Section 11
Industrial Food Processing Study Area

11.1 Introduction and Overview

Industrial food processing is an important economic activity in California; in 2009, Central Valley food processors generated over $26 billion in revenue and provided almost 60,000 jobs (Northern California Center of Excellence (COE) 2010). In the Central Valley there are over 640 facilities in industries such as tomato processing, dairy processing, slaughter houses, wineries, grain milling, and confectionary manufacturing (Figure 11-1) (Central Valley Regional Water Quality Control Board (RWQCB) 2006).

Wastewater generated from these industries contains high levels of nutrients, organic matter and salts which must be treated prior to discharge. Food processors in the Central Valley discharge their wastes either directly to publicly owned treatment works (POTWs) or to land under various permit requirements.

Figure 11-1

Locations of Industrial Food Processing facilities in the Central Valley (HCC 2007)

Industrial food processing serves as a prototype SSALTS study area describing salinity issues facing large industry adjusting to increased regulatory focus due to observed salt impacts to groundwater. Past regulation of food processing discharges focused on preventing nuisance conditions (e.g., odor problems or vector promotion), while encouraging beneficial reuse through land application. However, more recent implementation of existing regulations has focused on minimizing the risk of salt impacts to groundwater. In response, food processing industry groups have developed new guidelines for process water management including the *Comprehensive Guide to Sustainable Management of Winery Water and Associated Energy* developed for the Wine Institute and American Vineyard Foundation (Kennedy/Jenks, 2008) and the *Manual of Good Practice for Land Application of Food Processing/Rinse Water* prepared for the California League of Food Processors (Brown and Caldwell & Kennedy/Jenks 2007). In addition, Stanislaus County received a waiver from the Central Valley RWQCB to implement a Food Processing By-Products Use Program (Resolution No. R5-2008-0182).

11.2 Problem Statement

According to the Central Valley RWQCB, the 643 food processors operating in the Central Valley dispose of their waste waters in the following manners: 119 discharge to POTWs, which are regulated by federal National Pollutant Discharge Elimination System (NPDES) permits or the Central Valley RWQCB issued Waste Discharge Requirements (WDRs) depending on whether or not they discharge effluent to waters of the United States; 212 discharge to land under individual WDRs; 62 are classified as small wineries or food processors and discharge to land under the coverage of a general waiver (Order No. R5-2009-0097); 250 discharge to land without having submitted a Report of Waste Discharge (RWD) for Regional Board review, as required by the California Water Code (CWC) (Central Valley RWQCB 2006).

In 2005 the Central Valley RWQCB released a staff report titled *Regulation of Food Processing Waste Discharges to Land* (Central Valley RWQCB 2005). In it, the Central Valley RWQCB expressed concerns that significant groundwater impacts had occurred due to land application of food processing wastewater, and that changes in regulatory strategy were needed to prevent future impacts. A review

Table 11-2. California State Standards for Salinity (Central Valley RWQCB 2005)

Standard	Recommended Numerical Limit	
	EC (µmhos/cm)	TDS (mg/L)
California Secondary MCL (Recommended Limit)	900	500
California Secondary MCL (Upper Limit)	1,600	1,000
Threshold for reduced yield for sensitive crops	700	450

of monitoring well data from 105 Central Valley food processing facilities found that 90% of these sites had suspected or confirmed groundwater impacts from waste discharges to land (Central Valley RWQCB 2006).

Table 11-1 provides the quality of winery wastewater, other food processing wastewater, and domestic wastewater. Though winery wastewater data is provided below, waste discharge reports suggest that effluent from other food processing industries, such as olive processing and tomato canning, can be equally high (Central Valley RWQCB 2006). The maximum TDS concentration in food processing waste can be more than double the maximum concentration in domestic wastewater (greater than 2,300 mg/L and 1,000 mg/L respectively).

Table 11-1. Comparison of Raw Wastewater Quality from Wineries and other Food Processors to Untreated Domestic Wastewater Quality

Constituent	Value		
	Wineries[1]	Other Food Processors[2]	Domestic[1]
TDS (mg/L)	80 – 7,000	400 – 2,300	250 – 1,000

[1]Source: Central Valley RWQCB 2006
[2]Source: Central Valley RWQCB 2009a

There are no region-wide numeric salinity limits for effluent applied to land. Instead, the Central Valley RWQCB relies on the Antidegradation Policy[1] to determine whether an antidegradation analysis of a particular discharger is necessary. The Antidegradation Policy states that high quality water must be maintained, unless a change in water quality is of maximum benefit to the people of the State and there is no negative effect to current or future beneficial use. Generally, further investigation is warranted if the effluent salinity is greater than receiving water salinity. Regulation is therefore specific to the effluent water quality, groundwater water quality, geology, and other attributes of each discharger and discharge location. Table 11-2 provides the secondary drinking water standards for salinity, as well as the existing salinity limits above which sensitive crops may experience a reduced yield. These numerical limits guide the Regional Board in their decision to investigate potential degradation; however, in a 2009 memorandum the Regional Board emphasized that permitting decisions are case-specific and will not rely on "rules of general applicability" (Central Valley RWQCB 2009b).

11.3 Study Area Attributes

11.3.1 Land Cover and Uses

The Central Valley can be broadly divided into the San Joaquin and Sacramento River Basins to the north and the Tulare Lake Basin to the south. Together, these regions encompass 40% of the land area in California. The San Joaquin and Sacramento River Basins are largely agricultural and encompass a third of the state's irrigable land. The Tulare Lake Basin also relies heavily on agriculture, though nearly one third of the land is federally owned. Major cities include Fresno, Sacramento, Bakersfield, Stockton, and Modesto (Central Valley RWQCB 2004 and 2011).

Industrial food processing occurs throughout the Central Valley, though it is concentrated on the west side of the valley. Stanislaus and Fresno counties each have over 150 food manufacturing establishments; Sacramento, San Joaquin, Merced, and Tulare counties each have over 75 food manufacturers, and the remainder of the counties in the Central Valley have fewer than 75 each (COE 2010).

11.3.2 Water Resources

The Sacramento and San Joaquin Rivers and their tributaries provide over 50 percent of California's surface water supply. There are 63 and 39 groundwater basins underlying the Sacramento and San Joaquin watersheds, respectively (Central Valley RWQCB 2011).

The Tulare Lake Basin is essentially a closed system, only draining to the San Joaquin Basin in very wet years. Major rivers include the Kings, Kaweah, Tule, and Kern; however, native surface water supplies cannot support the levels of agricultural and industrial activity, and the Basin relies heavily on imported water and groundwater (Central Valley RWQCB, 2004).

[1] The State Antidegradation Policy (Resolution No. 68-16) requires that high quality water be maintained unless the following conditions are met:

A. A change in water quality is consistent with maximum benefit to the people of the State
B. There will be no unreasonable effect to present or future beneficial use
C. Water quality will not be lower than prescribed standards

Any activity that produces waste discharging to high quality waters must meet waste discharge requirements resulting in best practicable treatment or control to ensure no pollution or nuisance will occur and the maximum benefit to the people is maintained.

11.3.3 Precipitation

The northern Central Valley receives more precipitation than the semi-arid south. Average annual precipitation ranges from less than 5 inches in portions of Kern County to more than 20 inches in the northern Sacramento River watershed. Mountainous regions draining to the Sacramento River average greater than 70 inches of precipitation (Oregon Climate Service [OCS] 1995).

11.3.4 Regulatory

Food processing wastewater discharged to POTWs is regulated under the POTW federal NPDES permit, if discharging effluent to waters of the United States, or the Regional Board issued WDR if discharging to other waters or to land. Discharge to land is not generally regulated via federal permits. If a wastewater discharge to land is found to unreasonably degrade or pollute groundwater, it is regulated by the California Environmental Protection Agency (CalEPA) under Title 27 of the California Code of Regulations, which specifies stringent requirements for containment and disposal of wastes. Otherwise, dischargers must submit a RWD to the Regional Board and may be issued a WDR or a waiver.

11.4 Sources of Salt for Industrial Food Processing

A 2005 survey by Hilmar Cheese Company (HCC) found that Central Valley food processors annually discharged approximately 60,000 metric tons of Fixed Dissolved Solids (FDS) with their wastewater (HCC 2007). FDS rather than Total Dissolved Solids (TDS) is reported because it better represents the inorganic fraction of salts that would not be degraded through soil attenuation before reaching the groundwater. Table 11-3 shows the FDS load contribution from each industry in the food processing sector during 2003, 2004, and 2005. The biggest discharger of salt by weight is the fruit and vegetable canning industry (approximately 30,000 metric tons FDS annually).

Table 11-3. Food Processing FDS Loads for the Central Valley (HCC 2007)

Industry[1]	FDS Loads (metric ton)[2]		
	2003	2004	2005
Animal slaughtering & processing	560	570	540
Beet sugar manufacturing	0	0	0
Dairy product manufacturing	3,230	5,110	4,540
Dried & dehydrated food manufacturing	190	160	130
Fat and oils refining and blending	112	92	57
Frozen food manufacturing	1,510	1,630	1,820
Fruit and vegetable canning	30,900	28,400	28,200
Fruit and vegetable canning, pickling, and drying	11,100	10,100	9,900
Rendering and meat byproduct processing	0	0	0
Roasted nuts and peanut butter manufacturing	820	4,390	6,300
Waste and miscellaneous	3,440	3,820	4,050
Wineries	4,950	3,990	4,080
Total	**56,700**	**58,300**	**59,700**

FDS = Fixed Dissolved Solids

Notes:

[1] Data derived from surveys of 160 Central Valley food-processing facilities.
[2] Calculations of FDS loads utilized gap filling to estimate loads when processors reported an effluent volume but not an FDS value. Gap filling utilized a volume-weighted average salinity concentration for those months when salinity data was provided.

As seen in Figure 11-2, fruit and vegetable canning contributed between 54 and 47 percent of the annual FDS load. Other industries with large contributions include fruit and vegetable canning, pickling, and drying, roasted nuts and peanut butter manufacturing, dairy product manufacturing, and wineries. Other industries, Waste & Miscellaneous combined, contribute less than 10 percent of the FDS load.

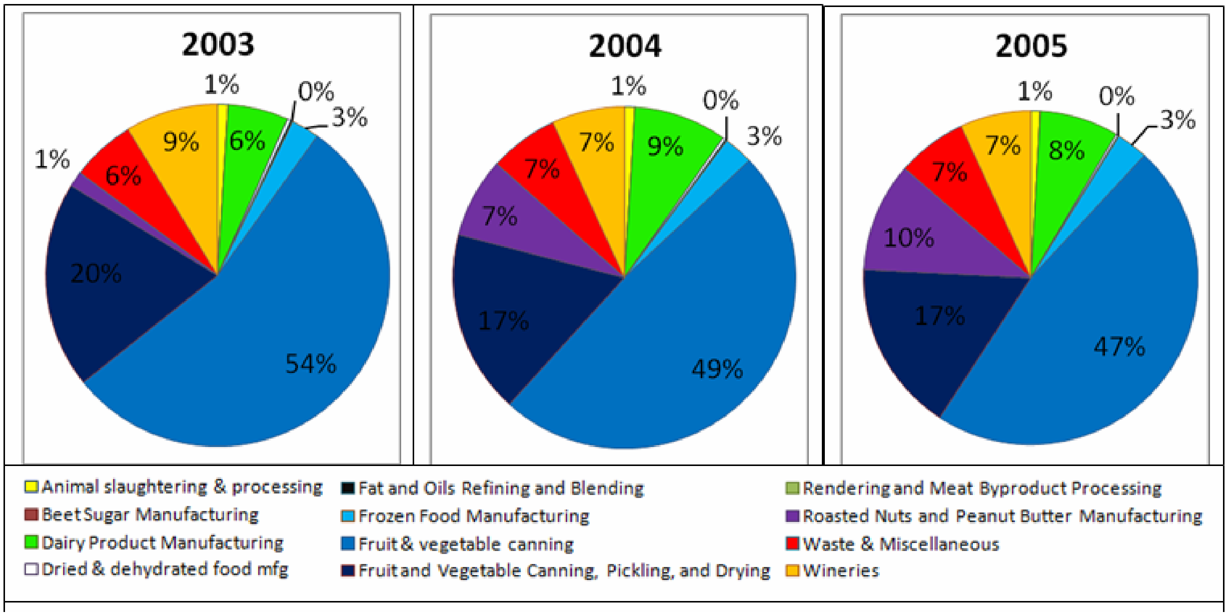

Figure 11-2

Percent of total FDS loads (metric tons) for the Central Valley by industry (HCC 2007)

The following are some general sources of salt in food process wastewater:

- Supply Water—Supply water can contribute a large salt load, particularly in areas with high-salinity groundwater or reliance on imported water. In the Tulare River Basin, nearly half of the basin's salt load comes from imported water (Central Valley RWQCB 2004). In a study of 10 Central Valley food processors located from Ripon south to Lemoore, supply water EC was found to range from 340 to 1,750 µS/cm (HCC 2007).

- Boiler Feed Water Treatment—To prevent calcification, boiler feed water is generally softened using ion exchange. This process removes calcium and magnesium ions from the feed water, exchanging them for sodium ions. The salts within the boiler concentrate as water evaporates, and this concentrate is regularly discharged as boiler blow-down.

- Food Product Loss—Product losses in food processing facilities contribute to the salt content of the waste stream according to the ash content of the food product. Typical TSS loads range from 128 lb TSS/ton for white potatoes to 2.0 lb TSS/ton for cherries (Brown and Caldwell & Kennedy/Jenks 2007).

- Cleaning and Process Chemicals—Salt-containing chemicals can be added to foods during processing for both flavor and preservation. Sodium hydroxides are commonly used for fruit and vegetable peeling prior to canning, and can also be utilized as cleaning agents.

Salt sources for specific industry segments are listed below.

11.4.1 Winery Salt Sources

Major process sources of salt in wineries are ion exchange regeneration and cleaning. Stabilization of wines following clarification can be accomplished through an ion exchange process. After use, the ion exchange resin is regenerated, often using sulfuric acid. Sulfuric acid and chemicals utilized to neutralize the sulfuric acid can be major sources of salt. Potassium hydroxide and sodium hypochlorite are chemicals commonly used to clean and sanitize winery equipment. Both can contribute to salt load. However, in an analysis of FDS load from four wineries, cleaning chemicals were found to only contribute between 2 and 5 percent of the FDS load (Table 11-4). The largest contributor to salt load was supply water (HCC 2007).

Salt loading is somewhat seasonal, with peak loads typically corresponding to the fall grape harvest. Figure 11-3 shows the monthly FDS loads from five Central Valley wineries. Peak monthly loading approaches 400 metric tons for a single winery. In a study of three Central Valley wineries, EC in wastewater ranged from 0 to 38,400 μs/cm (HCC 2007).

Table 11-4. Sources of FDS in winery waste (HCC 2007)

Source of FDS	Percent Contribution (%)			
	Winery 1	Winery 2	Winery 3	Winery 4
Supply	51	66	35	61
Product loss	15	11	10	22
Cleaning Chemicals	4	2	4	5
Unknown	31	20	51	11

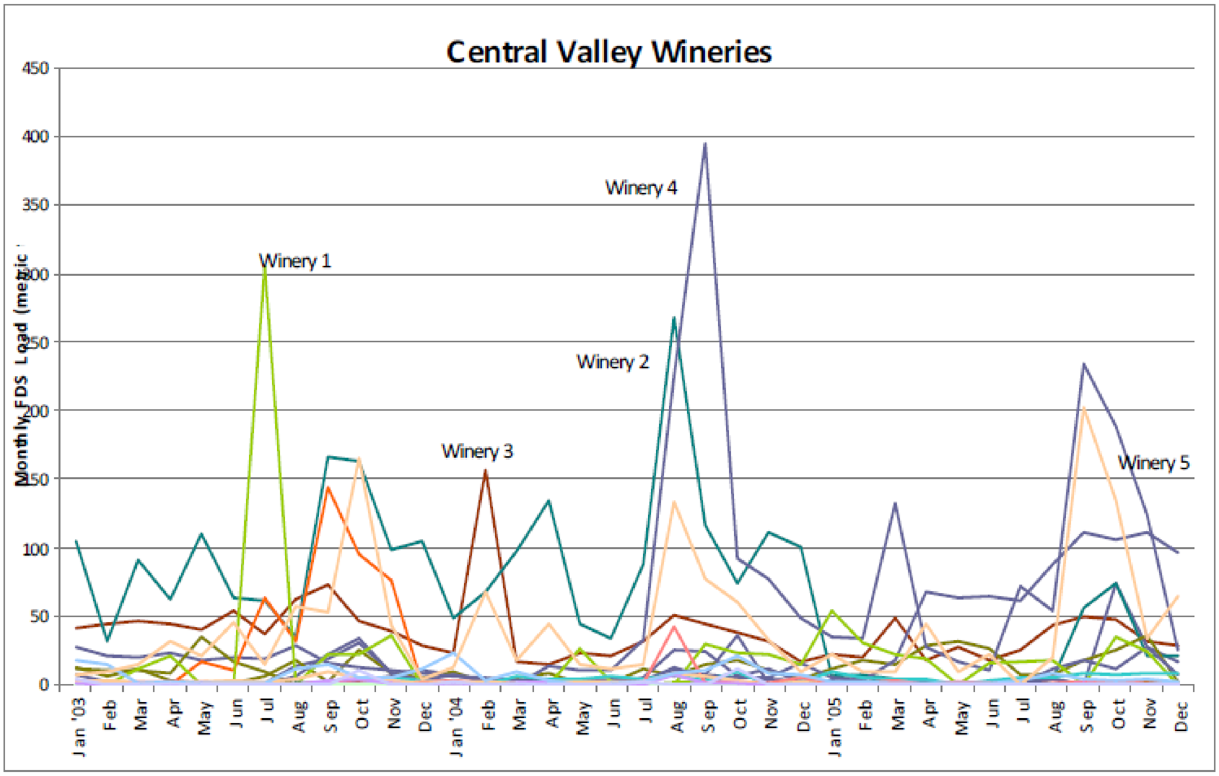

Figure 11-3

Monthly FDS loading (metric tons) for five Central Valley wineries (HCC 2007)

11.4.2 Tomato Processing Sources

Major sources of salt in tomato processing include source supply water, product loss, softener regeneration and boiler blowdown, cleaning chemicals, and process chemicals. An analysis of FDS load from a selected tomato processing plant is provided in Table 11-5. Supply water contributes the highest percentage of the FDS load (55 percent), and the largest process consumer of supply water is the flume used to transport tomatoes from the truck to the processing facility. Product loss is the second greatest source of FDS; the two main avenues for product loss are spillage from the flume and loss during peeling (HCC 2007).

Table 11-5. Sources of FDS in tomato processing waste (HCC 2007)

Source of FDS	Percent Contribution (%)
Supply	55
Product Loss	27
Softener Regeneration	9
Boiler Blowdown	3
Cleaning Chemicals	4
Process Chemicals	1

Tomato processing operates seasonally in conjunction with the tomato harvest during the months of July to August. As seen in figure 11-4, salt load is also highly seasonal. The majority of the load occurs as fresh tomatoes are processed during the harvesting season into canned products and tomato paste; paste can be stored and manufactured into other products in the off-season. In a study of three

Central Valley tomato processing plants, EC in wastewater ranged from 0 to 15,200 µs/cm (HCC 2007).

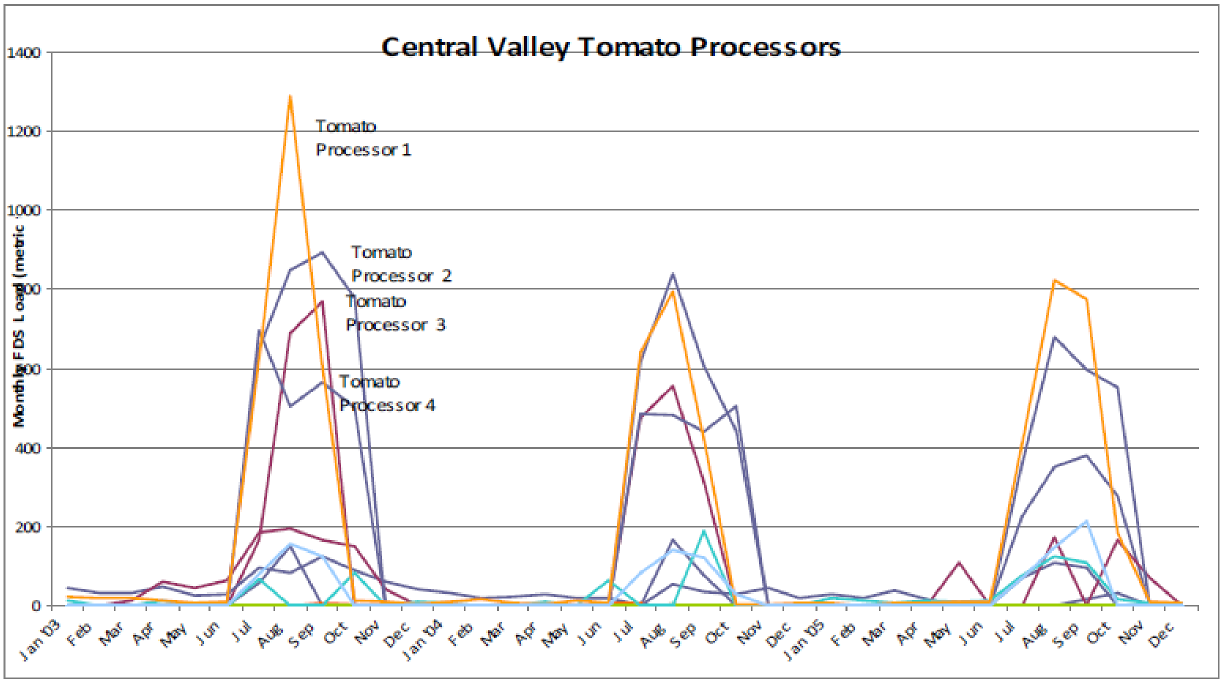

Figure 11-4

Monthly FDS loading (metric tons) for four Central Valley tomato processors (HCC 2007)

11.5 Reducing the Salinity in Food Processing Wastewater

The following are some general strategies for reducing salinity in food processing wastewater. The strategies used by a given food processor would be context-specific, and would necessitate a study of existing conditions at each specific processing and disposal site.

11.5.1 General Salt Reduction Strategies

- Supply Water Treatment—Supply water treatment occurs before food processing activities take place. The three main technologies available for salinity removal are Low Pressure Reverse Osmosis (LPRO), High Efficiency Reverse Osmosis (HERO), and electrodialysis. LPRO alone has limited applicability when supply water has high levels of hardness. Utilizing LPRO followed by HERO, with an intermediate water softening step, can result in a highly concentrated waste stream and low salinity product water. The waste stream then must be disposed of through alternate means. Options for waste stream disposal typically include evaporation ponds, seeded evaporation, crystallization, spray drying, and POTW disposal. Seeded evaporation involves introducing a crystalline "seed" to encourage formation of salt precipitate. This technique reduces fouling of heat exchanger equipment, as precipitation is more likely to occur on existing crystals than on new surfaces. Crystallization is the circulation of the waste stream through a heat exchanger and mechanical crystallizer; making multiple passes through the crystallizer increases the salt content of the effluent, as additional water evaporates in each pass. Spray drying involves spraying brine with an atomizer into a gas-fired drying chamber; dry salts can then be separated from vapor in a bag filter (HCC, 2007).

- Boiler Feed Water Treatment—Treatment of boiler water with a reverse osmosis system can reduce salts and boiler blow-down water volume.

- Product Loss Reduction—Product loss reduction strategies vary by industry. However, good housekeeping practices can yield some reduction in losses. For example, dry sweeping solids prior to hosing down work areas can save water and prevent salt additions.

- Cleaning and Process Chemical Treatment and Reduction—Utilizing potassium hydroxide rather than sodium hydroxide to clean processing equipment can result in a reduction of FDS. Although potassium hydroxide does contribute potassium salts, these salts are more likely to be utilized as nutrients when applied to soil than are sodium salts, which are more likely to reach groundwater. If salinity-adding chemicals are needed in the food processing train, spent chemical evaporation can be utilized to reduce the volume of chemicals for disposal.

- Effluent Treatment—When supply water and process strategies cannot meet discharge requirements, end-of-pipe or effluent treatment strategies can be utilized. Techniques for end-of-pipe treatment generally include a mix of biological treatment, chemical clarification, and reverse osmosis.

11.5.2 Winery Salt Reduction Strategies

Wineries can utilize alternate methods of stabilization in order to reduce reliance on ion exchange systems. Some alternative stabilization methods include cold storage or electrodialysis followed by reverse osmosis. Fetzer Vineyards in Mendocino County has been successfully utilizing electrodialysis to stabilize a portion of their wines since 2007 (Kennedy/Jenks, 2008). Wineries can also reduce salinity by using ozone for equipment sanitization, rather than sodium hypochlorite. J Vineyards and Winery in Sonoma County switched to ozone disinfection of equipment in order to prevent the alteration to flavor that chlorine can bring about; however this action also has the side effect of reducing salinity (Kennedy/Jenks, 2008).

11.5.3 Tomato Canning Salt Reduction Strategies

Two salt-reduction strategies specific to tomato canning facilities are product loss reduction and chemical substitution. To combat salinity addition through product loss, tomato processors can run process water through an evaporator. This results in the creation of tomato paste, which can have added product value, as well as a reduction in salinity. Salinity can also be reduced by changing out lye peelers in favor or steam peelers. In an analysis of seven Central Valley tomato processors, those using steam peeling had a lower added FDS concentration in their waste stream (range 140 to 600 mg/L added FDS) compared to those using lye peeling (range 950 to 1700 mg/L added FDS) (HCC, 2007). Steam peelers may result in additional product loss; however, if an evaporator is already in place, then product can be salvaged before wastewater is discharged.

11.5.4 Regulatory Salt Reduction Strategies

Stanislaus County has taken the lead in reducing salinity from food processors in a top-down strategy by receiving a conditional waiver from the Regional Board for application of residual wastes to land as soil amendments. The purpose of the program is to divert wastes from landfills, but it also results in more direct oversight and monitoring from the county government, conserving Regional Board staff resources. Residual wastes that are applicable for this program include bone meal from meat processing facilities and dried stillage leathers from wineries (R5-2008-0182).

11.6 Cost/Benefit Analysis

In a modeling analysis of the Lower San Joaquin River Basin, HCC found that the annual losses resulting from land application of food processing wastes are estimated at $400,000 through 2025. This value is based on the additional cost to agricultural and urban water consumers for blending high quality surface water with impacted groundwater. If consumers are assumed to rely wholly on groundwater, the losses associated with land application approach $1.5 million (HCC, 2007). The costs of various treatment approaches are listed in Table 11-6. The value of salt reduction in decreased impacts to groundwater would need to be balanced against the reductions in profit that would be experienced by the food processors immediately upon implementation.

Table 11-6 Unit cost of various treatment options (HCC 2007)

Technology	Unit Cost ($/kgal)
Supply Water Treatment	1.40 – 145.30
Boiler Feed Water Treatment	4.19
Product Loss Reduction	Varies by industry
Spent Chemical Evaporation	24.80
End of Pipe Treatment	9.87

11.7 Salt Capacity

Salt capacity is intended to be an estimate of the limiting capacity of each salt study accumulation area to assess the likelihood of achieving sustainable conditions within the Central Valley. Source control is the primary strategy for reducing salinity in food processing discharges. As such, the capacity is dependent on the site-specific technologies utilized and soil conditions at each disposal site.

As a theoretical solution, sustainable salt management could involve zero additional FDS discharges compared to background groundwater levels. Information in each discharger's RWD can be utilized to determine the source water quality and discharge water quality for food processors throughout the Central Valley; however, additional research would be needed to compile this data into a salt balance. Assuming a 50% reduction of current salinity loading through source controls, FDS loading to the Central Valley could be reduced by approximately 30,000 metric tons annually.

11.8 Institutional and Regulatory Barriers

11.8.1 Regulatory Barriers

The Porter-Cologne Act allows the Regional Board to regulate discharges to land through issuance of either WDRs or conditional waivers of WDRs. CWC Section 13269, amended in 1999, caused all Regional Board waivers to expire on January 1, 2003; entities wishing to renew their waivers had to submit to a case-by-case evaluation process by the Board and, if granted a waiver, were required to demonstrate compliance with the State's Antidegradation Policy through continued monitoring and reporting. At the same time, the Regional Board instituted a Consistency Policy which called for an appraisal of the WDR program to check for consistency with the State's Title 27 regulations governing disposal of solid waste to land (27 CCR § 20005, *et seq*.).

Current regulation of food processors discharging to land is based on interim standards as more permanent policy setting takes place (HCC, 2007). The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program will lead to future action, but until such policies are in place dischargers may be reluctant to institute potentially costly salt reduction methods.

11.8.2 Institutional Barriers

The technologies utilized by each food processor would depend upon site-specific conditions and goals. Because there is no basin-wide salinity standard for discharge to land, the relative impact of discharge concentrations on groundwater quality would also need to be considered.

11.9 Screening Level Analysis of Long-Term Sustainability

This section will be drafted as part of Task 1.4 and will be included in the Task 1.4 TM and Task 1.5 Phase 1 Report.

11.10 References

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