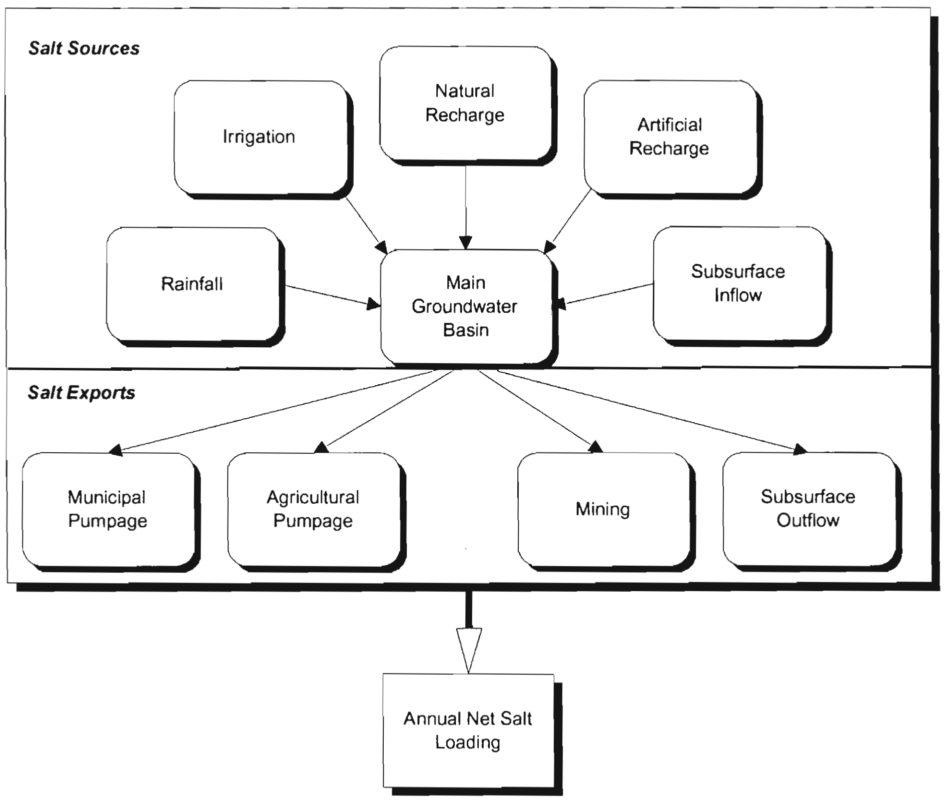


Table 8.1
Main Basin Relative Salt Loading Sources
1998 Water Year

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

Climatic Conditions	SBA TDS (mg/L) Winter	Summer	GW 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).

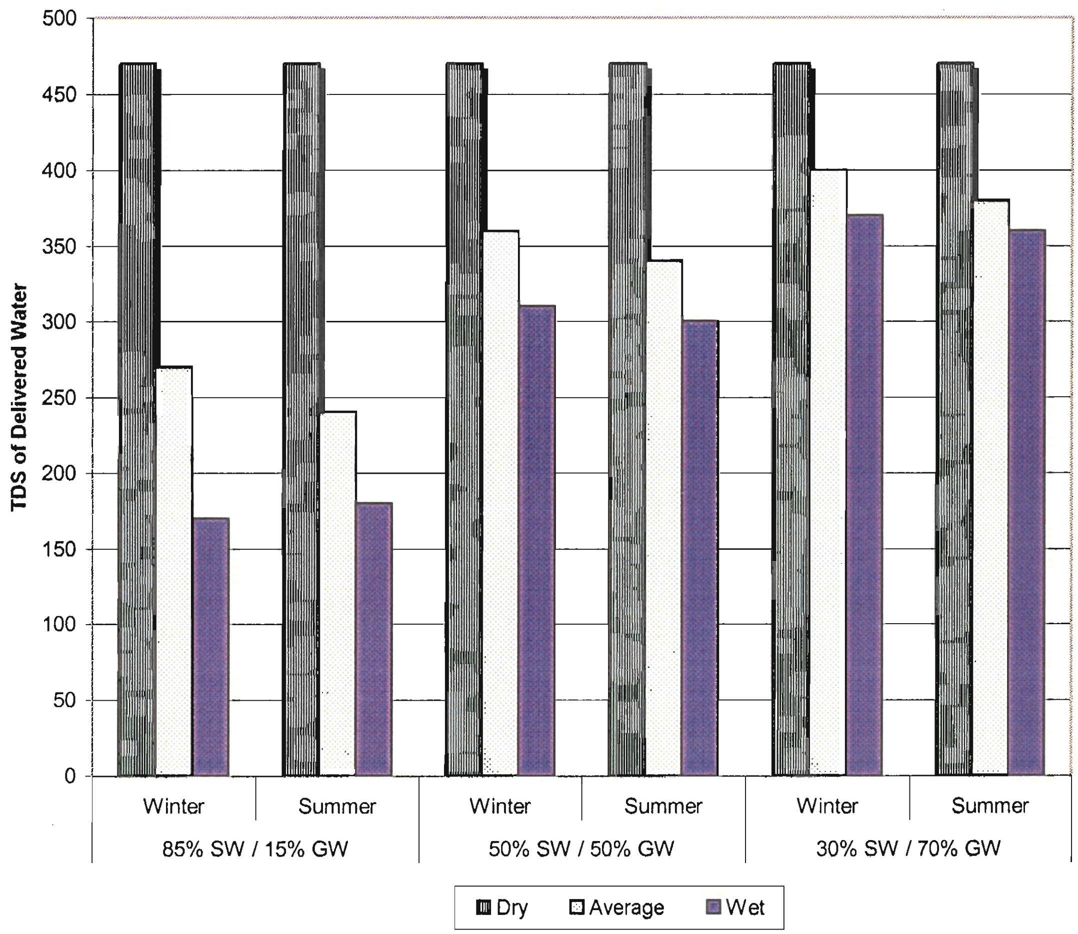
Figure 8.2 illustrates the previously presented advantages and disadvantages for these basin use strategies. The historic basin management strategy of maximizing surface water deliveries also minimizes the concentration of TDS in the delivered water. The differences between strategies are negligible 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



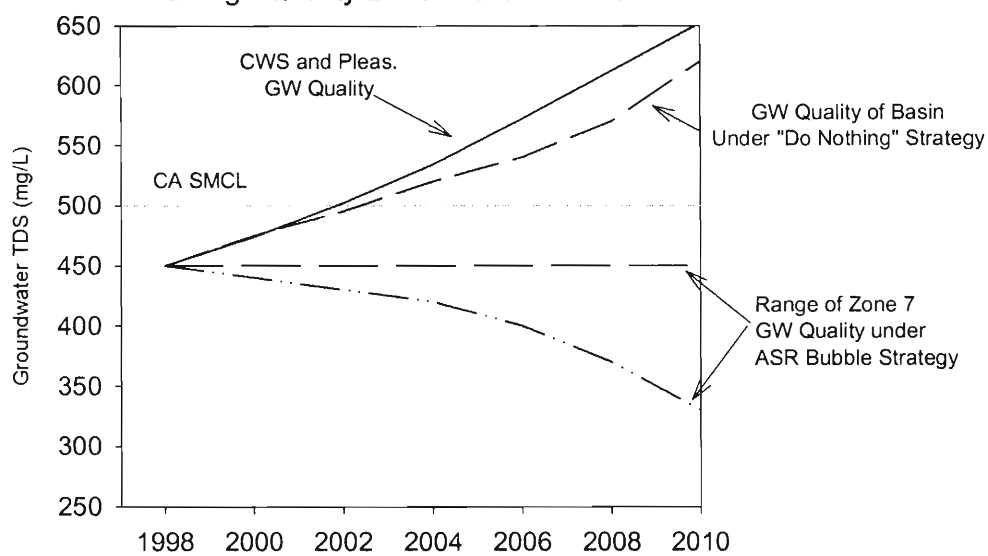
8.6 Zone 7 ASR Well Operation Strategy

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).

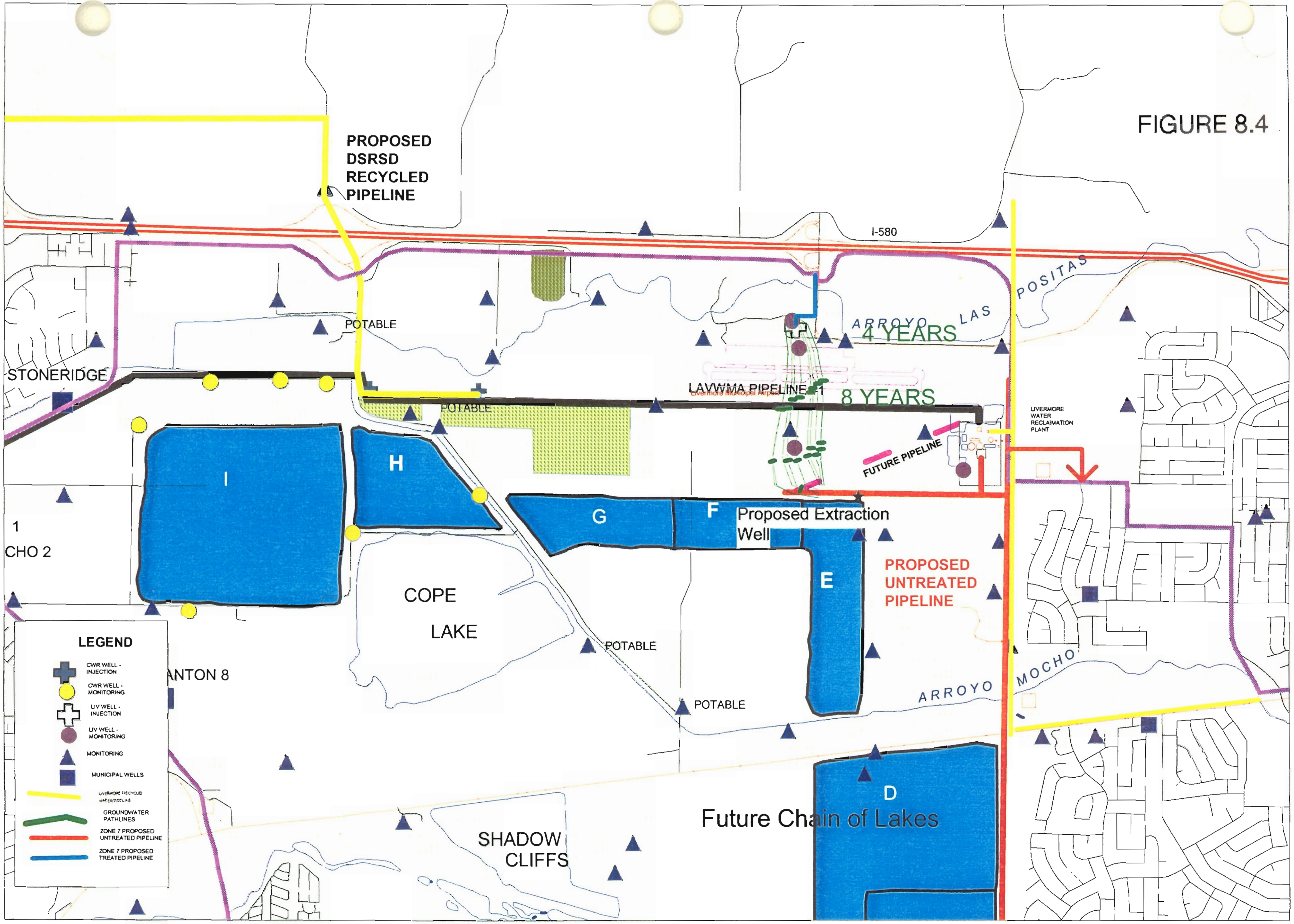
8.10 Seasonal Groundwater Export

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



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.

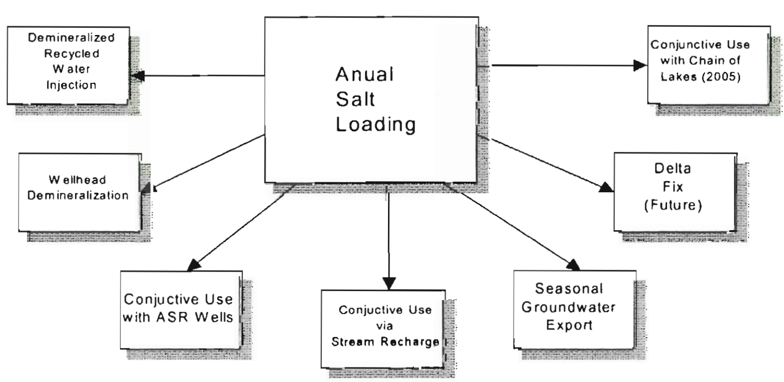
The fundamental disadvantages to the Delta Fix as a salt management strategy are that it is unknown what, if any, project will actually be implemented and when. The certainty and timing of the Delta Fix are such that it currently should not be relied on as the sole salt management tool to mitigate the 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

(**) $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.

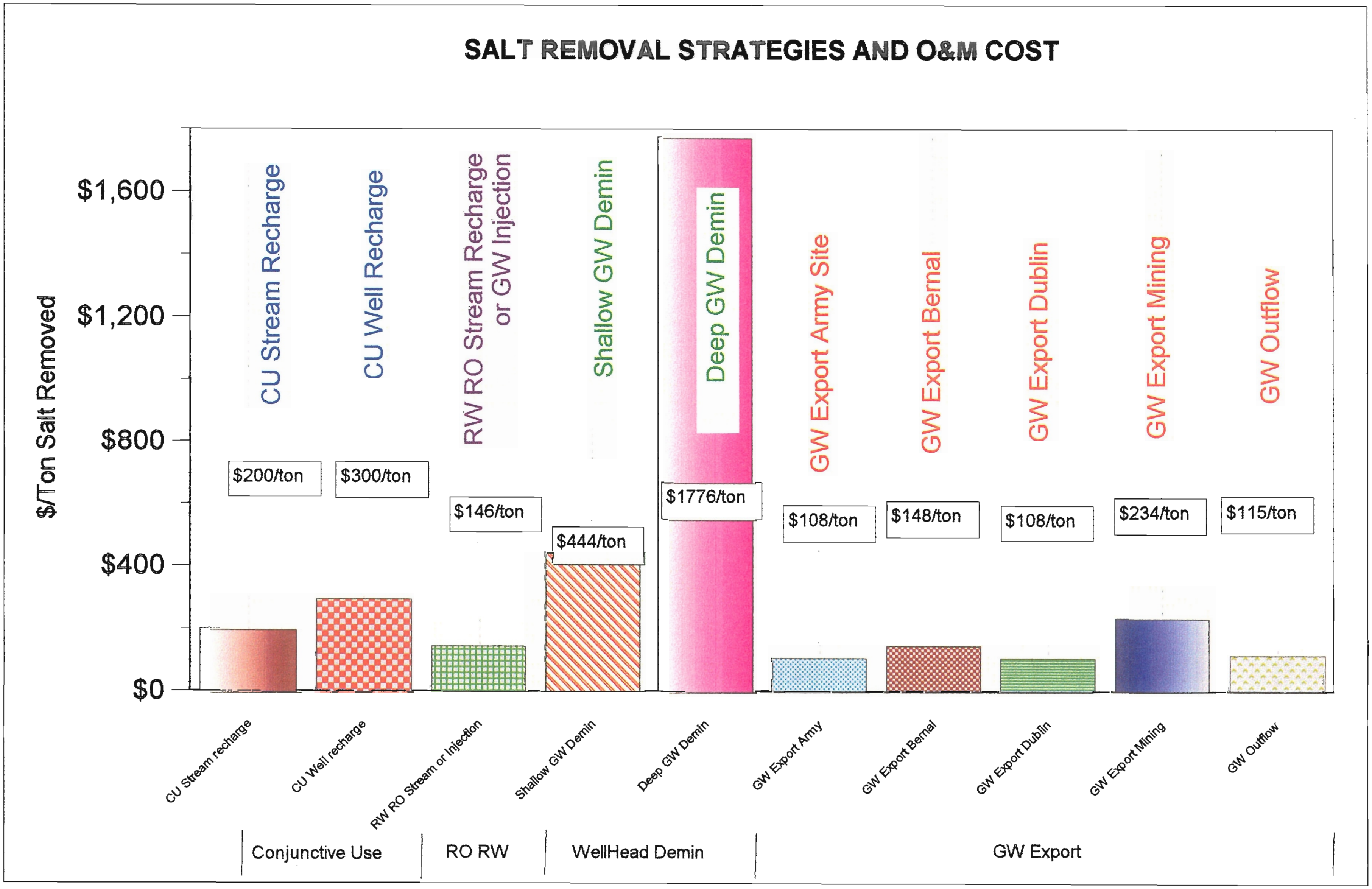
Net removal reflects replacement water TDS and pumpage/ salts reapplied over main basin.

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.