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About this draft: This is a working draft. It is incomplete. The chapter contains placeholders for some figures and tables. Much of the data is missing. Full discussion of some topics may be incomplete. This is the second of several drafts to be circulated in 2008 before the public review draft is distributed in December.

Subgroup: Improve Water Quality

Chapter [#] Salinity Management

“Salinity” describes a condition where dissolved minerals carrying an electrical charge (ions) are present. In water, salinity is usually measured as electrical conductivity (EC) or total dissolved solids (TDS); and the major ionic substances found in water are calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and nitrate. Salinity is present to some degree in all natural water supplies. Most salts provide some benefit to living organisms when present in low concentrations; however, salinity very quickly becomes a problem when consumptive use and evaporation concentrate salts to levels that adversely impact beneficial uses. Salts are everywhere; all Californians rely on salt in some form or other; and all Californians make choices that contribute to or compensate for salinity problems, whether they are aware of it or not.

Salinity Management in California

In California, as in other parts of the world, salinity problems tend to have both natural and human-made causes. Many of California’s most productive soils originated from materials that were once under the ocean. These soils are naturally high in salts. Oftentimes salts are added to soil or water intentionally as fertilizers or soil amendments, or to assist in some industrial, domestic, or other process. Examples of the latter include food processing and water softening. Salts may also enter a watershed through inadvertent means. These might be thought of as “unintentional salts,” where human action aimed at some other purpose has resulted in salts being added to the watershed. Seawater intrusion in coastal aquifers triggered by the removal of more fresh water than is being recharged is one example of this. Climate change and the predicted sea level rise associated with it will worsen this problem.

In California’s interior valleys, our extensively modified natural water systems and constructed conveyance channels supply large cities, small communities, farms and wetlands with water, but each water delivery carries a salt load. When water is consumed through use, the majority of its salt load remains behind. In the San Joaquin Valley, an area highly dependent on irrigation, not enough salt exits the basin through the area’s rivers and streams to offset the imported and recirculated salts. (Figure)

PLACEHOLDER Figure #1 (Salt load)

Salt is not always unwelcome. Coastal and estuarine environments require some measure of salinity to remain healthy. But even these systems can be adversely impacted when salt becomes too concentrated, nutrient salts become excessive, or, in the case of estuarine systems, when the mix of saline and fresh flows gets out of balance. The salt evaporation ponds in the southern portion of San Francisco Bay provide a noteworthy example of this. These ponds had a high environmental cost, destroying thousands of acres of marine habitat and reducing bird and fish populations in San Francisco Bay. Today they are slowly being restored to their natural condition, serving as a reminder that restoration is always more difficult than prevention.
Beneficial Uses

In California, waters of the State are designated as having one or more beneficial uses. State Water Resources Control Board Resolution No. 88-63 directs each Regional Water Board to designate surface water and groundwater in the region as potentially being suitable for drinking water unless certain existing conditions apply; and individual boards may use other region-wide use designations in their Water Quality Control Plans (Basin Plans). For example, in addition to the aforementioned drinking water designation, surface water and groundwater in the Central Valley Region is designated as also having agricultural and industrial use unless specified conditions similar to those constraining municipal use exist or the water has been evaluated and found to have specific beneficial uses. This is important because the three uses that are generally impacted by salinity first are agricultural production (AGR), drinking water (MUN), and industrial processing (IND-PRO) as shown in Table #1. Regulatory values are determined by taking into consideration established thresholds, background conditions, and existing and potential beneficial uses.

<table>
<thead>
<tr>
<th>Beneficial use</th>
<th>Salinity threshold (uS/cm)</th>
<th>What does the target protect?</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR Variable</td>
<td>The Food and Agriculture Organization of the United Nations (FAO) notes that an EC of 700 uS/cm protects the most salt-sensitive crops under normal irrigation operations. This target can be shifted somewhat by adjusting irrigation practices.</td>
<td></td>
</tr>
<tr>
<td>MUN 900 (long term)-2200 (short term)</td>
<td>This range of numbers, used by the Department of Public Health, is based on taste thresholds. Health-based standards exist for concentrations of specific ions such as nitrate or chloride.</td>
<td></td>
</tr>
<tr>
<td>IND-PRO Variable</td>
<td>The Region 5 Basin Plans do not cite a threshold value to protect industrial process use, but it is known that some industrial processes require low salinity water.</td>
<td></td>
</tr>
</tbody>
</table>

It is beyond the scope of this general salinity discussion to address the impacts of specific ions in great depth, but certain individual ions can limit attainment of beneficial use even when the general salinity level may not otherwise pose a problem. Other beneficial uses that can be impacted by salinity include but are not limited to groundwater recharge when the receiving aquifer cannot accept the saline water without violating California’s anti-degradation policy and recreation, fisheries, and habitat.

PLACEHOLDER: Box #1 Case Study 1: Santa Clara River Salinity Success Story

1 A water body is exempted from the designation if, for example, salinity is 5000 uS/cm or more and where “it is not reasonably expected by Regional Boards to supply a public water system.”


3 The Salton Sea Authority reports that salinity is a growing problem in this water body. If trends continue, beneficial uses including fish reproduction, commercial fishing, and recreation will be increasingly impacted. See www.saltonsea.ca.gov for more information.
Salt Dilution and Displacement

High salinity in surface water, soil, or groundwater impacts the organisms that rely on these media. Historically, dilution and displacement have been used to deal with problem salinity. Agricultural operations typically displace soil salts out of the root zone and relocate them in a lower part of the soil profile or in groundwater. The salt may then wick upwards again if evaporation exceeds recharge. Similarly, salt concentrations in surface water can be decreased by dilution with lower salinity water. However, the load of salt—the tons of salt carried in the water body—can actually increase as a result of dilution, since dilution water generally carries some load of salt. A high volume of low salinity water can therefore move significant amounts of salt to other areas, making it worthwhile to manage salinity in areas where salt problems do not yet exist.

Salt Treatment, Salt Storage

Other salinity management strategies have included treatment through membrane or distillation technologies. This is only a partial solution because treatment generates a highly saline solid or liquid waste product that must be managed appropriately. Salt collection and storage is another strategy that is often used in inland areas (see photo 1), however this may not be a sustainable solution if the collection area could release the salt to groundwater or if a severe storm event could potentially re-disburse the salt outside of the collection area. Evaporation basins raise other issues as well. The basin plan for the region where this photo was taken states: “evaporation basins cannot be considered permanent solutions due to wildlife impacts, and the cost of ultimate salt disposal and basin closure.” A collection and storage strategy is expensive, requiring a large amount of land and appropriate mitigation for the impacts to wildlife. Ideally, collected salt could be marketed as an industrial product. Some preliminary studies have been undertaken but marketing salt harvested as a byproduct of drainage management, for example, is not generally considered feasible at this time, since industrial salt users require a more reliable (not seasonally variable) and purer product than can be produced from most saline drainage collection facilities.

PLACEHOLDER: Photo caption: Salt collection and storage is a strategy that is often used in inland areas.

Adaptation

A very commonly employed but ultimately unsustainable management strategy is adaptation to increasingly saline conditions. This situation exists in the Tulare Lake Basin. The basin does not have a reliable natural outlet so in the absence of some mechanism to remove and dispose salts, salt imported into the basin in irrigation water, in soil amendments, for water softening and for other purposes stays in the basin. The Water Quality Control Plan for the Tulare Lake Basin recommends that a drain be constructed to remove the excess salts from the basin and start correcting the problem. This option is not being pursued at this time so the plan also includes a strategy of controlled degradation to extend the beneficial uses of the water in this basin and the environmental, economic and social infrastructure those uses support, for as long as possible.

The case studies provided illustrate types of approaches currently being used to address problem salinity in various parts of California. They range from a solution developed by local stakeholders to address a local salinity issue; salinity management spurred by regulatory action to address non-point source pollution in a small watershed; and collaborative efforts between regulators and stakeholders to develop and implement regional plans that encompass multiple salinity sources and an array of management options. CV-SALTS, showcased in Case Study 2, is a regional
collaborative salinity management effort that will have spillover benefits for areas within and outside of California that consume fruits, vegetables, wine, nuts, fiber, meat and dairy products grown in the Valley and Delta, enjoy fish, birds and other wildlife living in and migrating through the Valley and Delta, or relying on water pumped from the Delta for drinking, hydro-electric power, industrial processes or irrigation.

PLACEHOLDER: Box #-2 Case Study 2: We’re All in this Together: Regional Collaboration

Potential Benefits of Salinity Management

Sustainable salinity management in any hydrologic region in California protects a resource that may be serving multiple regions in the state. For example, salinity control in the Sacramento Basin may have a relatively small direct benefit in this watershed, which normally receives high rainfall and therefore usually has adequate dilution flows to maintain salinity at acceptable levels. But Sacramento River water is not only used in the Sacramento Basin. Reducing salt loads in the Sacramento River could provide a significant benefit to those receiving water through the California Aqueduct (much of Southern California) and Delta-Mendota Canal (much of the San Joaquin Valley). The San Joaquin River also contributes to out-of-basin flows, but its water is more saline than that of the Sacramento. While salinity management in both watersheds will be beneficial, salinity in the San Joaquin watershed will likely respond more dramatically to effective salinity management.

Salinity management does not simply reduce the salt loads leaving a region; it also reduces the need for dilution flows, allowing water to be made available for other uses. Salinity management is therefore a key component of securing, maintaining, expanding, and recovering usable water supplies.4

The local benefits of sustainable salinity management mirror the statewide benefits: securing and, in some cases, improving the reliability of the water supply and maintaining beneficial uses of water within the basin.

Potential Costs of Salinity Management

It is extremely difficult to estimate the cost of sustainable salinity management in California as an isolated strategy. Ideally, salinity control should be (and often is) incorporated into some broader effort to protect or expand water supplies, optimize water use, offset land subsidence, protect fisheries or store water for future use. But the economic impact of salinity can be measured. In a 1999 study, Metropolitan Water District estimated that reducing salinity levels by 100 mg/L TDS would result in $95 million (1999) dollars in savings to water users in the service area due to things like longer life for pipes, equipment, and appliances; decreased treatment and disposal costs; and less water needed for dilution purposes. The same study indicates that, not surprisingly, the economic impact of salinity increases as TDS levels increase over baseline.

4 Recovered water supplies would include recycled wastewater and brackish water desalination projects. Some water authorities in Southern California utilize both strategies.
Major Issues Facing Salinity Management

Although the local impacts of salinity have been severe in certain parts of California such as the Salinas Valley or Lower San Joaquin River Basin, salinity has not historically been a high profile issue in California. This water plan marks a paradigm shift in California’s thinking. We understand now that high quality water is a limited resource; that once salinity concentrations become excessive, there are very few feasible options for restoring the resource and those that are technically feasible are likely to be very expensive; that adaptation to increasing salinity is an interim measure at best; and that water quality protection is more cost effective and has a greater chance of success than water quality remediation. Some of the major challenges to salinity management are listed below.

Short-term Management, Long-term Needs

1. Trends in water management decisions in different water year types: In dry years the harm that can result from chronically insufficient or ineffective salinity management may become evident as impacts to surface streams and vegetation, but water may be in such short supply that there is no feasible means of dealing with the problem. In wet years, the need for salinity management may be “out-of-sight/out-of-mind”, since precipitation will at least partially mitigate problem salinity in streams and surface soils. Reactive salinity management cannot solve California’s growing salinity problem. A longer-range, more comprehensive, more preventive and more proactive approach is needed.

2. Water management decisions driven solely by water use efficiency policies: Consumptive use of water rarely results in the consumptive use of the water’s total salt load. As California uses water more efficiently, supplies will tend to become more saline unless practices and policies are intentionally implemented to maintain salinity at acceptable concentrations. Compromises between efficiency and quality will likely be needed to ensure a sustainable water supply for future generations.

3. A growing but too often ignored problem: Unlike the crisis scenarios California routinely prepares for, salinity problems do not trigger overnight evacuations or mobilize teams of emergency personnel, and they are rarely picked up by the media as newsworthy. There is no single solution that can be implemented once to make the problem go away. Salinity generally shows up in localized areas, it expands slowly and its effects are usually incremental rather than event-based. Salinity impacts can be measured as yearly reduction of crop revenues and farmable land, lost jobs, in higher utility rates, in reduction of community growth potential, loss of habitat, in premature corrosion of equipment, and in lost opportunities. It is all too easy in the short-term to adapt to an increasingly degraded saline environment, but this is not an economically, socially, or environmentally wise strategy for the State. The Central Coast water authorities fighting seawater intrusion, the estuarine and Delta fisheries managers, the farmers and wetland managers of the state’s interior valleys, and the communities relying on Colorado River water all bear witness that salinity cannot be ignored indefinitely.

Salt Disposal and Salt Relocation

Supporting beneficial uses when water is becoming increasingly saline often means that salt must be harvested from the water periodically and disposed. Treatment technologies like reverse osmosis or distillation generate a highly saline solid or liquid waste product. Some areas, such as the Santa Ana Basin, have conveyance channels that take brine from inland areas to the ocean,
where it mixes with the salt already there. A few facilities use deep-well injection to sequester saline wastewater, and some areas use lower-tech solutions such as evaporation basins to isolate and store collected salt. Other areas are investigating strategies such as Integrated Farm Drainage Management, which applies water to progressively more saline tolerant crops, ultimately disposing the remaining drainage in a solar evaporator (see Box #3 Case Study 3: Integrated On-farm Drainage Management—a Farm-level Solution to Problem Salinity). However, these options are not feasible for every saline discharge and may not be appropriate for many parts of the state.

**PLACEHOLDER: Box #3 Case Study 3: Integrated On-farm Drainage Management—a Farm-level Solution to Problem Salinity**

Salt problems are rarely attributable to a single cause, but rather reflect a suite of decisions, conditions, conflicting water needs, and shifting State and local priorities. Problem salinity in California, as in other parts of the country and other parts of the world, can often be traced back to decisions that seemed like a good idea at the time but that did not take into account the long-term impacts of salinity. Local salinity problems often are not solely due to local decisions or conditions. The most significant example of this is the operation of the State and federal water projects, which move water and the associated salt loads from one basin to another around the state (Figure #2).

**PLACEHOLDER Figure #2 (State and federal water projects)**

A few additional examples follow.

- Hetch Hetchy reservoir serves as a water supply for San Francisco, diverting a high quality water supply from its basin of origin. This constitutes a redirection of dilution flows that could otherwise assist in salinity management.
- Los Angeles Basin biosolids are exported and applied to land in Kern County. From a salinity standpoint salt is being redirected to a basin that is already under salt stress.
- In Southern California, only about half of the region’s salt comes from local sources. The rest is brought in with imported water. The Colorado River Aqueduct constitutes Metropolitan’s highest source of salinity, averaging about 700 mg/L TDS. This leads to scaling problems to indoor plumbing appliances and equipment at homes, business and industries, which can also contribute to a consumer choice to install water softening equipment, exacerbating the overall problem.

Salinity management cannot and should not be solely a local responsibility. These examples illustrate California’s need for long-term planning to deal with the ultimate disposal or long-term sequestration of salt. In some cases, salinity problems could have been avoided or mitigated if a longer or more comprehensive view of the project had been taken. In the case of the water projects, salinity was anticipated to be a potential problem but the planned mitigation strategy for the Central Valley Project (the San Luis Drain) was flawed. Today, after many lawsuits, the salinity problem in the project service area is again being discussed but in the interim, the problem continues to grow. This is one of the higher profile instances in the State where dealing with a salinity problem has been deferred or when local stakeholders have had to deal with a problem triggered by decisions and actions outside of their control, but it is by no means the only case. Salt disposal and re-location is therefore not simply a local engineering problem, but may also potentially pose economic, social justice or environmental problems for the State.
Urgent Needs (Loss or Impending Loss of Beneficial Use)

Each hydrologic region has its own priorities and limitations on the resources available to address those priorities. A few of the common, ongoing, and emerging threats are listed below.

- **Nitrates** – Dairy waste management, septic systems, and fertilizer use can all contribute to groundwater degradation by nitrate. Excessive nitrate in groundwater is a human health issue. Excessive nitrate in surface water can spur explosive, unwanted algal growth that not only impacts aquatic life but also interferes with recreational and commercial use of water bodies. (use photo?)

- **Seawater intrusion** – Coastal aquifers are at risk of seawater intrusion when more fresh water is withdrawn than can be recharged. Aquifers and surface water are vulnerable to sea level rise and seawater brought in by storm surges that may increase in intensity or frequency as a result of climate change. Seawater intrusion threatens drinking water and water used for irrigation.

- **Soil and groundwater salinization** – Salinization occurs when salts are allowed to accumulate over time in soil or groundwater. Soil salinization results in a loss of soil productivity due to a chronically unfavorable balance of salt and water in the soil profile. Groundwater salinization results in the loss of utility of an aquifer, meaning that the water no longer supports municipal or agricultural use. Both processes are virtually irreversible.5 Farming contributed $31.4 billion to California’s economy in 2006, but several of the most productive regions of the State (including the Imperial, Salinas and San Joaquin Valleys) are vulnerable to soil &/or groundwater salinization.

- **Reduced availability of freshwater flows** – Today, dilution is the primary means used to manage salinity in California. Dilution water in the right place may provide some side benefits (supporting aquatic life for example) but in general, water used for dilution is water that is unavailable for other purposes.

### Recommendations to Promote and Facilitate Salinity Management

1. Effective salinity management is not a stand-alone strategy, but should be paired with other strategies. Every water use, water reuse, and waste disposal decision should include consideration of how the decision will affect the local and regional salt balance.

2. Salt moves with water; therefore, effective salinity management must address the routes water takes within and between basins. Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) is an initiative aimed at developing and implementing sustainable regional salinity management plans for the Delta and Central Valley regions. Because water operations in the Delta and Central Valley and the beneficial uses the operations support are critical to the State, policy makers and stakeholders should support and participate in the CV-SALTS effort. (See case study 2 [Box #2])

3. Effective and sustainable salinity management decisions rest in the hands of a wide range of water managers, regulators, policy makers and other stakeholders in any given watershed. These entities should strive to coordinate their efforts where possible in order to utilize resources efficiently, develop regional solutions to regional problems, optimize funding opportunities and achieve a salt balance in the basin as quickly as possible.

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5 Some communities reclaim brackish water at great expense. Most California water users cannot afford to do this.
4 Over the next 10 years Federal, State and local entities with planning authority should review their planning documents (Integrated Regional Water Plans, Basin Plans, General Plans, etc) for consistency with sustainable salinity management, making revisions where necessary. Plans serving areas where salt accumulation in groundwater is currently unavoidable should address options for extending the life of the aquifer, including but not limited to source control strategies and construction of salt disposal or long-term storage facilities.

Working closely with CV-SALTS, DWR and USBR should develop Salinity Management Plans for their respective water projects that include:

- An implementation strategy for offsetting salt loads relocated to salt-stressed interior basins as a result of water project operations
- A funding strategy that supports the implementation strategy
- A stakeholder participation process to increase the likelihood of successful, collaborative salinity management within water project service areas and to ensure transparency in project planning and implementation.
- A monitoring program to track the success of the implementation strategy
- An adaptive management strategy that will ensure the plan can be modified to respond to climate change, drought, catastrophes and other changes appropriately

5 Over the next 5 years, entities with water policymaking authority should review existing policies, including those related to water use efficiency and funding of water projects, for consistency with sustainable salinity management. Revisions should be made where necessary.

6 Stakeholders in areas impacted by saline elements at levels that pose a threat to human health (for example, high nitrate) should without delay seek to identify sources, quantify the threat, prioritize necessary mitigation action and work collaboratively with entities with the authority to take appropriate action. Local solutions should be sought first, as these can be implemented more rapidly than those imposed by state or federal authorities.

7 Federal, state, tribal, local, non-government and private stakeholders should work collaboratively to fund, develop and operate a monitoring network or an array of compatible networks capable of identifying emerging salinity problems and tracking the success of ongoing salinity management efforts where such networks do not already exist. New or expanded networks should build off of and remain compatible with existing relevant statewide monitoring programs including the Surface Water Ambient Monitoring Program (SWAMP) and Groundwater Ambient Monitoring and Assessment (GAMA) program. Data

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6 REWRITE IF THINGS CHANGE – add link to MAA when/if signed
At this writing, the Bureau of Reclamation and the Central Valley Regional Water Quality Control Board are considering entering into a Management Agency Agreement to address salinity brought in to the Lower San Joaquin River as a result of Central Valley Project Operations. From 2008 -2010, the Bureau will implement an interim Action Plan to quantify offsets from current mitigation projects and take steps toward meeting salt load allocations that will become effective in 2014. Using the information gathered over this two-year period, the Bureau will develop a long term Action Plan.

While this is a good first step, more comprehensive salinity management planning will likely be necessary to achieve a salt balance in all federal water service areas. However, planning on that scale takes time. Efforts to estimate and earmark the funding that will be necessary to complete plans within 10 years and develop, construct and operate projects over the next 100 years should start immediately.
should be made accessible to the public through a web-based user interface such as the Integrated Water Resources Information System (IWRIS).

8 Salinity stakeholder groups (see case study 3 for examples) should conduct outreach aimed at educating specific target audiences with the ability to influence salinity decisions (legislature, interest groups, general public, etc) about the need for sustainable salinity management.

Selected References


California Department of Water Resources. July 2006. Progress on Incorporating Climate Change into Planning and Management of California’s Water Resources


Los Angeles Regional Water Quality Control Board. 2006, Upper Santa Clara River Chloride Reconsideration, Staff Report. May.


Figure #2 (State and federal water projects)
Box #1 Case study 1: Santa Clara River Salinity Success Story

The Los Angeles Regional Water Quality Control Board adopted a chloride Total Maximum Daily Load (TMDL) for the Upper Santa Clara River that became effective in 2005. Implementation of the TMDL included special studies to look at crop effects, endangered species protection, and groundwater impacts. Earlier TMDL studies had identified chloride sources in the region. Significant amounts of chloride are imported in State Water Project deliveries, but about one-third of the chloride entering the watershed could be attributed to self-regenerating water softeners. Although technically not nonpoint sources, water softener discharges end up aggregated in municipal wastewater collection systems so it makes sense to include these in the TMDL approach.

The State Water Project picks up water at the Sacramento-San Joaquin Delta and delivers it to Southern California. In drier years, seawater impinges on the Delta to a greater degree so chloride concentrations increase. The Los Angeles Region has no means of controlling chloride brought in with the water supply; however, the local authorities determined that it might be feasible to limit use of self-regenerating water softeners (SRWS) in the watershed. In 2003, a ban on SRWS installations was enacted. A buy-back program was initiated for existing SRWS, and by 2005 approximately 1,200 of these softeners had been inactivated or removed. Chloride loads in the Santa Clara River improved measurably. For more information on the softener buy-back program, go to www.lacsd.org/info/industrial_waste/chloride_in_santa_clarita.
Box #2 Case study 2: We’re All in this Together: Regional Collaboration

Once upon a time, the Santa Ana Basin was primarily an agricultural area and a large percentage of the state’s dairy farms were located here. A lot of dairies remain, but the former agriculturally based regional economy is now dominated by industry, urban development, and tourism (Disneyland is only one of the attractions the region is famous for). Groundwater salinity threatened this prosperity.

Regulatory limits were established that would protect the aquifer but which could have had the side effect of stopping growth and development in the area. Understanding the limits of the regulatory process, a group of stakeholders approached the Santa Ana Regional Water Quality Control Board with a plan to conduct the studies needed to determine what was going on in the watershed at a more detailed level and come up with an alternative strategy for dealing with salinity in the basin. They did so, the board agreed to work with the alternative, and the group began to construct facilities to deal with the problem. The local water authorities formed a Joint Powers Authority to coordinate salinity management efforts: Santa Ana Watershed Project Authority (SAWPA). The group has constructed a brine line to remove salt from the basin and member districts operate groundwater desalters (treatment and recharge facilities) to reclaim the degraded aquifer, and trunk lines connecting to the main brine line (the Santa Ana Regional Interceptor or SARI line). SARI line users pay a fee to remove salt from the basin based on the volume of wastewater they discharge to the line.

Salinity also threatens the long-term reliability of water supplies in the Central Valley Region. So, valley regulators and stakeholders have embarked a collaborative salinity management effort modeled on the SAWPA experience, only on a grander scale. The Central Valley Region is comprises three major basins and covers a 60,000 square mile area, extending from the Tehachapi Mountains in the south to the Oregon border in the north. CV-SALTS (Central Valley Salinity Alternatives for Long Term Sustainability) is an initiative to address salinity throughout the region and Delta in a comprehensive, consistent, and sustainable manner. Working in partnership with the State Water Resources Control Board, CV-SALTS will be the vehicle used to review and update the Water Quality Control Plans for the Sacramento and San Joaquin River Basins, the Tulare Lake Basin, and the Delta Plan in regards to salinity management. The effort encourages stakeholder-regulator collaboration so that management of saline discharges can be accomplished more economically, more effectively and more sustainably (success measured not only by permit compliance rates but also by quantifiable improvements in the watershed’s salt balance). Like the SAWPA effort, CV-SALTS will encourage and work with stakeholder-initiated actions that the Water Boards are unable to require but which will make it possible to achieve and maintain sustainable salinity management in the region.

Several working bodies are currently involved in the CV-SALTS initiative. The Water Boards provided the initial impetus for the effort and will continue to play key advisory roles. A Policy Group, made up of upper management from State, federal, and local governments; nongovernment, environmental, social justice, and industry organizations and top researchers in the field convenes biennially to review progress. Committees made up of policy group members, their designees, and interested parties serve as technical advisors, conduct outreach, review economic studies, and coordinate efforts. The Central Valley Salinity Coalition recently formed to secure and manage funding for key preliminary work. Groups seeking representation on one or more of the CV-SALTS committees or the Central Valley Salinity Coalition should contact (to be added later)
Box #3 Case Study 3: Integrated On-farm Drainage Management—A Farm-level Solution to Problem Salinity

Salinity problems tend to impact individual operations long before the effects are noticed in neighboring areas with more favorable hydrology and soil conditions. This was the case for Red Rock Ranch, where Integrated On-Farm Drainage Management (IFDM) was first pioneered. IFDM is a salinity management tool that is gaining in popularity as a means of maintaining farmability of salinity-impaired agricultural land.

IFDM is an integrated agricultural water management system that applies subsurface drainage water to a sequence of increasingly salt-tolerant crops. The number of steps comprising the reuse sequence is variable as are the crops to which the drainage water is applied at each stage of the sequence. The residual drainage effluent from the final stage in the sequence of the agricultural processes is disposed in a solar evaporator, an enhanced evaporation system that uses timed sprinklers or other equipment that allows the discharge rate to be set and adjusted as necessary to avoid standing water within the surface of the solar evaporator. When conditions are not favorable for evaporation, drainage water is stored, temporarily, in underground and/or covered reservoirs (figure ?). The operation and management of solar evaporators are regulated by Title 27 of the California Code of Regulations.

Existing IFDM systems have three or four stages designed to come to equilibrium at differing salinities for each of the crops begin grown so that the equilibrium salinity is appropriate to the salt tolerance of the particular crop (figure ?). The concentrated brine collected from the final stage is unsuitable for further treatment by agricultural processes and must be disposed in a solar evaporator. IFDM can be implemented at different scales. Different stages of the treatment process can be contained within a single farm, as is the case at Red Rock Ranch and Rainbow Ranch. Alternatively, different stages of treatment could be sited at different locations so that the overall IFDM system would assume a district or regional scale. At a regional scale, the 97,000 acres Grasslands Area Farmers, are planning under their Westside Regional Drainage Plan a version of an IFDM system using 6,000 acres for drainage reuse and a zero liquid discharge system to treat the effluent from the reuse area.

The IFDM system implemented at Red Rock Ranch, and at Rainbow Ranch first use irrigation water in a low-saline zone covering about 75 percent of the area growing vegetables and other salt-sensitive crops. Subsurface drainage water from this area is blended with tailwater (irrigation water in the case of Rainbow Ranch) and used to irrigate salt-tolerant commercial crops such as cotton, sugar beets and grasses on a “low-saline” zone occupying about 20 percent of the area. The drainage water from this zone is used on very salt-tolerant grasses or halophytes in the “moderate-saline” zone. This drainwater is used on halophytes in the “high-saline” zone (the Rainbow Ranch system only has the first three stages). The concentrated brine collected form the “high-saline” zone is disposed in a solar evaporator.

An advantage of IFDM is that it uses drainage water to produce marketable crops. For example, the cotton grown in the “low-saline” zone at Rainbow Ranch produces high yields. Research has determine the suitability of various salt-tolerant forages such as Bermuda and Jose Tall Wheat grasses that could be grown in the “moderate-saline” zone. These forages could be used to make up the existing shortfall of forages on the west side of San Joaquin Valley. Continuing research is examining the potential of halophytes, such as Atriplex, Prosopis Alba (a tree), Creeping Wildrye, and Salt Grass to concentrate brine in the “high-saline” zone and to produce marketable products such as biofuels and construction materials. Brine discharged as tile drainage from the “high-saline” zone is disposed safely on a solar evaporator resulting in crystallized salt.
Another option would be to collect the brine for further treatment and disposal by non-agricultural processes at regional centers. These centers could attract mining companies to separate and recycle marketable salts from the brine such as calcium sulfate (gypsum), sodium chloride, and sodium sulfate. Currently, high costs of transportation favors establishment of regional industries close to their markets.

References

Design of the Integrated on-Farm Drainage Management (IFDM) System
at Red Rock Ranch
Red Rock Ranch IFDM Project

<table>
<thead>
<tr>
<th>Total acres</th>
<th>640</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Sources:</td>
<td>California Aqueduct, Subsurface Saline Drainage Water, Recirculated Surface Runoff Water (Tailwater), and a water well on site.</td>
</tr>
<tr>
<td>Crop Mixes</td>
<td>Before IFDM</td>
</tr>
<tr>
<td>Wheat</td>
<td>Salt-sensitive crops</td>
</tr>
<tr>
<td>Alfalfa Seed</td>
<td>Broccoli</td>
</tr>
<tr>
<td>Safflower</td>
<td>Lettuce</td>
</tr>
<tr>
<td>Cotton</td>
<td>Tomatoes</td>
</tr>
<tr>
<td>Average yields</td>
<td>Before IFDM</td>
</tr>
<tr>
<td>Cotton</td>
<td>2 to 2.5 bales/ac</td>
</tr>
<tr>
<td>Land Value</td>
<td>Before IFDM</td>
</tr>
<tr>
<td>$1,500/ac (salinized soils)</td>
<td>$5,000/ac (2008 value)</td>
</tr>
<tr>
<td>Recycled Irrigation Salinity Range (TDS)</td>
<td>First reuse</td>
</tr>
<tr>
<td>3,000 mg/l</td>
<td>10,000 mg/l</td>
</tr>
<tr>
<td>Drainage Systems</td>
<td>Estimated Infrastructure Costs</td>
</tr>
<tr>
<td>Six fields with drainage collector placed 6 feet deep with 18 monitoring wells.</td>
<td>Drainage System $320,000</td>
</tr>
</tbody>
</table>