Kennedy/Jenks Consultants

303 Second Street, Suite 300 South
San Francisco, California 94107
415-243-2150
FAX: 415-896-0999

Energy Use in Wastewater Treatment in the Food and Beverage Industry

15 October 2010

Prepared for

Pacific Gas & Electric Company
245 Market Street
San Francisco, CA 94105

K/J Project No. 0865010*00

Table of Contents

Table of Contents (cont'd)

Table of Contents (cont'd)

Table of Contents (cont'd)

List of Tables

List of Figures

List of Appendices

Executive Summary

This study was prepared by Kennedy/Jenks Consultants (Kennedy/Jenks) at the request of Pacific Gas and Electric Company (PG&E) to gain insight on potential energy efficiency opportunities associated with wastewater management practices in the food and beverage industry in PG&E's service area. The study was designed to identify standard practices that are widely used for wastewater treatment in the various sectors of food and beverage processing, opportunities to improve the energy efficiency of treatment, and areas where development of energy-use benchmarks could be feasible and desirable. These findings are expected to be used by PG&E to provide recommendations to customers and/or potentially incentivize best practices, and may also be useful to processors seeking guidance on best practices.

The study targeted seven sectors of the food and beverage industry that typically have high rates of wastewater generation and energy usage.

- Vegetable, fruit and nut processors
- Poultry processors
- Wineries
- Dairy processors
- Dairy farm (raw milk) operations
- Meat processors
- Beverage manufacturers

Within these sectors, the study focused on evaluation of specific technologies used to reduce concentrations of biochemical oxygen demand, nitrogen, and/or suspended solids in the effluent. These included:

- Solids separation
- Aerated pond treatment
- Anaerobic treatment, including high-rate and low-rate options
- Activated sludge
- Membrane bioreactor

For each technology, standard applications and potential opportunities for improving energy efficiency were investigated based on customers' experiences and related research. The influence of applicable regulatory requirements and trends on selection of treatment technologies was also considered.

An online survey and telephone interviews were used to collect information from processors in each of the targeted sectors in order to gage the current state of treatment technology implementation. The survey questions covered a range of topics on processing type, water usage, wastewater management practices, treatment technologies, regulatory agency permits, and associated energy use. Although the number of responses that could be gathered from each of the targeted sectors was insufficient to allow statistical evaluation by sector, based on the aggregate of the results, as supported by literature review and Kennedy/Jenks' related experience, a number of specific conclusions were substantiated in this report.

Most facilities already employ some best practices for energy efficient wastewater treatment using the subject technologies, but additional measures could be implemented. The highest-impact opportunities identified to improve energy efficiency in wastewater treatment are in the following areas:

- Upgrades for DAFs, which are widely used by food processors for solids separation;
- Optimal management of aerobic ponds using DO sensors and timers;
- Anaerobic treatment for high-strength waste to avoid aeration energy demand and generate biogas;
- Energy-efficient pumps and motors, including VFDs; and
- Sector-specific opportunities, where energy use and the volume of wastewater generated are highest:
    - Dairy processing facilities in general, where both energy use and the volume of wastewater generated are among the highest in the food processing industry;
    - Fruit, vegetable, and nut processing facilities, where energy use is relatively high, but specific areas for improvement may warrant further investigation; and
    - Wineries, which constitute the sector with the largest number of facilities and the second highest energy use within the PG&E territory and offer opportunities with respect to improving aerobic pond treatment.

Study results suggest that poultry and meat processing sectors may be lower priorities for efforts to achieve energy efficiency improvements due to relatively smaller numbers of facilities within the PG&E service area. Although dairy farms may have some potential for energy efficiency improvement, they also have significant potential with respect to wastewater digestion for energy generation, offsetting energy use for treatment.

Development of benchmarks is potentially feasible and desirable for dairy processing and wineries. Benchmarks may also be appropriate for portions of the fruit and vegetable sector, but this would be complicated by the diversity of processing operations and commodities. Both the wine industry and beverage industry have associations that are actively working on metrics and benchmarks related to water use and wastewater generation; these groups may welcome collaboration with PG&E.

The highest priority for future research is to obtain direct measurements of energy use for key wastewater treatment technologies. This data would provide a baseline for measurement of potential energy savings from specific treatment system improvements. For the fruit, vegetable and nut sector in particular, it would be valuable to assess the energy associated with wastewater treatment for processing different commodities and potentially different processing methods in order to prioritize future studies. Specific recommendations are as follows:

- Implement pilot program for monitoring energy use of top treatment technologies in highest priority sectors:
    - Fruit and vegetable – solids separation, aerobic technologies
    - Wineries – aerobic technologies, anaerobic treatment
    - Dairy processors – aerobic technologies, anaerobic treatment
- Use results to provide facility-specific baselines for measurement of future improvements;
- Investigate the energy savings potential of specific treatment improvements, relative to baseline;
- Evaluate emerging or innovative treatment technologies for application in sectors with high treatment energy cost; and
- Develop outreach and incentive programs to promote efficient technologies and improvement options.

(This Page Intentionally Blank)

Section 1: Introduction

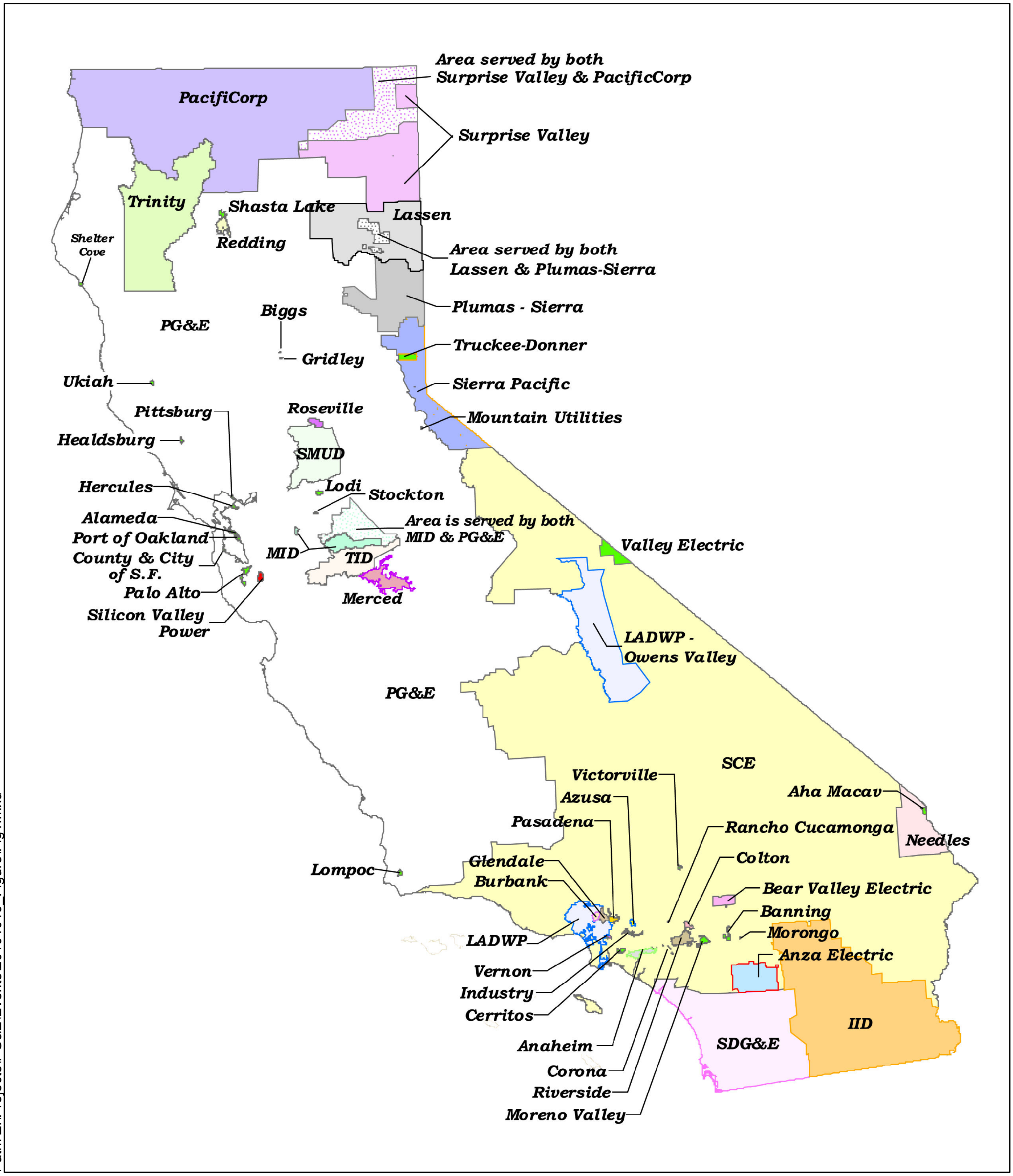
According to the California Public Utility Commission (CPUC), the food processing industry (exclusive of dairy farms) is the largest industrial user of electric power in the state, and the second largest peak user (CPUC, 2008). In general, food processing requires large volumes of water, and treatment of the resulting wastewater can be an energy intensive process. This study was prepared by Kennedy/Jenks Consultants (Kennedy/Jenks) at the request of Pacific Gas and Electric Company (PG&E) to gain insight on potential energy efficiency opportunities associated with wastewater management practices in the food and beverage industry in PG&E's service area (Figure 1).

The study was designed to identify standard practices that are widely used for wastewater treatment in the various sectors of food and beverage processing, high-impact opportunities to improve the energy efficiency of treatment, and areas where development of energy-use benchmarks could be feasible and desirable. These findings are expected to be used by PG&E to provide recommendations to customers and/or potentially incentivize best practices, and may also be useful to processors seeking guidance on best practices. Detailed objectives are listed below, followed by an overview of the report organization and contents.

1.1 Objectives

The study was designed to focus on widely used wastewater treatment methods in various sectors of the food and beverage industry that are known to have high rates of water and energy use. Research objectives were to:

- Identify and describe water usage and wastewater management practices in food and beverage sectors with the highest energy use.
- Identify major energy efficiency opportunities related to wastewater treatment based on discussions with customers and equipment vendors.
- Provide an overview of the wastewater treatment regulatory landscape including variations among California Regional Water Quality Control Boards (CRWQCB) regulations within PG&E's service area.
- Identify wastewater treatment needs by sector.
- Identify standard practices for wastewater treatment.
- Infer best practices for energy efficient and sustainable wastewater treatment and disposal, based on vendor projections for energy use and processor's reported energy use for existing treatment systems (if records are available – measurement of energy usage was not part of this project).
- Identify key wastewater source water reduction opportunities by sub-sector.
- Identify regional environmental concerns and issues related to wastewater disposal (e.g. nutrient or soil salt concentrations).



Source: The California Energy Comission, 2009

Kennedy/Jenks Consultants

Energy Use in Wastewater Treatment in the
Food and Beverage Industry
San Francisco, California

California Electric Utility Service Areas

0865010*00
October 2010

Figure 1

Specific objectives for implementing the study were defined as follows:

- Identify key sectors within PG&E's agricultural and food and beverage processing customers with high wastewater generation and energy usage. Include, at a minimum, the following sectors:
    - Vegetable, fruit and nut processors
    - Poultry processors
    - Wineries
    - Dairy processors
    - Dairy farm (raw milk) operations
    - Meat processors
    - Beverage manufacturers
- Research wastewater treatment technologies that are currently used or could be used in the sectors listed above, and focus on technologies used to reduce concentrations of biochemical oxygen demand, nitrogen, and/or suspended solids in the effluent. Focus on:
    - Solids separation
    - Aerated pond treatment
    - Anaerobic treatment, including high-rate and low-rate options
    - Activated sludge
    - Membrane bioreactor
- Perform an analysis of identified wastewater treatment technologies to develop an understanding of their energy efficiency potential and applicability to PG&E's Agriculture and Food Processing Customers, based on customers' experiences.
- Provide for review and comment on the project deliverables by a panel of industry peer reviewers, referred to as the Technical Advisory Group (TAG).

Methods that were used to accomplish these objectives are presented in Section 2.

1.2 Report Organization

The report is organized as follows:

Section 1: Introduction, including study objectives

Section 2: Methods that were used for research and analysis

Section 3: PG&E customer demographics

Section 4: Treatment technologies

Section 5: Food and beverage sectors

Section 6: Regulation of wastewater from food and beverage processing

Section 7: Related food and beverage industry survey

Section 8: PG&E Survey results

Section 9: Energy-saving potential of treatment technologies

Section 10: Energy efficiency opportunities by sector

Section 11: Basis for benchmark development

Section 12: Areas for further research

Section 13: Conclusions

In addition, appendices to the report provide a copy of the full survey, abridged survey results, and additional background information on water regulatory policies.

1.3 Acknowledgements

A number of industry associations participated in outreach efforts for this project. The assistance provided by the following organizations is greatly appreciated:

- California Enological Research Association
- California League of Food Processors
- California Poultry Federation
- California Sustainable Winegrowing Alliance and Wine Institute
- Craft Brewers Association
- Manufacturers Council of the Central Valley
- Sustainable Conservation
- Western United Dairymen

The Kennedy/Jenks' project team for preparation of this report included:

- Bob Chrobak, P.E.
- Gregg Cummings, P.E.
- Joe Drago, P.E., Ph.D.
- Sharon Melmon
- Owen Ratchye, P.E.

Section 2: Methods

This section provides an overview of the primary research and data analysis methods that were used in this study.

2.1 Conduct Background Research

Background information from a number of sources was compiled and interpreted. Focus areas included:

- PG&E food and beverage customer demographics
- Treatment technologies that are widely used by food processors
- Food and beverage sector characteristics
- Regulations that influence wastewater management practices
- Related studies conducted by or for individual sectors of the industry

Pertinent information obtained through this task is summarized in the report sections that follow.

2.2 Develop Survey

A questionnaire was developed to gather detailed information from food and beverage processors (Appendix A). The survey covered current and planned operations and practices in the following areas:

- Products and Processing Operations
- Water Supply and Water Use
- Wastewater Management
- Energy Efficiency
- Optional Contact Information

The draft survey questions were reviewed with PG&E and the TAG for the study, who provided valuable feedback on the breadth of the questions and language.

2.3 Implement Online Survey

The survey questions were uploaded to SurveyMonkey, an online survey utility. All questions within the survey were designated as optional, with the goal of allowing processors to skip questions they were unable or unwilling to respond to, rather than opting out of the survey completely. The survey was fully confidential. Respondents were not required to provide their name or the company name, unless they chose to do so. Initial testing suggested that the survey would require 15 to 30 minutes to complete; however, in practice it was found to be 15 minutes or less.

A one-page description of the study objectives with a link to the survey was prepared for distribution to food and beverage processing companies. Industry associations in the targeted sectors were contacted for assistance in recruiting survey participants. These organizations encouraged their members to participate in the survey. Various media were used to advertise the survey, including posting information on websites, sending it out in newsletters, and including it general announcements.

2.4 Conduct Telephone Interviews

To supplement responses from the online survey, Kennedy/Jenks contacted companies by telephone and completed the survey through an interview process. In some cases, the telephone calls yielded more detailed information than could be collected through the online survey.

To identify processors that would be called, Kennedy/Jenks utilized the PG&E customer list for all sectors except dairy farms (not included). Because it was not feasible to contact all customers in the database, it was assumed that the most useful companies to interview would be those that have relatively high energy usage (defined as greater than $250,000 per year in electrical charges). In the absence of other indicators, it was assumed that high energy use *may* correlate with a larger-scale facility that uses more water and generates significant wastewater. Although treatment practices at facilities of all sizes were of interest for the study, it is known that facilities with higher wastewater discharge rates are more likely to employ onsite pretreatment or full treatment, and information about such systems was desirable for the study.

In contrast, facilities with lower energy use were considered more likely to be smaller operations that either discharge to publicly owned treatment works (POTWs) or employ relatively simple pretreatment systems; therefore the scope of information they could provide in an interview would be limited. Smaller facilities with low energy usage may also represent a lower priority opportunity for PG&E in terms of improving the energy efficiency of customer systems for wastewater treatment. If the number of responses/interviews from companies in the higher energy-use bracket for a given sector was insufficient to describe the sector, customers with smaller energy use (greater than $25,000 per year in electrical charges) were pursued to obtain additional information.

For dairy farms and meat processors, PG&E account representatives provided referrals to companies to contact. Kennedy/Jenks also requested survey information from selected current and past clients and other contacts.

2.5 Contact Treatment System Vendors

Kennedy/Jenks researched and contacted representatives or vendors of each of the main treatment system technologies that were the focus of the study. Kennedy/Jenks appreciates the time and participation of the following technology vendors:

- Siemens Water Technologies Corp.

- Mazzei Injector Company, LLC
- JBI Water and Wastewater Equipment
- Ryan Process Equipment
- Ecolab, Inc.
- Water Street Solutions, Inc.
- Heron Innovators

In some cases, vendors suggested companies using their systems that could be contacted for more information.

2.6 Conduct Site Visits

Kennedy/Jenks, in consultation with PG&E, selected several food processing facilities for site visits to observe treatment system operations. Facilities that were toured included one poultry processing facility and two dairy processing operations, all within PG&E's service area. One of the dairies included a former dairy farm. Treatment systems at the facilities were operating with various technologies described herein, including screening, dissolved air floatation (DAF), aerated lagoons, and land application systems. In general, the site visits served to validate the research findings of this study.

2.7 Compile and Analyze Data

Online and telephone survey results were aggregated for review (Appendix B). Due to the number of respondents from each sector, statistical evaluation of results by sector was not feasible; however, the data set was interpreted in conjunction with related background research and Kennedy/Jenks' past experience working with food and beverage processors to provide an indication of industry trends. Data gaps were also identified, as discussed in the section on areas for further research later in this report.

2.8 Evaluate Basis for Benchmarks

Information obtained through the study for each food and beverage processing sector was evaluated to assess whether development of sector-specific benchmarks for energy use in wastewater treatment would be both feasible and meaningful, based on existing information, if coupled with additional data and industry concurrence.

2.9 Prepare Report

This report has been prepared for reference both by PG&E and by food and beverage processors with an interest in wastewater treatment technologies that are commonly used in each sector, regulatory constraints and trends that influence technology selection, and energy efficiency opportunities. The report also outlines potential next steps to address data gaps and complete the development of benchmarks, as appropriate.

Section 3: PG&E Customer Demographics

PG&E provided a list of their customers that are classified as food and beverage facilities (with the exception of dairy farm customers), based on their North American Industry Classification System (NAICS) code. The NAICS codes corresponding to sectors that are included in the study (and related NAICS codes that were not included) are summarized on Table 1.

Table 1: Summary of Food and Beverage Sector NAICS Codes

Sector		NAICS Codes	NAICS Code Description
1	Vegetable, fruit and nut processors	311000	Food Manufacturing
		311400- 311499	Frozen Fruit, Juice, and Vegetable Manufacturing
		311911	Roasted Nuts and Peanut Butter Manufacturing
		311991	Perishable Prepared Food Manufacturing
2	Poultry processors	311615	Poultry Processing
3	Wineries	312130	Wineries
4	Dairy processors	311500- 311599	Dairy Product Manufacturing
5	Dairy farm (raw milk) operations	112120	Dairy Cattle and Milk Production
6	Meat processors	311600- 311699	Animal Slaughtering and Processing (except NAISC code 311615 - Poultry Processing)
		311711	Seafood Canning
		311712	Fresh and Frozen Seafood Processing
7	Beverage manufacturers	312100- 312199	Beverage Manufacturing (except NAISC code 312130 – Wineries)
Related NAICS Codes Not Considered in the Study			
NA	Other	311100- 311199	Animal Food Manufacturing
		311200- 311299	Grain Milling, Oil Refining and Processing
		311300- 311399	Sugar and Confectionery Product Manufacturing
		311800- 311899	Bakeries and Tortilla Manufacturing
		311900- 311999	All Other Miscellaneous Food Manufacturing (except NAISC codes 311911 & 311991)

NA – Not applicable

The number of customer accounts in each sector and their total 2008 energy usage and energy cost data are shown on Table 2. Some customers had multiple accounts presumed to be associated with same facility, as well as multiple facilities, so the number of discrete facility locations was difficult to determine.

Table 2: Summary of PG&E Customer Account Data

Food/Beverage Sector		Number of Customer Accounts in Sector	2008 Total Energy Use in Sector (Million KWH)	Number of Accounts with Electric Revenue >$25,000	Number of Accounts with Electric Revenue >$250,000
1	Vegetable, fruit and nut processors	329	617	165	58
2	Poultry processors	16	74	11	6
3	Wineries	1,222	349	321	38
4	Dairy processors	85	384	44	14
5	Dairy farm (raw milk) operations	Not Included in Customer List*			
6	Meat processors	137	133	55	18
7	Beverage manufacturers	161	195	59	18

* California has approximately 2,200 dairies, and 1,650 of them are located in the Central Valley Region (CRWQCB website)

The data for total energy use provided a gross indication of facility size, but the portion of energy use attributable to wastewater treatment (or other discrete operations) was not differentiated.

Section 4: Standard Treatment Technologies

Treatment technologies are used in the food processing industry to improve the quality of effluent from processing operations prior to final discharge onsite or offsite. Typically, the term pretreatment is used to refer to the level of treatment provided prior to discharge to a POTW, where additional treatment is conducted before final discharge. Onsite discharges of treated wastewater may be used for crop irrigation or management by other land application methods. Offsite discharges are typically via piped connection to a POTW, but sometimes entail discharge to surface water under a National Pollutant Discharge Elimination System (NPDES) permit. Alternatively, certain high-strength waste streams (or in some cases the entire effluent volume) are sometimes hauled to an appropriate offsite treatment facility. Processors select treatment technologies based on their cost and effectiveness for meeting federal, state and local permit requirements applicable to the final discharge. Other selection criteria include ease of operation, footprint size, flow-through rate/capacity, and tolerance for flow variability. Increasingly, however, energy costs and greenhouse gas (GHG) emissions have become important considerations.

To meet discharge requirements, treatment objectives for food processing wastewater often include removing solids; fats, oils and grease (FOG); biochemical oxygen demand (BOD); nutrients (nitrogen and phosphorous); and/or salts. Salts pose the greatest challenge for energy efficient wastewater. Although a single technology can sometimes stand alone to accomplish a facility's treatment objectives, it is more common that several technologies are used in series. For example, anaerobic treatment is often followed by aerobic treatment to oxidize or polish the final effluent.

For purposes of this study, five types of standard treatment technologies that are widely used in the food processing industry were selected to be the main focus of the investigation. These technologies are introduced individually below, and applications are summarized in Table 3. For more detailed engineering design guidance for wastewater treatment systems, refer to a standard engineering handbook, such as *Wastewater Engineering: Treatment, Disposal and Reuse* (Metcalf and Eddy, 2003); or *Pretreatment of Industrial Wastes* (Water Environment Federation, 1994).

Note that treatment technologies applied specifically for salts removal were outside the scope of the study. Accordingly, reverse osmosis (RO), a primary technology available for salts reduction, is not included below; however, RO has not been widely used in the food processing industry to date, and trials of the technology by food processors have had mixed results. In addition, costs for RO can be prohibitive for processors. Evaporators, another primary technology used for salts reduction, were also not included in the study.

4.1 Solids Separation

Most food processors use some form of physical and chemical solid separation process to remove total suspended solids (TSS) and coarse solids from wastewater. These systems may also reduce concentrations of FOG. Options include screening and sedimentation, pre-aeration, chemical precipitation, DAF, and filtration. In many cases, solids removal is a precursor to further treatment steps, but if the wastewater will be discharged to land as irrigation or routed to POTW, screening methods alone may provide sufficient pretreatment.

Table 3: Overview of Treatment Technologies

Treatment Technology	Action / Application	Options	Components with Energy Demand	Comments/Pros/Cons
Solids Separation	Removal of coarse solids, TSS and FOG with physical/chemical processes	• Screening • Sedimentation • Pre-aeration • Precipitation • DAF • Filtration • Gravity trap	• Pumps • Motors • Mechanical blowers or compressors for DAF • Residuals management	• Used by virtually all food processors • Effective and relatively low cost • Requires maintenance and sludge management • Possible odor issues
Aerated ponds	Remove or stabilize organic matter with aerobic bacteria Can also facilitate nitrification	• May be facultative (aerobic at surface, anaerobic at depth)	• Mechanical aerators • Blowers • Diffusers • Pumps • Motors • Residuals management	• Larger pond surface = greater oxygen transfer, faster treatment • Use timers/sensors to optimize treatment • Effective and relatively low cost if land is available • Potential for odor issues if not well managed
Anaerobic treatment	Treat high BOD wastewater Can remove 90% of BOD and TSS Can convert 25% of TN to ammonia	• Low-rate (covered reactor lagoon) • High-rate (covered concrete or steel reactor/tank	• Pumps • Mixers • Heat for reactor	• Biogas generation can offset energy use • If alkalinity is added for treatment, effluent TDS may rise • Effective for high strength wastewater • Capital costs can be prohibitive

Treatment Technology	Action / Application	Options	Components with Energy Demand	Comments/Pros/Cons
Activated sludge	Reduce organic matter with bacteria in aerated chamber; use clarifier to separate sludge from mixed liquor.	• Fine bubble diffusers Coarse bubble diffusers • Sequencing batch reactor • Extended aeration	• Blowers • Diffusers • Pumps • Mixers • Sludge handling	• Well known process, commonly used for municipal systems • May not scale-down well for food/beverage facilities • Relatively high energy demand • Prone to upsets when loads vary
Membrane Bioreactor	Reduce organic matter with activated sludge system; use membranes for sludge separation (instead of a clarifier).	• Various membrane options available	• Blowers • Diffusers • Pumps • Mixers • Sludge handling	• Requires extra energy to force water through membranes • Membranes provide high quality effluent • Small footprint systems

DAF systems are frequently used by meat and poultry processors and dairies. Chemicals, such as flocculants, are often added to improve solids separation efficiency.

Energy requirements for separation technologies vary, but are primarily a function of the need for pumps and/or motors to force water through solids separation units and to supply air for floatation with mechanical blowers or air compressors. Carefully designed and controlled chemical use can decrease the amount of recycle pumping and aeration required for some solids separation technologies, thereby reducing energy demand.

Residuals generated through solids separation include screened and filtered solids as well as sludge from DAFs. Detailed consideration of residuals management strategies is beyond the scope of this study. In general, energy use to manage residuals can include pumps to transfer the materials and the energy associated with stand-alone treatment systems for sludge treatment, dewatering, drying or digestion, if needed.

4.2 Aerated Pond Treatment

The basic reaction that occurs in aerated ponds is removal and biological stabilization of residual organic matter by aerobic bacteria that grow in the ponds and remain in suspension. The ponds can also facilitate nitrification if sufficient aeration is provided. The oxygen source for metabolizing carbonaceous material and for nitrification is generated by pond mechanical aerators or an air diffusion system. A multi-compartment pond approach provides a staged treatment process that is economical, flexible, effective, low maintenance and easy to operate.

At some facilities, facultative ponds are used. These ponds provide an environment for aerobic degradation of wastewater constituents near the surface, coupled with anaerobic degradation by microbes at depth. They must be managed carefully to avoid formation of nuisance odors.

Pond systems are sized based on the expected wastewater quality and flows coming into the pond, as well as the quality of effluent needed to match potential reuses or meet discharge requirements. Systems should be designed to recirculate the wastewater. This serves multiple purposes, including buffering intermittent loading conditions, naturally supplementing oxygen to reduce the needs for aeration and nutrients, improving the efficiency of treatment for removal of BOD and TSS, and raising the alkalinity for pH control. Pond design must also address contingencies for emergencies, potential overflows, 100-year precipitation events and any applicable local regulations.

In general, a greater pond surface area provides for higher surface oxygen transfer, which allows treatment objectives to be met with shorter detention times. For higher flows, the primary drawback of pond systems is that significant land areas must be available to develop ponds large enough to meet treatment objectives with reasonable detention times. Detention times for pond treatment during various times of the year can be estimated based on the daily volume of wastewater discharged into the pond, the average BOD concentration of that water, pond size, aerator or aeration system characteristics and the target BOD concentration of the pond effluent. Pond systems have been effectively used by wineries and fruit and vegetable processors, or as one step in an aerobic/anaerobic treatment train to treat higher strength and/or high volume wastewater streams. Chemicals are sometimes added to ponds to improve treatment efficiency or control odors, foaming, and pests.

Energy requirements for pond treatment include pumps and/or motors to transfer water to and from the ponds and for aeration with mechanical turbines or brushes (surface aerators), or blowers and diffusers. The unit energy consumption of municipal wastewater treatment plants using aerated pond treatment ranges from 600 to 1,400 kWh per million gallons treated (WEF, 2009). Typically, efficient energy use is largely a function of careful aeration system design and operation. Management of residuals from pond treatment can require additional energy. Residuals solids that settle at the bottom of the ponds must be removed periodically by draining the ponds and physically removing the solids, or by pumping.

4.3 Anaerobic Treatment

Anaerobic biotechnology, in the form of either low-flow rate or high-flow rate systems, is typically used to treat high BOD wastewater. Low-rate systems typically consist of covered reactor lagoons, whereas high-rate systems use covered concrete reactors or tanks. These systems can reduce BOD by about 90% and TSS by about 90%. Anaerobic systems also convert about a quarter of the total nitrogen in wastewater to ammonia, while reducing some of the organic nitrogen. However, if alkalinity is added during the anaerobic treatment process, total dissolved solids (TDS) may increase. The full treatment train for a large-scale anaerobic system typically incorporates a number of different technologies. A conceptual system could include the following series of steps:

- Coarse screening via rotary drum screens
- Equalization tank with mixer
- DAF clarifier
- Nutrient addition
- Alkalinity addition
- Preconditioning tank with mixer
- Boiler and heat exchanger
- Anaerobic reactor
- Biogas handling system
- Sludge digester and/or sludge thickener
- Sludge dewatering
- Odor control

When a discharge permit requires BOD and TSS reductions beyond the 90% level, this can be achieved by incorporating an aerobic polishing step or a solids separation process into the design.

The primary energy needs for an anaerobic system, whether high-rate or low-rate, are to operate pumps and mixers and to heat the reactors. However, anaerobic systems may generate more energy than required for their own operation through the production of biogas, and that excess energy can be used elsewhere in the facility. High- and low-rate systems have comparable potential for energy generation.

Anaerobic treatment is typically very energy efficient when compared to other secondary treatment measures, and also can include a significant amount of other opportunities for energy efficiency improvements. High-rate anaerobic systems are more expensive to install and maintain than other treatment technologies, and are typically used at facilities that produce large amounts of wastewater. Additionally, these systems can use significant power for fluid transfer. Some examples of the energy efficiency advantages of anaerobic treatment are listed below:

- Energy intensive aeration is not needed.
- Anaerobic systems produce methane, which can be used to generate heat and/or power.
- Control systems for anaerobic treatment are often sophisticated and can be used to monitor energy use and implement energy efficiency measures.
- Anaerobic systems can contain excess storage capacity, so they may candidates for implementation of demand-side management programs.
- Anaerobic treatment has the potential for energy savings through re-use of treated water or heat capture for use in food and beverage processing plants. Examples include using treated water for clean up or processing needs, and capturing heat from the treated water for use in the food processing plant.
- Anaerobic systems can generate less residual wastes than other treatment technologies, and sludge volume can be further reduced in some cases by subsequent sludge digestion. However, residuals management may still require energy input.

The differences between low-rate and high-rate anaerobic system are described in further detail below.

4.3.1 Low-Rate Anaerobic Option

A low-rate anaerobic process may consist of a lined, covered reactor lagoon constructed of native or imported earth fill. The reactor would have an influent and effluent distribution system and mixers; supernatant recycling and sludge systems; process instrumentation and controls; a compressed air system; biogas handling system, including an enclosed biogas flare with flame arrestor; an HDPE liner with leak monitoring and collection capabilities to protect groundwater (any leakage that accrues is pumped back into the reactor); and a flexible, insulated geomembrane cover. Typically, the low-rate anaerobic treatment process does not require nutrient supplementation to provide alkalinity and pH neutralization; however, if needed, this can be accomplished at the influent pump station.

Heating the water improves the treatment efficiency of the anaerobic reactor. This can be done with a boiler, but there may be other, more efficient ways to heat the wastewater, such as using spare hot water heater capacity or waste heat from other processing operations. If the influent flow to the reactor is near 80° Fahrenheit (F), the water heater and heat exchanger may not be needed at all. A low-rate system can have a number of benefits:

- Simple to operate using a programmable logic controller/personal computer (PLC/PC) system that provides a graphical interface and allows optimization of the anaerobic process.

- Efficient, reliable and robust. Designed to cope with peak organic and hydraulic loading conditions, given the long hydraulic and solids retention times.
- Provides consistently high performance and efficient removal of chemical oxygen demand (COD), BOD and TSS.
- Can accept high TSS concentrations and spikes without the need for extensive pretreatment, with the exception of coarse screening.
- Can achieve high performance at less-than-optimum anaerobic operating temperatures because it is a low loaded system with a large inventory of biomass.
- Sludge production and nutrient requirements are minimized due to the high solids retention time. Depending on reactor size, sludge wasting may not need to begin until several years after installation.
- Sludge is relatively thick and very stable. It makes an excellent soil conditioner and amendment if used for land application.
- The geomembrane cover and biogas handling system minimize the potential for release of objectionable odors. Biogas that is captured can be used for hot water heaters or boilers to heat influent wastewater for improved reactor stability and performance.
- Operation and maintenance costs are comparatively lower than for other anaerobic and aerobic systems. Residuals require periodic removal by draining the ponds and physically removing the solids, or by pumping.

Covered lagoons are being used for treatment of wastewater from meat and poultry farming and processing operations, including dairies.

4.3.2 High-Rate Anaerobic Option

A high-rate anaerobic system may consist of covered concrete reactors or tanks that treat wastewater biologically at a relatively high rate using a type of fluidized biofilm bed or sludge blanket. High-rate systems typically include: an influent and effluent distribution system; mechanical screen system; supernatant recycle and sludge systems; chemical addition system; process instrumentation and controls; compressed air system; influent wastewater heating system; and biogas handling system, including an enclosed biogas flare with flame arrestor.

The high rate anaerobic treatment process may require some nutrient supplementation and alkalinity addition for pH control. If spent alkaline cleaning compounds can be recovered from the processing operation, they can be reused for this purpose. Alkalinity or pH control is typically accomplished in a preconditioning tank upstream of the reactors or through recirculation. It may be necessary to include a heating system to bring the influent process water temperature up to near 90° F. To maximize efficiency, processors should assess their existing process water heating options, such as using spare boiler capacity or available waste heat. A high-rate system can have a number of benefits:

- Occupies a relatively small footprint compared with a low-rate system.

- Modular and can be expanded with additional reactors if greater capacity is needed.
- Simple to operate using a PLC/PC system that provides a graphical interface and allows optimization of the anaerobic process.
- Efficient and reliable, and can accept peak organic and hydraulic loading conditions if upstream equalization is integrated.
- Provides consistently high performance and efficient removal of COD, BOD and TSS.
- Can treat wastewater at high organic loading rates.
- Can accept high TSS concentrations and spikes without the need for extensive pretreatment, with the exception of coarse screening.
- The cover on the reactors seals biogas from the atmosphere, and coupled with the biogas handling system, minimizes potentially objectionable odors. Biogas can be used for hot water heaters or boilers to heat influent wastewater for improved reactor stability and performance.
- A two-compartment or tank high-rate system provides flexibility for peak season flows, and offers redundancy during off-peak periods.
- Anaerobic solids in the effluent can be collected and further stabilized in a downstream aerobic treatment system.

High-rate systems are being used to meet treatment requirements for high strength, high volume waste streams that are typically produced by beverage manufacturers, wineries, dairies and others. There are more energy efficiency opportunities with high-rate anaerobic treatment, due to its larger energy demands for equipment such as pumps and mixers. Residuals in the form of sludge produced by high-rate anaerobic systems can generate additional biogas when processed to reduce sludge volume by digestion.

4.4 Activated Sludge

An activated sludge system consists of an aeration chamber where aerobic bacteria are supplied with oxygen to promote consumption of remaining organic matter in the wastewater. The mixed liquor (combination of sludge and wastewater) is then transferred to a clarifier where the sludge settles to the bottom and the treated wastewater flows over a weir to discharge or to further polishing steps. A percentage of the settled sludge is recycled back to the aeration chamber for mixing with incoming wastewater. The remaining sludge is passed to a digester or thickener for breakdown and discharge to a solids handling system.

The energy use for aeration is typically associated with operation of blowers and diffusers. Other energy demands include operation of pumps and mixers. The unit energy consumption of municipal wastewater treatment plants using activated sludge treatment ranges from 1,300 to 1,800 kWh/million gallons treated, which is substantially larger than the energy consumption of plants using aerobic ponds (WEF 2009).

Based on studies of relatively small (1 MGD and 5 MGD) municipal activated sludge plants, the two largest energy demands for activated sludge treatment are aeration (51 to 63 percent of the estimated total plant energy demand) and wastewater pumping (17 percent) (WEF, 2009). This excludes energy use for sludge handling and digestion, as those operations are typically not often performed at industrial food and beverage wastewater treatment plants. If residuals management is conducted onsite, this may require additional energy

4.5 Membrane Bioreactor

A membrane bioreactor is an activated sludge system equipped with membranes (in lieu of a clarifier) to provide solids separation via filtration. After the activated sludge process, the mixed liquor is passed through hollow fiber membranes to separate the sludge from the wastewater. The treated wastewater is discharged or routed to next treatment steps. The sludge is directed to the solids handling system. Membrane bioreactors have certain advantages when applied to the treatment of food and beverage wastes because they can typically handle high concentration wastewater streams, they take up less space than many other treatment options, and they provide a much higher quality effluent than a clarifier.

As with conventional activated sludge systems, the energy demand for a MBR is a function of the rate that oxygen is supplied to the aeration chamber, but is usually higher because of energy required to force water through the membranes. The largest energy use is typically aeration to power blowers and diffusers. Other energy demands are for the operation of pumps and mixers, and for residuals management, if conducted onsite.

Section 5: Food and Beverage Processing Sectors

The seven sectors of the food and beverage industry that were targeted for the study are introduced below. For each sector, typical processing steps are generalized, with an emphasis on the sources and characteristics of associated wastewater and applicable treatment approaches. Treatment technologies that are commonly used in each sector are also compiled on Table 4. Note that sanitary wastewater is excluded from the discussion because it is segregated and managed separately from process wastewater in all but the smallest facilities.

5.1 Vegetable, Fruit and Nut Processing

The vegetable, fruit and nut processing category includes a diverse range of products that are canned, frozen, dried, fresh-packed, bulk-packed, or preserved and prepared for distribution by other means. Most facilities are located adjacent to crop acreage in the Central Valley, Central Coast or North Coast area.

5.1.1 Vegetable/Fruit – Production Steps

While vegetable, fruit and nut processing operations vary by facility and product form, a number of common production steps are outlined below.

Washing and Fluming - Harvested crops are washed with water, under high-pressure sprayers and conveyed through flumes; chlorinated water is used for bacterial control. Alternatively, some crops are cleaned using an air blower to remove lightly held plant and soil particles. Another method is a froth floatation cleaner, in which a solution of oil and soap is used to suspend and remove particles. Screens are also used to separate waste materials.

Peeling – Three of the most commonly used methods of peeling are:

<u>Abrasive</u>: peels are removed by rotating rollers coated with abrasive. Waste materials are washed off with water. This is a continuous process used for root vegetables.

<u>Lye</u>: peels are removed by immersion in hot caustic (a 12 to 15 percent solution at 60 degrees C) for several minutes. This is a continuous process used for potatoes, carrots and other products. It is the most widely used method, though the high pH effluent can present management challenges.

<u>Steam</u>: peeling is accomplished in a closed container where high pressure and temperature steam is maintained for 1 to 2 minutes. This is a batch process used for a variety of products.

Research on alternative peeling methods is underway. Some studies have shown that infrared radiation (IR) is feasible. California Department of Food and Agriculture is funding a research to develop a peeling method that does not require water.

Blanching – Products to be canned or frozen are blanched by immersion in steam or hot water for period of 1.5 to 6 minutes, depending on size. For products to be frozen, blanching serves to brighten colors and inactivate enzymes that would produce off flavors. For products to be

Table 4: Standard Technology Applications by Sector

	Solids Separation	Anaerobic	Aerobic Ponds	Activated Sludge/MBR	Effluent Discharge
Vegetable/ Fruit/Nut	• Screening • DAF	• Anaerobic sludge blanket • Anaerobic lagoons	• Aerobic ponds	• Activated sludge • Sequencing batch reactor	• Land application • Sewer
Dairy Processing	• Screening • pH control • DAF	• Anaerobic sludge blanket • Anaerobic lagoons	• Aerobic ponds	• Activated sludge • Sequencing batch reactor	• Land application • Sewer
Dairy Farms		• Anaerobic lagoons • Anaerobic reactor tanks			• Land application
Meat	• DAF	• Anaerobic lagoons • Anaerobic contact reactors • Biofilm filters	• Aerobic lagoons • Oxidation ditches • Biological filters • Stabilization ponds	• Activated sludge • Sequencing batch reactors	• Land application
Poultry	• Screens • Filters • DAF	• Anaerobic lagoon		• Activated sludge	• Land application
Beverages	• Screening • Grit removal • Gravity separation • pH adjustment • Flocculation	• Anaerobic biological	• Aerobic systems	• Activated sludge	• Sewer discharge
Wineries	• Filtration	• Anaerobic biological	• Aerobic systems • Pond systems	• Activated sludge	• Land Application • Septic systems • Sewer

canned, it improves packing by inducing shrinkage and softening, and removes cellular respiratory gases with corrosion potential. Blanching water is warm, and the wastewater may contain dissolved starch or other materials leached from the product.

Cutting and Filling – Products are cut and packed in cans, bags or other packages by specialized machines. Cleanup of these surfaces contributes to wastewater loading.

Brining – After cans are packed, a weak salt solution is added to fill the can.

Freezing – Blanched products are quick-frozen either by batch processes or continuous tunnel freezing that uses a conveyor belt or fluidized bed.

Dehydrating – Blanched products are dehydrated in a variety of ways, depending on desired output. Final products include dried whole fruit/vegetables, chips, granules, flakes, starches and flours. Dehydrating is energy intensive.

5.1.2 Vegetable/Fruit – Sources and Characteristics of Process Wastewater

In most fruit, vegetable and nut processing facilities, wastewater is generated from a series of steps, such as:

- Raw produce fluming, washing, grading and trimming
- Washing after steam/lye peeling
- Blanching and fluming
- Filling
- Sanitation and plant cleanup
- Processed product cooling

Processing and associated wastewater generation often occur at high volumes during the peak summer harvest season, followed by relatively low volumes during other months of the year. This has significant implications for treatment system design. Product washing and sanitation are typically the largest uses of water. Wastewater generally contains high concentrations of biodegradable components, and is influenced by the commodity processed, specific processing operations, and seasonal variations in the crop due to growing conditions and age at harvest. In addition to plant organic material, wastewater may include dirt, residual pesticides, fat, and caustic and other cleaning and preserving chemicals.

Some fruits and vegetables are peeled with lye, which produces a very caustic effluent (pH 11 to 12) that generally requires pretreatment prior to disposal. The industry is seeking alternative peeling methods to avert this issue. For some commodities such as potatoes, heat treatment steps produce effluent containing gelatinized starch and coagulated proteins (Wang, et al., 2006). Solid residuals from processing are either composted or hauled offsite. Although case studies for treatment technology applications exist for individual facilities, it is difficult to extrapolate these examples to sector average values due to the variability of products, operations, scale, and other factors. In some studies, wastewater volume is normalized to processing output per day, which represents an important metric for developing energy baselines and benchmarks. For example, Wang, et al cites potato washing at 1,300-2,100 gallons of water per ton of raw potatoes and potato peeling at 600-715 gallons per ton of raw potatoes. (Wang, et al. 2006).

5.1.3 Vegetable/Fruit – Wastewater Treatment Options

Kennedy/Jenks has observed that most vegetable and fruit processors manage wastewater by implementing pretreatment steps for solids removal, followed by land application or irrigation onsite. This approach has a long history of use, but has become more difficult due to regulatory compliance requirements for groundwater protection. If effluent characteristics or available acreage for land application are such that pretreatment is needed to reduce BOD loading prior to land application, biological treatment, either aerobic or anaerobic, may be needed. However, the seasonality and high variability of the effluent may limit treatment options. The California League of Food Processors' "Manual of Good Practice for Land Application of Food Processing/Rinse Water" (CLFP, 2007) is a widely used guidance resource for designing land application systems in accordance with regulatory requirements.

5.2 Dairy Processing

A variety of dairy products are produced from milk in California at facilities of all sizes. There are growing numbers of small, boutique producers located in or near urban areas. In contrast, some of the largest cheese processors in the country have operations in rural areas of the Central Valley. Larger facilities tend to be situated close to dairy farms. Manufacturing processes, wastewater sources and characteristics and wastewater treatment options are summarized below.

5.2.1 Dairy Products – Production Steps

An overview of the production steps for various dairy products is as follows:

Pasteurized milk – manufactured by a process that includes pasteurization, standardization, deaeration, homogenization, cooling and packaging.

Milk and whey powders – produced by evaporating water under a vacuum. Residual water is removed by spray drying.

Cheese – generally manufactured by mixing pasteurized milk with rennet, a starter culture, and sometimes color. The coagulant that forms is heated and subject to mechanical processes to separate the whey. Curds are salted, pressed into cheese and cured. Many varieties of cheese are produced with additional or modified processing steps.

Butter – produced by churning cream, which separates butter and buttermilk.

Evaporated milk – produced from milk through a series of steps that includes standardizing, pasteurizing, concentrating in an evaporator, homogenizing, packaging and sterilization. For sweetened, condensed milk, sugar is added during the evaporation step.

Ice cream – manufactured from a mixture of water, cream, butter, milk and whey powder. The product is homogenized, pasteurized and aged, and flavors and colors are added before freezing. Air is entrained during the primary freezing step to adjust the texture.

Yogurt – produced from milk with addition of sugars and stabilizers. This mixture is heated, homogenized, reheated and cooled. Then it is inoculated with a starter culture and allowed to incubate, either in the retail packaging or in bulk. The final product is cooled prior to distribution.

5.2.2 Dairy Products – Sources and Characteristics of Process Wastewater

Wastewater is generated intermittently during dairy processing from cleaning and sanitation activities, certain processing steps, and facility heating and cooling operations. Clean-in-place (CIP) systems are typically used for tanks, lines and other equipment that is in contact with the product. CIP is usually a three-step process: pre-rinse, hot caustic wash, and cold final rinse to remove the caustic. Additional waste streams result from cleaning and sanitation for bottles, general facility cleanup for leaks and spills, and tanker truck cleaning.

Production steps that yield wastewater can include cheese washing and various evaporation and drying operations that result in a condensate stream, such as extracting the water from whey. The condensate can be recycled as boiler feed water; however, the wastewater volume may exceed the needs for the system and require an alternate disposal. Dairy processing wastewater production can vary greatly in volume and chemical characteristics over time, depending on the product and type of processing; this can cause problems for treatment systems.

The chemistry of process wastewater is influenced by characteristics of the milk products. The biochemical oxygen demand (BOD) in milk and cream, for example, is very high; reported concentrations are greater than 100,000 mg/l and 400,000 mg/l of BOD, for milk and cream, respectively. As a result, BOD concentrations in wastewater can be significant. The organic load is composed of lactose, fats and proteins, as well as high levels of associated nitrogen and phosphorous. Process wastewater also contains residuals of detergents and any product additives. CIP chemicals often include caustic soda, nitric or phosphoric acid, and sodium hypochlorite, all of which influence wastewater pH.

5.2.3 Dairy Products – Wastewater Treatment Options

The primary options available to dairy processors for wastewater management are discharging to a sewer, if they are in an urban area, or reusing the wastewater for irrigation onsite. In either case it is likely that a form of treatment will be needed. In addition, they may need to segregate and haul certain high-strength wastes off-site for disposal.

Pretreatment options that are used by dairy processors include physical screening, pH control, load balancing or equalization, and fats, oils and grease (FOG) removal. Because FOG concentrations can be significant and have the potential to interfere with subsequent treatment steps (whether they are municipal or onsite), most dairy processors use a form(s) of FOG removal, such as gravity traps, air floatation, or DAF systems. (Refer to Section 3 for more detailed discussion of technologies).

To address BOD loading, aerobic and/or anaerobic biological treatment methods are used. Aerobic methods include activated sludge systems, sequencing batch reactors, aerated treatment ponds and other permutations. Anaerobic methods that are used include various types of digesters, such as an upflow anaerobic sludge blanket (UASB) reactor or relatively simple anaerobic (covered) lagoons.

Following treatment, most dairies discharge wastewater to land onsite as irrigation, unless water and nutrient balances calculated for the effluent volume and available acreage are not acceptable. To obtain a discharge permit (WDRs), the processor will need to demonstrate that irrigation will not impact beneficial uses of groundwater. Kennedy/Jenks has observed that salt is likely to be the constituent of dairy processing effluent that poses a problem for land application permitting. (As noted above, salt removal technologies were outside the scope of this study).

5.3 Dairy Farms

Dairy farms operations entail managing cattle to produce raw milk. California is the top dairy farm state in the United States, based on volume of milk produced. Most of the larger operations are in the Central Valley. Additional farms are located in the San Francisco Bay and North Coast regions.

5.3.1 Milk – Production Steps

The main areas of activity in dairy farming are:

Cow barn – Alleys and walkways of the cow barn are cleaned several times a day, typically using recycled water. Bedding material is replaced. Most barns provide for air circulation and temperature control.

Milking parlor – Cows are milked 2 to 3 times per day using automated milking machines. Prior to each milking, pipes and equipment are cleaned and sanitized, the cows are rinsed, and their udders are washed and dried.

Milk tank room – Milk flows to sanitized tanks and is cooled to 40 degrees. It is transported to the processing plant in cooled trucks.

Manure management – Mechanical separators are used segregate solids and liquids. Solids are applied to crop land where animal feed is grown or composted and sold as fertilizer. Liquids are typically routed to a covered or uncovered lagoon(s) for aerobic or anaerobic treatment. Covered lagoons allow for methane capture for energy recovery. Treated effluent is used to irrigate fields and/or is reused for cleanout activities.

Dairies with more than 1,000 cows meet the USEPA definition of a Concentrated Animal Feeding Operation (CAFO). If not properly managed, manure from large-scale operations can have potentially significant environmental impacts. For every 5 or 6 cows, an acre of cropland is needed for manure disposal; this translates to thousands of acres for large CAFOs.

5.3.2 Milk – Sources and Characteristics of Process Wastewater

Wastewater is generated during washdown of the barns and cleaning and sanitation of the milking equipment, pipes, and milk storage tanks. Liquids separated from manure are also generally managed with the wastewater stream.

The chemistry of wastewater from dairies is influenced by the way that manure and milk are handled at the facility. Average COD in dairy wastewater in an EPA study was 4,997 mg/L, and BOD was 1,003 mg/L (EPA, 1999).

5.3.3 Milk – Wastewater Treatment Options

Most dairy waste is treated and stored in large, ambient temperature anaerobic treatment lagoons with depths of 5 to 20 feet. The lagoons are anaerobic or facultative (oxygen may penetrate the upper 2 to 4 feet) and serve to stabilize organic matter, promote solids separation and reduce odors. During cold winter months, biological reactions are slowed, and lagoons function primarily as storage facilities. Effluent has a relatively long detention time (up to a year), and both effluent and solids are ultimately land applied. Multiple-stage anaerobic lagoons provide improved treatment, allowing effluent to be reused for some purposes. Alternatively, anaerobic digestion of dairy wastewater (coupled with an additional feedstock) in closed reactor tanks allows for recovery of biogas which is increasing valued as a renewable energy source and a means to mitigate air impacts of dairy farming.

In the Central Valley, CRWQCB Region 5 regulates wastewater management at existing diary farms under a General WDRs Order (refer to Regulatory Framework above). This is includes specific design criteria for construction and management of storage and treatment lagoons, and requirements for land application of effluent and monitoring.

5.4 Meat Processing

Meat processing includes the series of operations beginning with livestock slaughter, through meat packaging for cattle, calves, hogs, sheep and lambs. The number of facilities in California is small and declining.

5.4.1 Meat – Production Steps

Slaughterhouse steps include holding, stunning, killing, bleeding, hide or hair removal, evisceration, offal removal, carcass washing, trimming, and carcass dressing. Processing and packaging may occur in the same facility or offsite. In addition to wastewater, the volume of solid waste by-products generated during processing is significant. By-products with no economic value are landfilled, composted or anaerobically digested.

5.4.2 Meat – Sources and Characteristics of Process Wastewater

Wastewater is generated from washing carcasses, washing after evisceration, processing offal, and cleaning and sanitizing equipment and building surfaces. It also used for facility heating, vacuum and cooling (HVAC) systems, including boilers, steam and refrigeration units. Sanitation performance standards for meat and poultry facilities were established by the Food Safety Inspection Service (FSIS) of the United States Department of Agriculture (USDA) in the Federal Register on 20 October 1999 (FSIS Docket 96-037F; 64 FR 56400). The performance standards provide an objective to be achieved, but do not prescribe the means to achieve that objective. Therefore, establishments may develop and employ sanitation or processing procedures customized to the nature and volume of their production.

Meat processing wastewaters can be divided into five general types: (1) manure-laden from pens and holding areas; (2) manure-free, high-grease from the slaughterhouse floor and rendering operations; (3) manure-free, low-grease from the slaughterhouse; (4) manure-free, low-grease from packaging areas; and (5) clear water, which may include cooling water, steam condenser water, canned product chill water, and onsite stormwater runoff. The volume wastewater generated varies widely depending on the type of meat being processed and whether the facility is a slaughterhouse and/or a packinghouse. Metrics for wastewater are normalized as volume of wastewater produced per animal or per weight of meat produced (Wang, et al., 2006). Meat processing facilities that perform slaughtering generate more wastewater, and wastewater with higher strength, than facilities that only provide subsequent operations, such as packaging of cut meat.

Wastewater is characterized by high loading of solids, floatable matter, manure and other organic substances. Fats and proteins are present in both particulate and dissolved forms. Analyses will show high concentrations of BOD, COD, suspended solids, nitrogen, phosphorous, coliforms (total, fecal and streptococcus), and enteric pathogens. Concentrations are highly variable depending on processes and effectiveness of solids separation.

5.4.3 Meat – Wastewater Treatment Options

Wastewater treatment requires a series of primary and secondary steps. Primary treatment for grease removal is typically accomplished using a baffled tank of DAF. The effectiveness of a DAF is influenced by wastewater temperature, and declines significantly at high temperatures above 100 degrees F. Chemicals are often added to improve treatment efficiency. For example, ferric chloride is used to precipitate proteins, and polymers are used aid coagulation. These additions tend to increase sludge volume. Alternatively, some plants rely on a series of screening and sedimentation steps.

Secondary treatment to reduce BOD is accomplished biologically using systems that may include lagoons, activated sludge, oxidation ditches, sequencing batch reactors, or anaerobic digesters. Covered, low-rate anaerobic lagoons are often used in series with aerobic lagoons to maximize BOD removal. Membrane covers are used on anaerobic lagoons to avert odor issues and improve methane recovery. High-rate anaerobic systems are also used, including conventional contact reactors or biofilm filters. Use of upflow anaerobic sludge blanket (UASB) systems for treatment of meat processing wastewater has been limited due to the interference of high fat concentrations with formation of stable microorganism granules on the treatment bed.

Aerobic treatment options include activated sludge systems, biological filters, waste stabilization ponds and aerated lagoons. While these systems are proven to be effective for meat processing wastewater, most systems require supplied air or aerators which are energy intensive and costly to operate.

5.5 Poultry Processing

Poultry processing refers to slaughter and packaging operations. These operations are located predominantly in the Central Valley. This section does not address farming operations associated with growing and managing a live flock of birds.

5.5.1 Poultry – Production Steps

Steps in poultry processing include:

- Delivery and holding
- Stunning and slaughter
- De-feathering, hide removal and de-hairing
- Evisceration
- Trimming and carcass washing
- Boning
- Chilling

5.5.2 Poultry – Sources and Characteristics of Process Wastewater

Water is needed for each of the steps identified above. Sanitation performance standards for meat and poultry facilities were established by the Food Safety Inspection Service (FSIS) of the United States Department of Agriculture (USDA) in the Federal Register on 20 October 1999 (FSIS Docket 96-037F; 64 FR 56400). The performance standards provide an objective to be achieved, but do not prescribe the means to achieve that objective. Therefore, establishments may develop and employ sanitation or processing procedures customized to the nature and volume of their production.

Total water use in poultry plants is estimated at 6 to 7 gallons of water for each bird processed (Heintz, 2008). The wastewater contains organic solids and high concentrations of BOD, TSS, pathogens and chlorine. Poultry facilities that perform slaughtering generate more wastewater, and wastewater with higher strength, than facilities that only provide subsequent processing/packaging operations. Slaughter operations typically produce 5 to 10 gallons of wastewater per bird (CAST, 1995).

5.5.3 Poultry – Wastewater Treatment Options

Particulate organic matter must be removed from the poultry processing waste stream prior to discharge to a sewer or disposal by land application. Physical methods, including screens and filters are widely used for this purpose. FOG and dissolved solids are often removed with DAF systems. This may be followed by biological treatment in an anaerobic lagoon or an activated sludge system. The poultry processor observed by Kennedy/Jenks and PG&E on a tour of facilities for this study used a DAF, followed by lagoon aeration. Treated effluent was used for irrigation onsite.

5.6 Beverage Processing

The beverage sector includes soft drinks, beer, juice and bottled water. There are a variety of large soft drink makers, brewing companies of all sizes, and other drink manufacturers located throughout PG&E’s services area. Although the products vary, uses of water and wastewater management needs are similar.

5.6.1 Beverages – Production Steps

Because water is the primary ingredient in many beverages, pretreatment of the source water to ensure desired purity is often the initial step in production. This can include coagulation/flocculation, filtration, ion exchange and adsorption. Subsequent steps vary by product, but all operations include cleaning and sanitation activities.

Soft Drinks – Soft drinks are comprised of water, carbon dioxide, sweeteners, acids and sometimes caffeine. Production entails preparation of a concentrated sugar syrup. The syrup is mixed with carbonic acid and water and piped to the bottling machine. Bottles are prepared by washing, filled and inspected.

Beer – Beer making involves a series of heating, cooling and separating processes. The general steps in beer-making are summarized below:

- Malting: malting prepares the barley for brewing by releasing starch through steeping, germination and high-temperature drying or kilning;
- Milling: this serves to crack the grains, which are then referred to as grist;

- Mashing: the grist is mixed with hot water, and starches are converted to sugar for fermentation. The wort is separated from the grain residue by a series of spinning and filtering steps;

- Brewing: the wort is boiled in a copper vat and hops are added. Spent hops and other residues are subsequently removed;

- Cooling: the wort is transferred to a heat exchanger for quick cooling;

- Fermentation: the wort is transferred to a fermentation tank, and yeast is added to begin converting the wort sugar to alcohol;

- Racking: the beer is transferred to a conditioning tank for aging;

- Finishing: the beer may be filtered and carbonated; and

- Bottling: the beer is transferred to bottles.

Bottled Water – The bottled water category includes spring water, purified water, naturally sparkling water, and mineral water. Seltzer water is regulated as a soft drink. Sources of water that is bottled are typically springs or artesian wells. Municipal water supplies are also sometimes used. Source water is processed by treatment steps that may include filtration, ultraviolet light (UV), reverse osmosis, micro-filtration, distillation and/or ozonation. Steps for producing purified water deionization, distillation and reverse osmosis. Minerals (e.g., calcium, magnesium, and fluoride) may be injected to replace those lost during purification. The final step in production is bottling.

Juice – Juice has a high water content, which makes it susceptible to micro-organisms. Consequently processing hygiene is critical. After obtaining juice from whole fruit, an equalization process is needed to ensure product consistency. Bottling includes heat treatment at up to 80 degrees C. Products include:

- Direct juice: juice is pressed and processed directly

- Juice: some water is removed for transportation and re-added prior to bottling

- Nectar: contains 25 to 40 percent juice, added water and other ingredients

- Fruit juice drink: contains 6 to 30 percent juice, plus added sugar

5.6.2 Beverages – Sources and Characteristics of Process Wastewater

Wastewater from soft drink production may contain residuals of soft drink and syrup spills or leaks, effluent from bottle cleaning, lubricants associated with the machinery, and facility washdown water, including caustics and detergents. As a result, wastewater analyses will include total suspended solid (TSS), BOD, chemical oxygen demand (COD), nitrates, phosphates, sodium and potassium.

Similarly, wastewater from brewery processes tends to have high concentrations of BOD due to the organic product components, including sugars, soluble starch, ethanol and volatile fatty acids. The wastewater retains some of the heat from processing, ranging from 77 to 86 degrees F. Depending on the use of caustics and acids for cleaning, pH of the wastewater may be anywhere from 2 to 12. Nitrogen and phosphorous concentrations depend on raw materials.

Wastewater from juice processing will be similar to wastewater from other fruit processing, with high concentrations of organic matter that must be filtered to stabilize the wastewater and avoid fermentation and associated odors.

5.6.3 Beverages – Wastewater Treatment Options

The main objective in treating beverage processing wastewater is to reduce BOD loading. Kennedy/Jenks has observed that most soft drink and beer producers are located in urban areas, where they discharge to a sewer system. However, some form of pretreatment is generally implemented before discharging to the system. This typically includes both physical and chemical treatment steps. Physical methods remove solids by screening, grit removal and gravity separation. Chemical methods include pH adjustment and flocculation. Facilities with higher loadings or those that do not discharge to a sewer generally use a biological treatment to address the organic loading. Anaerobic biological treatment systems are used to reduce BOD concentrations from a few thousand to a few hundred. If further reductions are needed to meet permit limits, an aerobic system can be used. Kennedy/Jenks has observed that one of the biggest challenges for soft drink manufacturers is managing an unexpected spill or leak of concentrated product that results in an upset or failure of the biological treatment system.

5.7 Wineries

There are over 2,000 commercial wineries of all sizes in California. Facilities are clustered in the San Francisco Bay, North Coast, and South Coast regions, but the largest-scale facilities on a production volume basis are located in the Central Valley.

5.7.1 Wine – Production Steps

Winemaking involves a series of steps that are common to most wineries, but the equipment and practices employed vary by facility depending on production volume and winemaker preferences. Typical unit processes include:

- Crushing/destemming
- Pressing
- Fermentation
- Cellar Operations (racking/fining)
- Barreling/aging

- Filtration
- Wine Ion Exchange
- Bottling

In addition, some wineries also run distillation operations to produce brandy and other spirits. Activities in all wineries (except non-crushing facilities) are at a peak during the fall crush season. Following crush, a smaller crew continues with various production operations year-round at most facilities.

5.7.2 Wine – Sources and Characteristics of Process Wastewater

Sources of winery wastewater linked to the unit operations above include the following:

Tank Washing – spent wash water, cleaning agents and rinsewater used to clean and sanitize product storage and fermentation tanks

Filtration Cleaning – includes aggregate process wastewater generated from cleaning plate and frame pressure leaf, filter presses and other types of filters including milipore or nano filtration equipment

Centrifuge/Decanter – wastewater generated during cleaning and rinsing centrifuges and decanters

Barrel Washing – wastewater generated during rinsing, cleaning and sanitizing barrels

Bottling – wastewater from cleaning, sanitizing and rinsing bottles and bottling equipment, as well as wash water from cleanup of the bottling area

Boiler Water Blowdown – periodic blowdown from boiler operation

Cooling Tower Blowdown/Evaporative Condenser Bleed – blowdown from cooling tower or evaporative condenser bleed stream used from refrigeration and chilling operations

Spent Water Softener Regenerant – spent concentrated sodium chloride solution used to regenerate the water softener resin

Wine/Juice Ion Exchange Regenerant – spent concentrated acid used to regenerate the wine or juice ion exchange resin

Stillage – stillage or bottoms product generated from distillation operations

The greatest flows of winery wastewater occur during the crush season in late summer or fall. Lower flows occur during the rest of the year as various aging and bottling steps continue.

5.7.3 Wine – Wastewater Treatment Options

Treatment options for winery wastewater include physical and chemical processes to remove solids (lees, stems and seeds); biological processes to remove organic matter; and membrane or thermal evaporation processes to remove salts. Selection of the treatment technology or combination of technologies that will be most effective at a particular winery will depend on the volume and strength of the wastewater, availability of land for irrigation, and the discharge objectives. Kennedy/Jenks has observed that many wineries are located in rural areas where discharge to a sewer is not available. As a consequence, many small to medium-sized wineries use aerated pond systems. Treated effluent from the ponds is used for irrigation. Kennedy/Jenks has also worked with smaller wineries where septic systems have been used with good results for low flows; however, this approach is discouraged in some areas.

For larger wineries and those that can discharge to a POTW, pretreatment for partial reduction of organic loading, nitrogen and suspended solids may be necessary. If the wastewater will be reused for irrigation, biological anaerobic and/or aerobic pretreatment may be required in order to obtain permit for the discharge, as described in Section 5. In some cases, this can be accomplished with packaged treatment plants.

Section 6: Regulation of Wastewater from Food and Beverage Processing

Wastewater discharged from food and beverage processing facilities in California is highly regulated. Various Federal, state and local agencies may be involved, depending on the nature of the discharge, location of the facility, and other factors. An overview of applicable water policy that is the basis for these regulations is provided for reference in Appendix C. Specific regulations that apply to California dischargers are summarized below, with a goal of highlighting constraints and opportunities that may influence selection of disposal methods and treatment technologies.

This discussion includes requirements for California processors opting to manage wastewater by (1) land treatment, including pond, subsurface and irrigation methods; (2) discharge to surface water; (3) discharge to a municipal sewer system; and (4) discharge of high-strength wastewater to a digester for biogas generation. The potential impact of pending climate change legislation on wastewater management is also addressed. For land treatment, the requirements and programs that vary by geographic region are highlighted. Portions of this discussion were adapted from the *Manual of Good Practices for Land Application of Food Processing/Rinse Water, 2nd Edition* (California League of Food Processors, 2007); the *Comprehensive Guide to Sustainable Management of Winery Water and Associated Energy* (Wine Institute and Kennedy/Jenks, 2008); and the website of the California State Water Resources Control Board (SWRCB).

Although the information in this report is current as of the publication date, the regulations, policies and their interpretation are subject to change over time. It remains incumbent upon the discharger to contact regulatory agency representatives in their region to ensure they are aware of all applicable requirements, including site-specific considerations.

6.1 Permits for Discharge to Land

Food and beverage processors that intend to discharge wastewater to land must obtain a permit from the California Regional Water Quality Control Board (CRWQCB) in their region. PG&E's territory (Figure 1) spans four of the CRWQCBs (Figure 2):

Region 1 – North Coast

Region 2 – San Francisco Bay

Region 3 – Central Coast

Region 5 – Central Valley

Source:
'Boardview.pdf' - downloaded from the State Water Regional Control Board website (http://www.swrcb.ca.gov)

Kennedy/Jenks Consultants

Energy Use in Wastewater Treatment in the Food and Beverage Industry
San Francisco, California

California Regional Water Quality Control Boards

08065010.00
October 2010

Figure 2

Permits are issued by CRWQCBs as a set of Waste Discharge Requirements (WDRs). Before WDRs can be issued, a discharger must submit a Report of Waste Discharge (ROWD) to the CRWQCB describing their site, production operations, and wastewater management practices. The ROWD typically includes detailed information on site soil and groundwater characteristics, production output, rates of water use and wastewater generation, wastewater chemistry, and existing treatment systems. Any planned improvements or expansions should also be described to ensure they are accounted for in the resulting permit. If a company decides to expand their facility or make changes in their wastewater management practices after a permit has been issued, they will need to inform CRWQCB of these plans. In most cases, they will be asked to submit a revised ROWD to obtain an updated permit.

Some of the challenges encountered by facilities seeking new or updated WDRs are a function of their location, facility type, size of operations, and discharge characteristics, as discussed below. Companies with comparable facilities in several different CRWQCB regions may find that requirements and expectations of agency staff in each region vary. As a result, the most appropriate wastewater management strategy and permit conditions must be identified for each discrete facility location. This approach is consistent with research on best practices for land application that has shown there is no "cookbook" methodology for designing a land application system to ensure groundwater protection. Rather, best management strategies must be determined on a site-specific basis, with reference to available guidance (Wine Institute, 2008; CLFP, 2007). Characteristics of each CRWQCB within the PG&E territory and differences in permitting programs are summarized in the subsections below.

6.1.1 Region 1 – North Coast

The North Coast CRWQCB spans a significant geographic area extending from the Oregon border through Del Norte, Siskiyou, Humboldt, Trinity, Mendocino and a portion of Sonoma Counties. PG&E territory includes only the portion of Region 1 in Humboldt, Mendocino and Sonoma Counties. Food processing facilities in this region are primarily wineries. Retail bakeries are the second most common operation, and there are smaller numbers of each of the other subject sectors.

The region generally records the highest precipitation totals in the state. Groundwater is encountered at relatively shallow depths and generally characterized as good quality. Considering the precipitation rates, North Coast CRWQCB limitations on wastewater discharge are typically less restrictive than in other parts of the state.

For winery waste discharges to land, the North Coast adopted a General WDRs Order on 14 March 2002 (Order No. R1-2002-0012). Key provisions of the General WDRs are summarized as follows:

- Any existing or new winery that does not have a permit must apply for General WDRs.
- North Coast CRWQCB will consider transferring wineries with existing individual WDRs to the General WDRs program at the time of permit renewal.

- The Executive Officer (EO) of the North Coast CRWQCB may require a winery to maintain individual WDRs if their operations are larger than or different from the range of conditions addressed by the General WDRs.
- The General WDRs include numeric effluent limits for spray irrigation, frost protection and drip irrigation. Ponds must be maintained with 1 mg/l dissolved oxygen (DO) and 2 feet of freeboard.
- The General Monitoring and Reporting Program (MRP) associated with WDRs may include groundwater monitoring, at the discretion of the EO.
- The winery must submit a Notice of Intent (NOI) to be covered under the General WDRs, and under the California Environmental Quality Act (CEQA), must publish a public notice to that effect.
- Coverage under the General WDRs can ordinarily be authorized by the Executive Officer, whereas Individual WDRs can only be adopted by action of the Board.

Small, non-commercial wineries producing less than 200 gallons of wine per year can apply for a waiver from WDRs, provided that the discharge is to land and no adverse water quality impacts are anticipated.

For non-winery food processors, the region does not offer options for a general permit or waiver. Therefore processors that discharge wastewater to land need to apply for individual WDRs. The North Coast CRWQCB database of adopted waste discharge orders in the region showed very few food processors in the PG&E territory.

6.1.2 Region 2 – San Francisco Bay

The San Francisco Bay CRWQCB includes portions of Marin, Sonoma, Napa, Solano, Contra Costa, Alameda, Santa Clara, San Mateo and San Francisco Counties. The entire region is served by PG&E, with small, localized exceptions. A variety of food and beverage processors and wineries are present in rural parts of Sonoma, Napa and Marin. Other processing facilities are located in communities where connections with a sewer system are utilized. Nonetheless, onsite pretreatment is often needed to meet the requirements of local discharge ordinances or to reduce fees for excess loading.

For wineries in Napa County, the San Francisco Bay CRWQCB has signed a Memorandum of Understanding (MOU) with the County that gives the County authority for regulating winery wastewater management onsite. Key provisions of the County's program are summarized below:

- The County issues discharge requirements to winery pond operators which specify standards for pond operation and for use of treated water from the ponds.
- Objectives are odor control and minimizing any nuisance conditions from ponds and irrigation areas and associated runoff.

- Ponds must be maintained with pH of 6 to 9, a minimum of 2.0 parts per million dissolved oxygen, and minimum freeboard (the distance from the top of the water to the top of the berm) of two feet.

- Water discharged from winery wastewater ponds can only be used to irrigate vineyards or other agricultural land, and must have BOD less than 50 mg/l and dissolved sulfides less than 0.1 mg/l.

For confined animal facilities (CAFs), the San Francisco Bay CRWQCB adopted a General WDRs Order (Order No. R2-2003-0093). The primary types of CAFs covered by the order are cow dairies, horse facilities, a few goat dairies, and a few egg, chicken, and/or turkey production facilities. The majority of covered facilities are cow dairies in Marin and Sonoma County. There are approximately 51 cow dairies currently operating in the Region. Other types of processors that are not covered by this Order or the MOU need to obtain individual WDRs.

6.1.3 Region 3 – Central Coast

The Central Coast CRWQCB covers a long, narrow area adjacent to the coastline that includes the southern portion of Santa Clara County, and Santa Cruz, San Benito, Monterey, San Luis Obispo and Santa Barbara Counties. PG&E's service area covers the entire region, with the exception of the southern portion of Santa Barbara County.

The region has General WDRs and waivers for both small wineries (Order No. R3-2008-0018) and fruit and vegetable processors (Order No. R3-2004-0066). Small wineries are eligible for a waiver from WDRs and associated monitoring under the following conditions:

- Winery crushes less than 160 tons of grapes per year, producing less than 10,000 cases or 26,000 gallons of wine per year.

- Depth to groundwater is greater than 50 feet below ground surface (bgs), or greater than 8 feet bgs if the wastewater is to be used for vineyard irrigation

The General WDRs provide specifications for various aspects of pond construction, constructed wetlands, soil absorption system design, operations, effluent reuse, solids disposal, and effluent and groundwater limitations. Key specifications are noted below (refer to the Order for the complete list):

- Ponds must be lined with either a membrane, 2-feet of low permeability soil (less than 10^{-6} centimeters per second, or an approved engineered alternative.

- At sites with new subsurface disposal systems, land must be reserved to allow for 100 percent replacement of the disposal area.

- Subsurface disposal systems must have sufficient clearance above groundwater. The required distance between the trench bottom and groundwater is as follows:

Percolation rate (minutes/inch)	Distance from Trench to Groundwater (feet)
< 1	50
1-4	20
5-29	8
>30	5

- Discharges to land must have BOD loading of less than 300 pounds per acre per day at any time.
- General MRP may include groundwater and/or disposal area monitoring.
- A winery must submit a NOI to be covered under the General WDRs (equivalent to ROWD)

Smaller fruit and vegetable processors may be eligible for a waiver from WDRs if they meet one of the following conditions:

- Discharge less than 5,000 gallons per day of process wastewater, and are located in an area where the depth to groundwater is greater than 100 feet below ground surface
- Discharge less than 10,000 gallons per day of process wastewater, with adequate depth to groundwater and a sufficiently large disposal area. To apply for the waiver thee processors must submit a ROWD/NOI for approval by the Central Coast CRWQCB.

6.1.4 Region 5 – Central Valley

The Central Valley CRWQCB covers a large, predominantly agricultural portion of the state extending from the Oregon border through a portion of Kern County. Most of the region is within PG&E's territory, except Tulare County, a portion of Kern County, and portions of Siskyou, Modoc and Shasta Counties in the north state. Some communities within the PG&E footprint are served instead by local irrigation districts. Both Region 5 and PG&E exclude the areas on the eastern side of the Sierra Nevada range. Central Valley CRWQCB staff is based in three offices – Redding, Sacramento, and Fresno. Compliance expectations of staff in each of the offices sometimes differ.

For dairy farms, Region 5 has a General WDRs program for Existing Milk Cow Dairies (Order No. R5-2007-0035). The order was adopted on 3 May 2007, and as of March 2009 the program covered 1,467 dairy farms out of an estimated 1,600 in the region. Monitoring conducted by the CRWQCB has shown that groundwater impacts (increased salinity and nitrates) have occurred below dairy farms; accordingly, the General WDRs program promotes implementation of best practicable treatment or control practices to avert pollution and nuisances. The provisions of the order include operating specifications and design standards for construction of new lagoons or ponds and expansions. The order also contains requirements for land application to preclude groundwater impacts. Each dairy must implement their Waste Management Plan in 2011 and Nutrient Management Plan by 2012.

For Small Food Processors and Wineries, Central Valley CRWQCB has a waiver program (Order No. R5-2009-0097). Food processors (except meat processors) that discharge less than 100,000 gallons to land per year can apply for the waiver. Wineries that crush less than 80 tons are eligible, and can land apply all process wastewater associated with this crush amount. To be covered under the waiver, applicants must submit a ROWD with detailed information about their operations. Key specifications of the waiver include the following:

- Process wastewater and residual solids cannot be held in a surface impoundment, pond or lagoon.
- Process wastewater and residual solids cannot be discharged to a septic system.
- The discharger shall take all reasonable steps to reduce the salinity of the wastewater that is applied to land.
- A waiver can be used by small processors and wineries that store any amount of wastewater in a tank onsite prior to hauling it offsite to a permitted treatment and disposal facility.

Due to existing groundwater quality concerns, Kennedy/Jenks has observed that individual WDRs for processors in this region tend to be established with more stringent conditions than permits in other parts of the state. Groundwater quality is threatened by high concentrations of salinity and nitrate nitrogen, which are attributable to a range of factors, including naturally occurring geologic materials, septic systems, legacy farming and irrigation practices, and use of irrigation water imported from the delta that contains elevated salt concentrations. In response to these conditions, the Central Valley CRWQCB has established the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) group, which is a collaborative planning effort aimed at developing basin plan amendments and implementing a comprehensive program for salinity and nitrate management. Food processors and wineries are encouraged to participate in this process. The outcome is likely to influence the level of effort required to obtain a permit, the acceptable treatment methods, and effluent quality standards.

Recent permits have been challenged by a non-profit environmental organization which contends that land application should not be exempt from Title 27 requirements. Under Title 27, dischargers must comply with design standards that were developed for containment of hazardous waste. To be exempt from Title 27, permit applicants must provide more comprehensive data to demonstrate that their operations will not impact groundwater before the permit is issued. In the past, permits were generally written to allow operations to proceed as long as monitoring was appropriate to verify that impacts were not incurred. Until these challenges are resolved and/or additional permits are adopted that serve as precedents, it will be difficult to predict the standards that will be upheld for future permit applicants or renewals. As a result, dischargers in this region who are selecting wastewater treatment and disposal strategies are advised to assume that more stringent permitting and compliance requirements will be forthcoming, and factor that into their decision-making process.

6.2 Permits for Discharges to Surface Water

WDRs for discharges to surface water are issued as NPDES permits. The SWRCB or CRWQCBs will issue WDR/NPDES permits based on the type of production activity, characteristics of discharge, treatment or containment method, receiving water quality, and other factors. Permits require pretreatment and include self-monitoring programs that require collection of water quality data. NPDES permits expire after five years and must be reissued.

In general, NPDES permits are significantly more difficult to obtain and comply with than WDRs for land application. During the public hearing process required for permitting, stakeholders often challenge new discharges as a potential threat to water quality and beneficial uses. Some permits are issued with limitations contingent on the flow and chemistry of the receiving water, in addition to limitations on the discharge itself. As a result, dischargers must have an alternate plan for wastewater management during periods of time when the surface water discharge is not available.

A significant concern for NPDES permit holders is the risk of incurring Mandatory Minimum Penalties (MMPs) for certain permit violations. These can result in large fines that accrue on a daily basis in some cases, regardless of whether the violation was willful, accidental and or the result of negligence. Considering the threat of MMPs as well as the difficulties encountered in permitting, most processors avoid pursuing new NPDES permits, and typically consider other options at the time of NPDES permit renewal.

6.3 Permits for Discharges to a Municipal System

The permitting process and associated effluent limitations for discharge of wastewater to a POTW vary locally, but POTWs are still accountable for meeting the requirements of the NPDES and National Pretreatment Programs, as noted in Section 6.1 above. In some communities, a pretreatment ordinance was established by the city, whereas in others areas a county agency is responsible. In most cases, some form of pretreatment will be needed to avoid fines for permit violation and discharge volume limits may be specified. Some POTWs have sufficient capacity to accept flows and concentrations greater than permit limits for additional fees, either on a temporary or ongoing basis within PG&E's service area

As NPDES permits for POTWs become more stringent, this pressure is transferred upstream to industry in the form of either more restrictive limits or higher discharge fees. In some communities, dischargers are under pressure to help finance new POTW facilities in order to meet permit requirements. These costs may lead processors to consider onsite pretreatment options more closely, potentially in conjunction with land application to avoid discharge fees entirely, in locations where site conditions are conducive.

6.4 Permits for Use of Anaerobic Digesters

Facilities that plan to discharge high-strength process wastewater, such as dairy manure, to an anaerobic digester for biogas production will need to manage not only the facility's wastewater effluent in accordance with WDRs or a NPDES permit, as appropriate, but also the air quality impacts of the digester. When the biogas (principally methane) is converted to electricity, nitrogen oxides (NOx) are produced. In the Central Valley, NOx emissions are limited to control smog by the San Joaquin Valley Air Quality District (based on Federal standards). Low NOx equipment can be costly, and may make digester projects infeasible. In addition, the system will require a permit from local air pollution control district (APCD) or air quality management district (AQMD) to flare any excess gas that is not needed.

6.5 Impact of Pending Climate Change Legislation

At the time of this publication, an array of legislative initiatives to reduce the rate of climate change through greenhouse gas (GHG) control and carbon accounting are proposed at both the state and Federal level (or adopted, in the case of California Assembly Bill 32, but still potentially subject to further modification). Although the specific requirements of the final legislation cannot be predicted, an eventual impact on conventional wastewater management practices is anticipated. For example, volatile organic substances in wastewater applied to land may be further restricted to preclude volatile emissions, and aerobic treatment methods that rely on biological activity to reduce organic content could conceivably be limited. Increasingly, there may be conflicts between air and water regulatory agencies, as the optimal wastewater treatment methods from a GHG control perspective may be less than optimal, or even detrimental to other environmental media.

Section 7: Related Food and Beverage Industry Surveys

During the initial background research, two closely related surveys were identified that warrant discussion herein.

7.1 Brewers Association Wastewater Management Survey

The Brewers Association is an international organization comprised of more than 1,000 brewery members, as well as members of the American Homebrewers Association and allied trade and distribution companies. The Brewers Association conducted a survey of its members in 2009 to assess water use and wastewater management practices and costs. A total of 76 breweries of all sizes completed the survey. A brief summary of the survey results follows as Table 5.

Table 5: Summary of Brewers Association Survey Results

		Discharge Point			Treatment Technology			
Facility Size	Total Responses	Municipal treatment facility	Onsite septic	Collect for discharge elsewhere	pH adjust or EQ	Solids removal, settling or screening	Anaerobic digestion	Aerobic treatment
0-1,000 bbl	19	17	2	0	5	3	0	0
1,001-5000 bbl	18	15	3	2	3	5	2	2
5,001-15,000 bbl	9	9	0	2	2	4	0	0
15,001-50,000 bbl	10	9	1	0	3	5	0	1
50,001-100,000 bbl	9	9	0	2	5	3	1	3
100,001 + bbl	11	10	0	2	5	4	2	1
TOTAL	76	69	6	8	23	24	5	7

Notes:

bbl = barrel of beer
1 bbl = 31 gallons
EQ = equalization tank

7.2 Poultry Industry Wastewater Management Survey

A graduate student at the University of Georgia conducted research on wastewater management practices in the U.S. poultry processing industry using a mail-in survey (Kiepper, 2003). The survey received 58 responses from 16 states (two of the responses were from California). Operations at more than 75 percent of the facilities included slaughter, cut-up and deboning; additional operations varied. Based on the number of production staff (averaging 756 employees), these were relatively large facilities. All of the plants had a permit for either land discharge or sewer discharge. Treatment or pretreatment processes that were reported are summarized in Table 6 below.

Table 6: Summary of Poultry Industry Survey Results

Treatment Process	Typical Technology	Number of Plants	Percentage of Plants
Physical	Screening	48	84
Physical/chemical	DAF	42	74
Biological	Anaerobic digestion Activated sludge Aerated lagoon Facultative lagoon Pack tower	34	60

Adapted from Kiepper, 2003.

Most facilities used a combination of two or all three of the treatment process. Physical screening, followed by a DAF system is the most widely used. This is followed by activated sludge system, aerated lagoon or anaerobic digestion at many facilities. Treatment problems that were reported included:

- Poor DAF sludge separation
- Poor phosphorous removal
- Activated sludge bulking
- Sour anaerobic digester
- High effluent nitrate concentrations
- Denitrificaton in clarifier
- High effluent BOD concentrations

The most common solutions involved addition of chemicals. Other options included mechanical adjustments, DO adjustments, pollution prevention, and to a lesser extent, addition of microbes to enhance biological activity or adjustments to activated sludge biomass.

Section 8: PG&E Survey Results

Full survey results are summarized in Appendix B, and findings are highlighted below.

8.1 Respondents

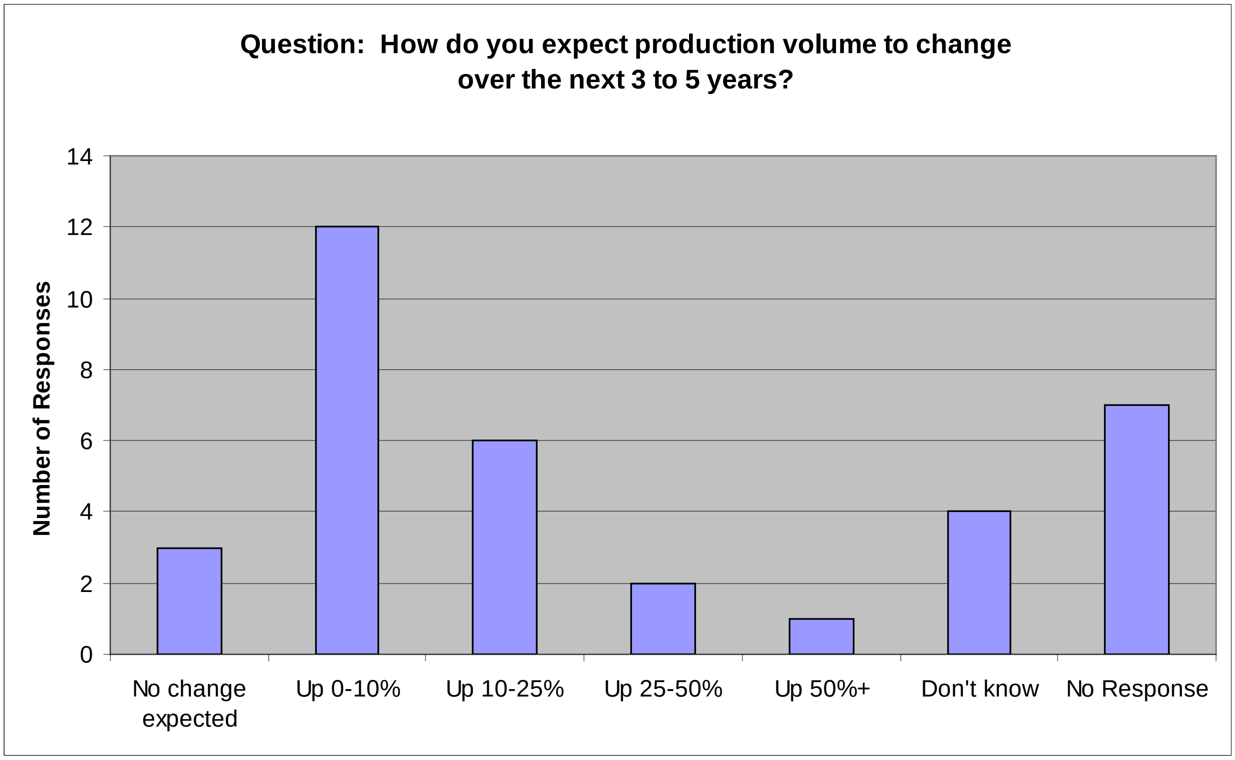
Surveys were completed online and by telephone for a total of 39 facilities. The initial outreach efforts to industry groups led to completion of 14 surveys online, and the balance were completed through telephone interviews. As detailed in Section 2, facilities were identified for telephone interviews using a list of customers supplied by PG&E, by referral from PG&E sales and service representatives, through Kennedy/Jenks contacts, or by referral from equipment suppliers.

Although responses were obtained from all sectors, the numbers varied. By following the implementation of the voluntary, online survey with telephone interviews, it was possible to target and address some of the data gaps. For example, meat processors did not complete the survey online, but several provided input when contacted directly by telephone. Dairy farms were the most difficult sector to reach because they did not respond to the online survey and they were not included in PG&E's customer database. Although the response rate for fruit, vegetable and nut processors was relatively low, information on treatment practices in this sector was available from literature sources, such as the Manual of Good Practice for Land Application of Food Processing/Rinse Water (CLFP, 2007), as well as from Kennedy/Jenks' experience working with these processors.

8.2 Facility Background Information

The majority of survey respondents were either PG&E customers (17 out of 39), or they declined to state their gas and electric provider (19 out of 39). Six of the respondents indicated they were served by another power company. Many respondents (19 of 39) estimated that their company's production would increase in the future, while others did not respond (12 of 39) as shown on Figure 3 below.

Figure 3: Survey Results for Production Volume Changes

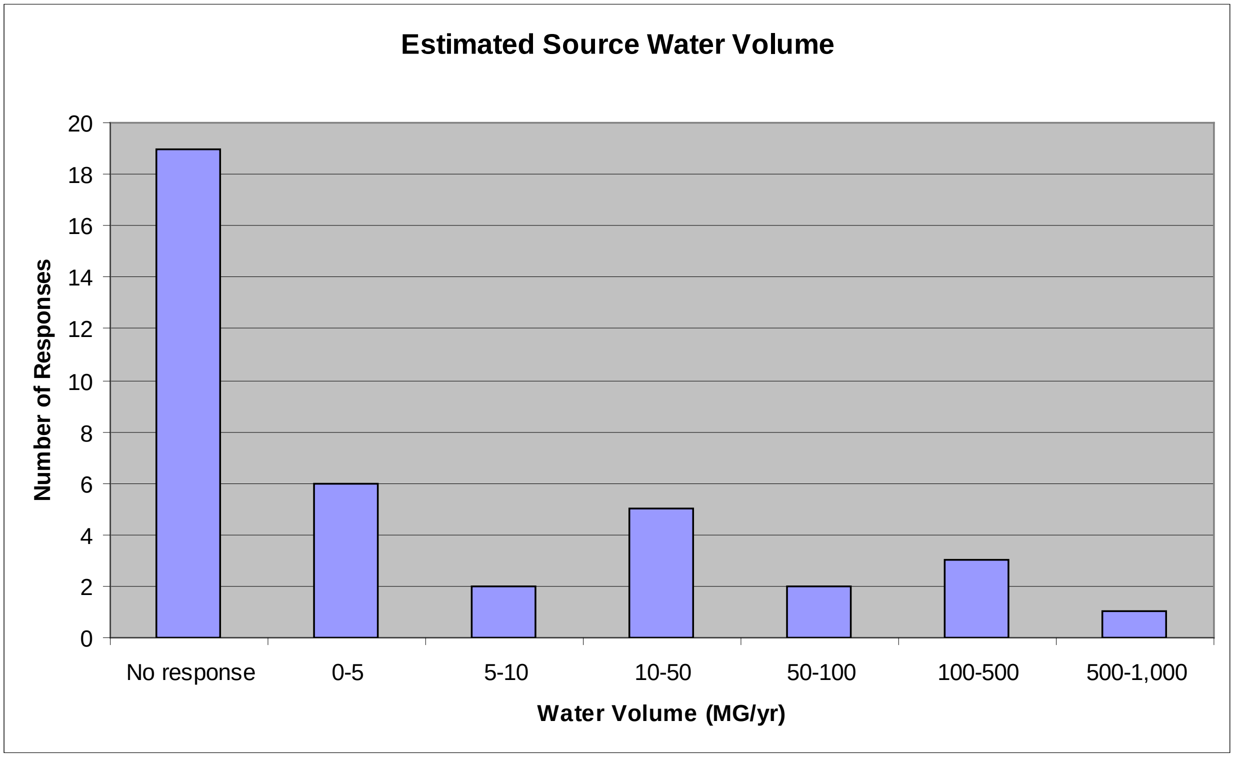


Note: None of the respondents indicated production was expected to decline.

8.3 Water Use and Conservation

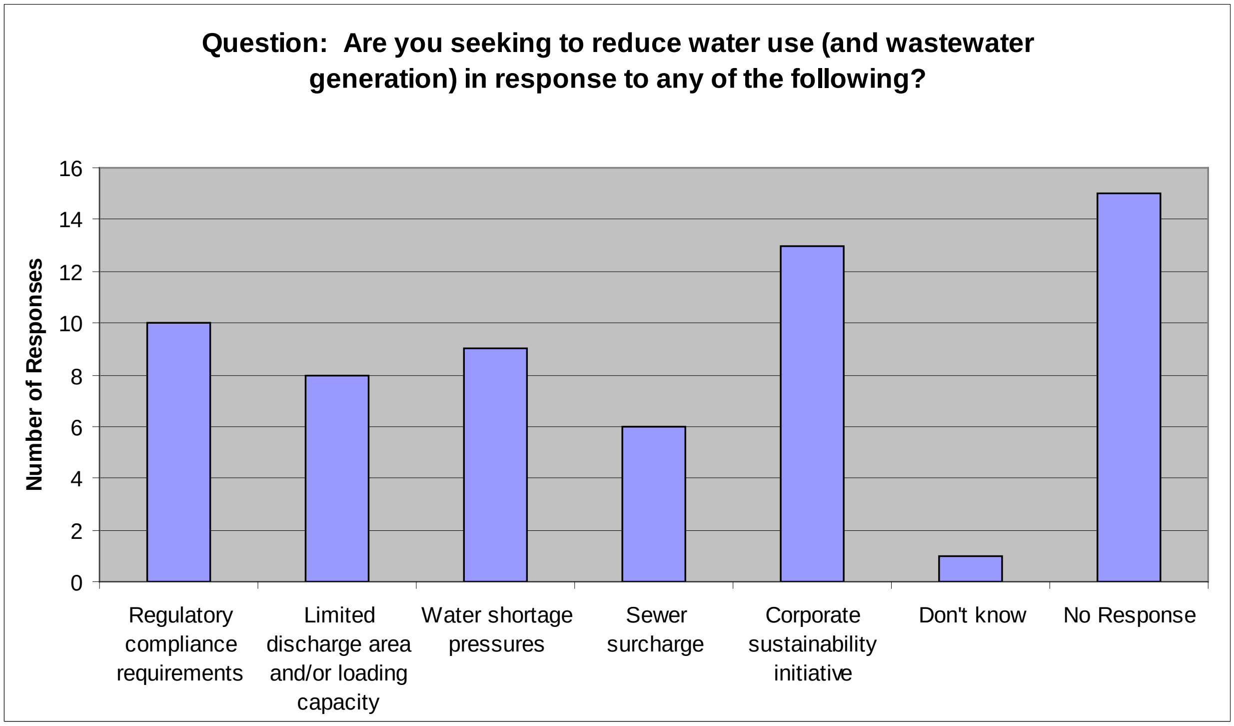
Just over half of survey respondents reported that they monitor their water use. Seven respondents indicated they did not monitor water use, while ten did not respond. Among facilities that monitor their water use, annual volumes ranged from 0 to more than 1,000 million gallons per year, as shown on Figure 4:

Figure 4: Survey Results for Water Use



Survey respondents attributed water and wastewater reduction efforts to a variety of factors, as shown on Figure 5:

Figure 5: Survey Results for Drivers for Water and Wastewater Reduction



8.4 Wastewater Management

The technologies used by processors in each sector are summarized on Table 7 below. In most sectors, the number of technologies selected by respondents exceeds the total number of responses from that sector, confirming that facilities utilize multiple technologies (the question asked respondents to check all that apply).

Table 7: Survey Results for Treatment Technologies

		Number of Survey Respondents	Treatment Technology								
			Solids separation/ screening	Aerated pond/tank	Anaerobic Treatment	Activated sludge	Membrane treatment	None	Don't Know	Other	No Response
1	Fruit/Vegetable/Nut	4	3	1	1	0	0	0	0	1	0
2	Poultry Processors	8	7	3	3	1	1	0	0	2	1
3	Wineries	7	2	4	0	1	0	1	1	0	1
4	Dairy Farms	2	2	1	1	0	0	0	0	2	0
5	Dairy Processors	8	1	2	0	0	1	2	0	1	3
6	Meat Processors	4	3	0	0	0	0	0	0	3	1
7	Beverages	6	2	1	1	0	0	2	0	3	0
	Total:	**39**	**20**	**12**	**6**	**2**	**2**	**5**	**1**	**12**	**6**

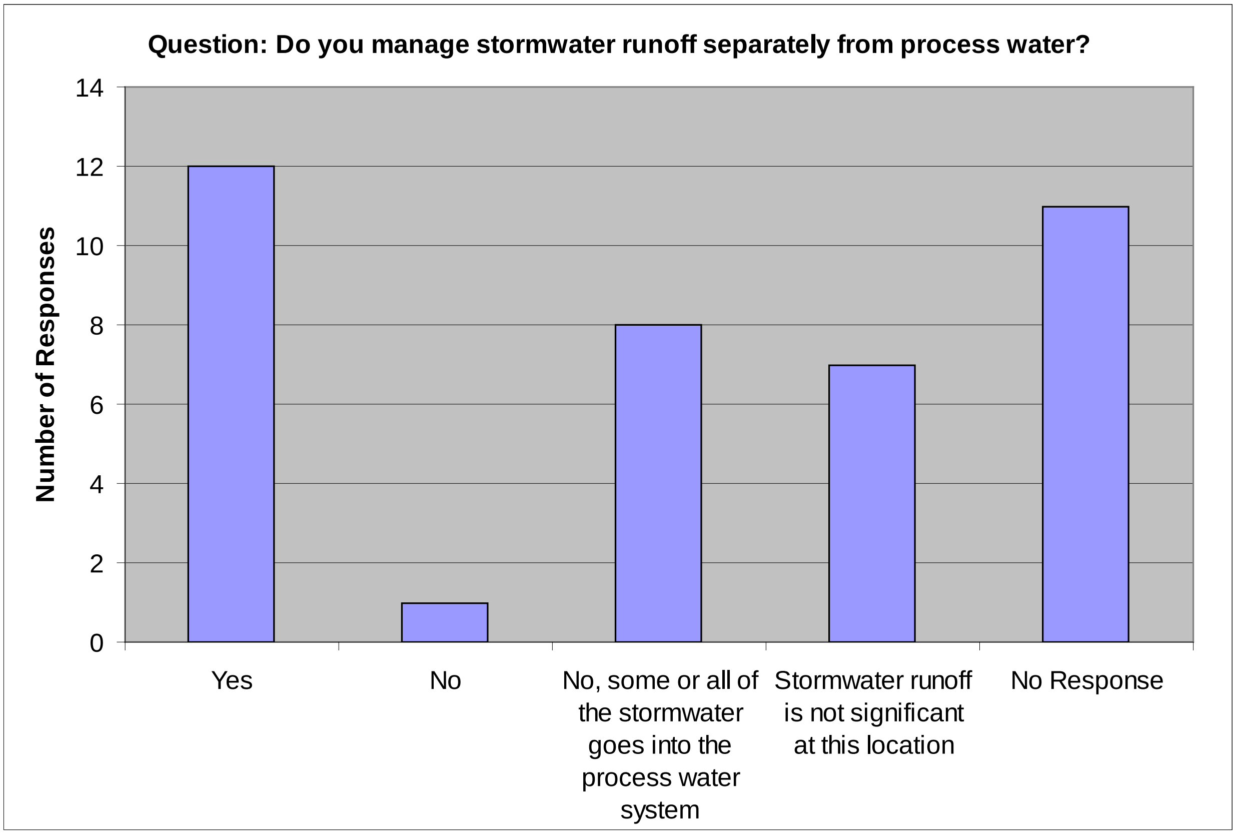
Responses regarding the facility's effluent discharge location illustrate that few processors rely on surface water discharges, given the challenges of obtaining a NPDES permit. As shown in Table 8, respondents were evenly divided between sewer discharge and land application or other onsite methods:

Table 8: Survey Results for Discharge Location

		Number of Survey Respondents	Discharge Method								
			Irrigation	Land Application	Onsite Septic System	Sewer	Constructed Wetlands	Groundwater	Surfacewater	Other	No Response
1	Fruit/Vegetable/Nut	4	1	3	0	3	0	0	0	0	0
2	Poultry Processors	8	0	2	0	5	0	0	0	0	1
3	Wineries	7	3	4	1	1	0	0	0	1	1
4	Dairy Farms	2	1	1	0	0	0	0	0	0	1
5	Dairy Processors	8	1	1	0	4	1	0	0	0	2
6	Meat Processors	4	0	1	0	2	0	0	0	0	1
7	Beverages	6	1	0	1	5	0	0	1	0	0
	Total:	**39**	**7**	**12**	**2**	**20**	**1**	**0**	**1**	**1**	**6**

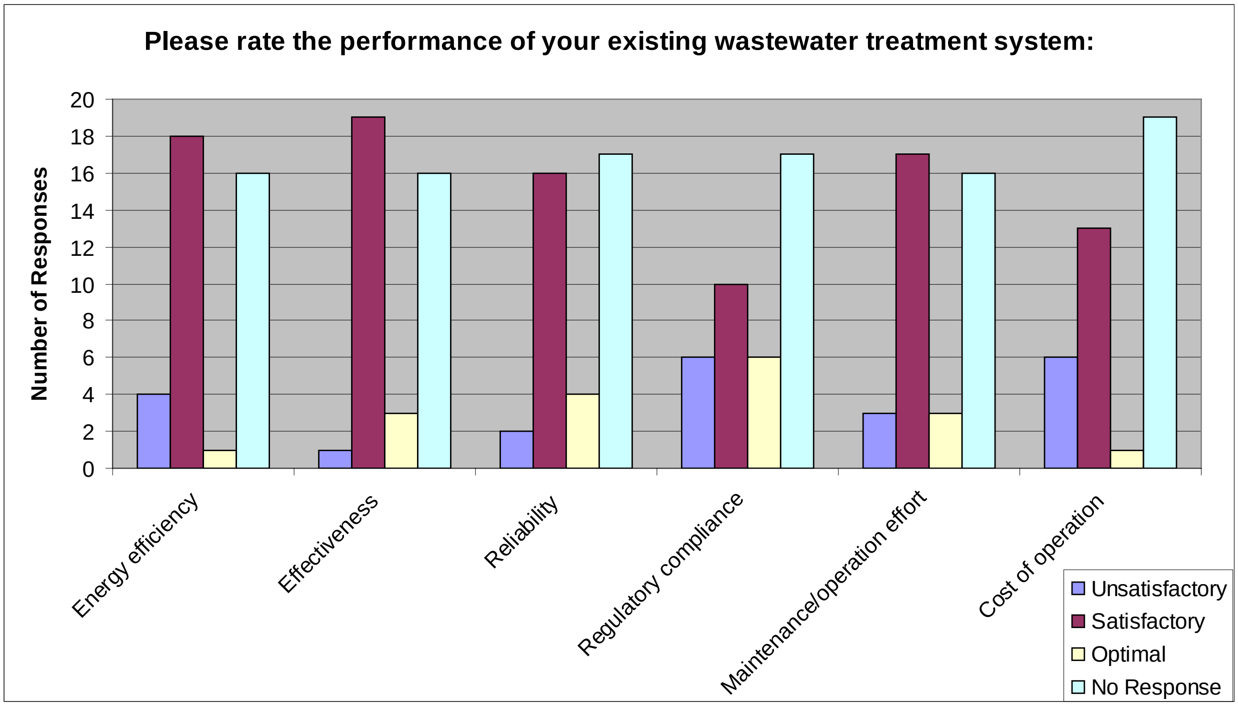
Responses to a question regarding stormwater management were diverse (Figure 6). Almost a third of respondents (12 of the 39) did indicate they manage stormwater separately from process water, which is generally a preferred approach for treatment efficiency.

Figure 6: Survey Results for Stormwater Management



Respondent evaluations of treatment system performance over a range of factors are summarized in Figure 7 below. While a significant number of the respondents were either unable or unwilling to provide this evaluation, of those who did, the majority indicated they were satisfied with their systems. Treatment effectiveness and energy efficiency received the highest satisfaction ratings, while regulatory compliance received the lowest. In a subsequent question asking whether their company planned to make changes to the treatment system, the overwhelming majority (34 out of 39) opted not to respond, while six said yes.

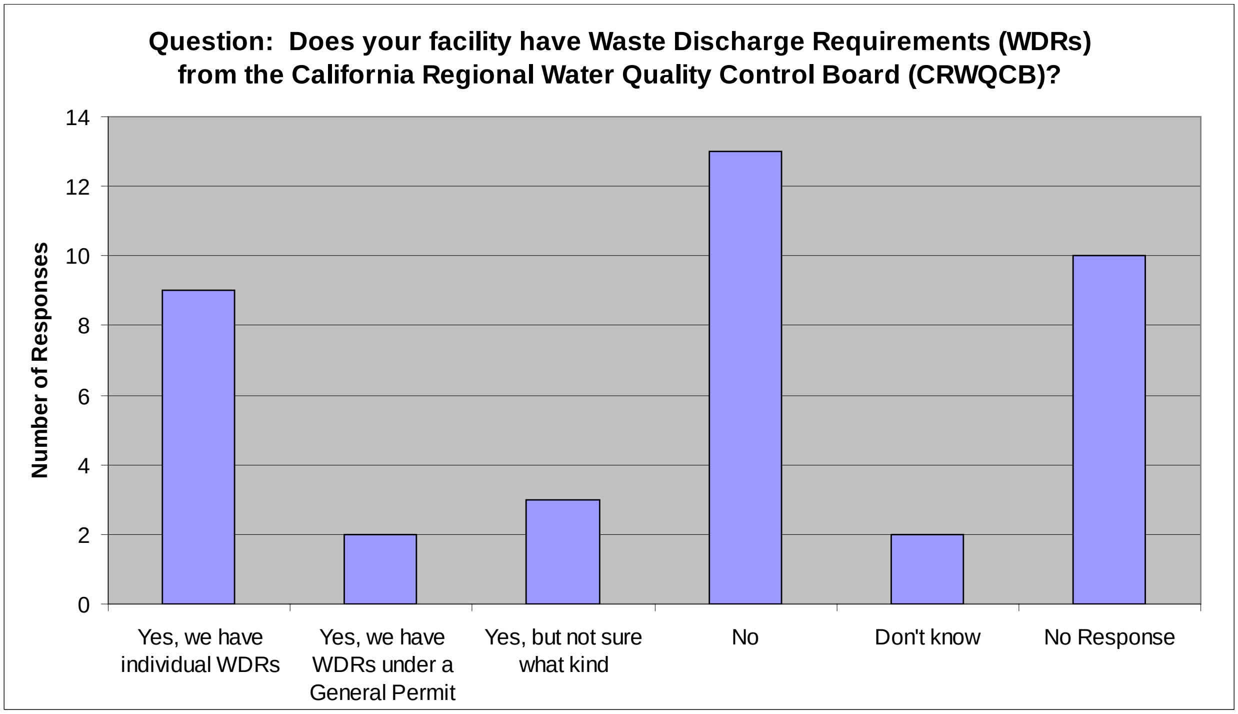
Figure 7: Survey Results for Wastewater Treatment System Performance



8.5 Regulatory Agency Permits

The wastewater discharge permitting status of respondents is shown on Figure 8. Those that do not have WDRs are likely to discharge to a POTW.

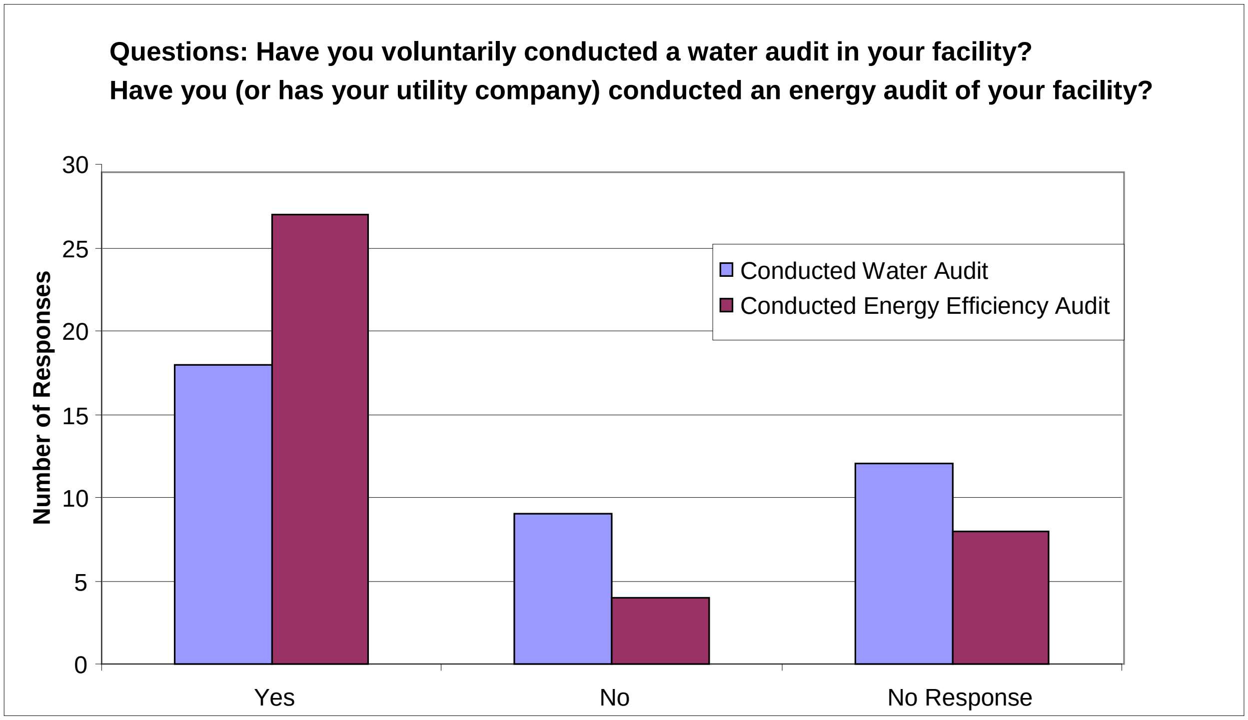
Figure 8: Survey Results for Discharge Permits



8.6 Energy Management

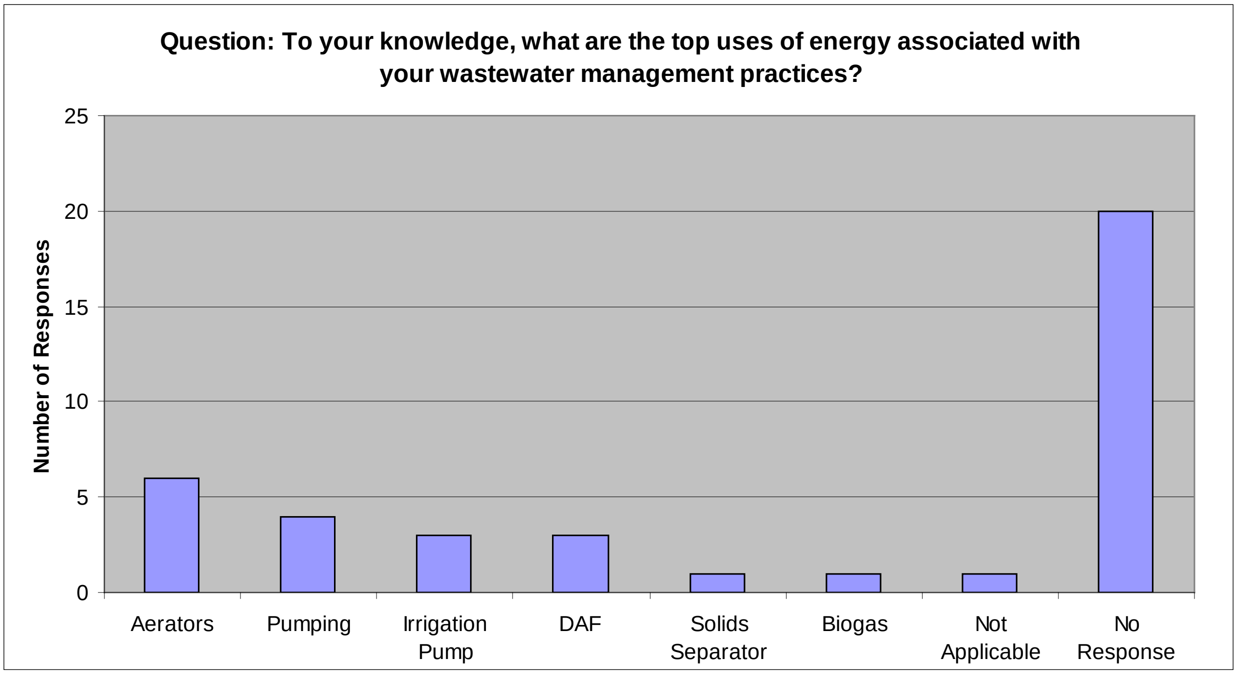
Figure 9 shows the number of respondents who have had energy audits in their facility, compared to the number that have had water audits. As expected, more companies reported prior energy audits than water audits.

Figure 9: Survey Results for Water and Energy Audits



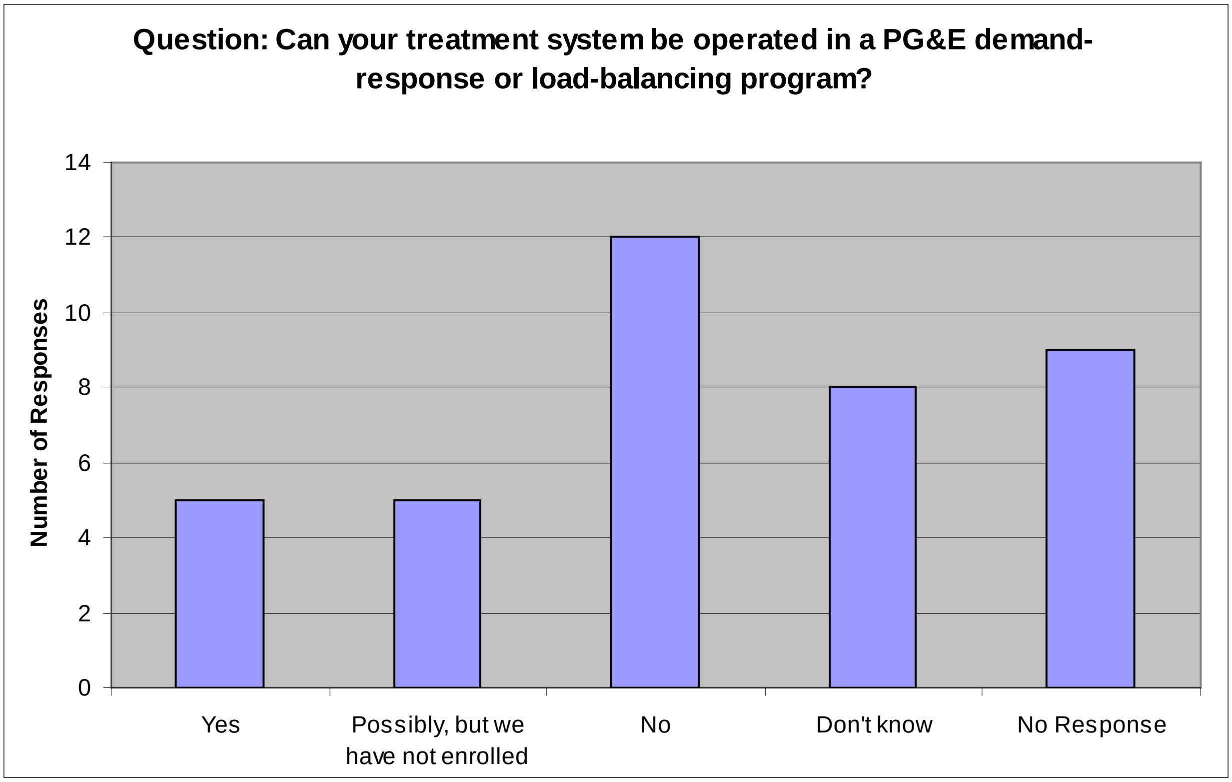
When asked to select the top uses of energy associated with their wastewater management practices, half of the respondents indicated they did not know (Figure 10). This suggests that there may an opportunity for education.

Figure 10: Survey Results for Energy Use for Wastewater Management



The survey included a question regarding participation in demand-response or load-balancing programs. Responses varied (Figure 11).

Figure 11: Survey Results for Demand-Response Participation



Section 9: Energy–Saving Potential of Treatment Technologies

This section provides an assessment of the energy savings that could potentially be achieved through best practices for optimal installation (including equipment and design) and operation of the five types of treatment technologies that are the main focus of this study. Further energy savings may be realized from installation of new or emerging treatment technologies, but consideration of those options was beyond the scope of the study. In the absence of direct energy measurements from treatment at food processing facilities, estimates of energy savings that were achieved through best practices at municipal treatment systems are first provided for reference below. This information is followed by qualitative evaluation of the energy efficiency opportunities for each of the treatment technologies individually.

9.1 Municipal Wastewater Treatment

Estimates of the amount of energy required to treat wastewater at municipal facilities, which have been investigated in more detail than industrial facilities, ranged from 1,073 to 4,630 kWh per million gallons using varying technologies (SWB, 2002). Food and beverage processing facilities are generally smaller than municipal plants and may require more energy per volume of treated wastewater. Food and beverage facilities can also generate wastewater with substantially higher BOD concentrations than municipal plants, which may translate to higher energy demand relative to municipal plants.

Best practices for energy efficiency at municipal wastewater treatment systems have also been the focus of more research than industrial treatment systems; lists of municipal system best practices can be found in the literature. Table 9 shows a subset of the municipal treatment best practices that are applicable for food and beverage operations. The list only includes energy efficiency measures that are related to water and wastewater management (e.g., lighting is not addressed). To convert from percentages of energy savings to units of energy that can be saved at food processing facilities, however, it will be necessary to conduct direct monitoring of energy use.

Table 9: Opportunities to Improve Energy Efficiency in Wastewater Treatment at Food and Beverage Facilities

Process Technology, Equipment or Practice	Standard Approach	Energy Efficient Approach or Best Practice	Potential Energy Savings
All	None	Demand side management (DSM)	
Source water conservation	No monitoring, controls, or systems to reduce water use	Water metering, auditing, source water reduction programs, advanced clean-in-place (CIP) systems	Approximately 10% water use. Impact on energy use unknown.
Pumps	Standard pump that may or may not closely match requirements	Energy efficient pump design and selection	Up to 10-40%
	Operation may be continuous	Variable frequency drives (VFDs)	Up to 50% of pump energy
		Pump testing for energy efficiency	Up to 10%
Motors	Standard motors	Premium efficiency motors	Up to 5%
		Motor efficiency testing	Up to 10%
	No VFDd; operation may be continuous	VFDs	Up to 50% of motor energy
Controls systems	No controls	PLC/SCADA systems	
	Aeration not matched to need	Automatic aeration control based on dissolved oxygen sensor input	Approximately 15-30%
	None	Demand side management (e.g., timers)	Up to 10-20% of aeration energy
Solids separation	Screening approach not optimized	Screening – energy efficient design and equipment selection	Up to 10-20% of motor energy
	Dissolved air flotation (DAF) - not selected, designed or managed for efficiency	DAF - efficient design and selection of DAF technology, pumps and motors (including sludge pumps), air compressors, and chemical / flocculent addition	Up to 10-30% of process energy
	Filtration – not selected for efficiency	Filtration – design and selection of energy efficient filtration technology	Up to 10-30% of process energy

Process Technology, Equipment or Practice	Standard Approach	Energy Efficient Approach or Best Practice	Potential Energy Savings
Aeration – blowers (diffused air)	Conventional design that may or may not be well matched to requirements	Diffuser design and selection (fine bubble diffusers)	Up to 50% of aeration energy
	No VFD or controls	Blower control – VFD motors and controls based on dissolved oxygen sensor input or timers (for demand side management)	Approximately 15-30% of blower energy
Aerators – mechanical	No controls	Automatic control based on dissolved oxygen sensor input or timer (for demand side management)	Approximately 15-30% of aerator energy
	No VFDs	VFDs	Up to 50% of aerator energy
	No VFDs or controls	VFDs and control based on timers (for demand side management)	Up to 50% of compressor energy
Anaerobic treatment	Not implemented or no consideration of energy efficiency in design	Design and selection of anaerobic technology and equipment for energy efficiency – including consideration of biogas production, peak flow handling, storage capacity (for demand-side management)	If biogas is recovered, may produce more energy than needed to operate the wastewater treatment plant.
	No biogas capture/use	Biogas handling system, including potential for power generation and onsite heating uses.	If biogas is recovered, may produce more energy than needed to operate the wastewater treatment plant.
Activated sludge treatment	Conventional features	See above for design, pumps, motors, aerators, dissolved oxygen control	Approximately 15-30% of aeration energy
Membrane bioreactors	Conventional features	See above for membrane selection, system design, pumps, motors, aerators, dissolved oxygen control	Approximately 15-30% of aeration energy

Sources: SBW, 2002; BASE Energy, 2006; and WEF, 2009.

9.2 Solids Separation / Screening

Solids separation was the most widely used technology among survey respondents, with 20 of the 39 facilities reporting some type of solids separation. The specific technologies included DAFs for FOG removal at poultry and meat processing plants, as well as settling tanks and screens. The two dairy farming operations participating in the survey both used solids separation. DAFs were used by 4 of the 20 respondents using solids separation.

Because solids separation is often paired with other treatment technologies, any increase in use of other technologies due to regulatory or environmental constraints is likely to be accompanied by further use of solids separation. As more advanced treatment technologies are used, more advanced solids separation can also be called upon to replace conventional gravity settling.

The amount of energy used by solids separation systems varies greatly with the specific process technology applied and the character of the wastewater. For example, gravity separators can use very little power, while DAFs can be energy intensive due to the associated sludge pumps, transfer pumps, blowers and/or compressed air. Rotary screens are typically not as energy intensive as DAFs, but do utilize motors to operate, and pumping may also be required to transfer wastewater to or from the screening equipment.

Considering the prevalence of solids separation and screening in food and beverage applications and the requirements for various pumps, motors, blowers, and air compressors, there is a significant potential for energy efficiency improvements in the application of this technology. More complicated solids separation technologies, such as DAFs, offer the most opportunities for savings through more efficient pumps, blowers, motors and control systems. In addition, with careful operation of the treatment system, the volume of air used, as well as chemical and polymer additions can be minimized.

9.3 Aerated Pond Treatment

Use of aerated pond treatment was reported by 12 of the 39 survey respondents. In particular, many wineries and poultry processors indicated they rely on aerated pond treatment. Only two of the respondents using aerated ponds discharge to a POTW; the other 10 discharge using some combination of irrigation and/or direct discharge to land. This is to be expected, considering that aerated ponds are generally used where land is available, including rural areas that are not connected to a POTW.

Aerated ponds offer a proven, effective treatment technology that is appropriate where sufficient land is available to accommodate effluent flows and retention requirements for treatment. However, ponds must be carefully managed to avoid nuisance odor issues. At the time of discharge permit renewal, older aerated ponds may need to be upgraded or lined to meet current requirements.

The highest energy demand for aerated ponds is often from mechanical aerators, followed by pumping to transfer wastewater to or from the ponds. The amount of energy used by pond aeration systems can be significant, depending on the amount of pumping and aeration required to produce effluent that meets treatment objectives, and how these systems are controlled and operated. For example, automated controls linking aerator operation to timers or DO sensors can yield significant savings. These devices are mechanically simple, often inexpensive to purchase and install and can provide measurable savings on energy use, as confirmed by numerous case studies. Other energy efficiency measures, such as efficient motors and pumps, and VFDs for pumps have also been shown to yield significant energy savings.

Aerobic ponds often are designed with excess storage capacity, so they may be candidates for implementation of demand-side management programs. Aerators can often be shut down for a few hours at a time without causing significant lapses in treatment odor issues.

9.4 Anaerobic Treatment

Use of anaerobic treatment was noted by 5 of the 39 survey respondents. One respondent, a poultry processor, reported use of a high-rate anaerobic system, while the others indicated they had low-rate systems. The low-rate respondents included another poultry processor, one fruit and vegetable processor, one beverage manufacturer, and one dairy farm. All of these sectors can generate high-strength wastewater, which can warrant an advanced treatment process such as anaerobic treatment. Meat processing typically generates similar wastewater, but anaerobic treatment was not noted in the survey respondents. This may be due to the small number of survey respondents from that sector.

The surveys indicated that the anaerobic treatment systems were combined with solids separation or aerated pond treatment in four out of the five facilities. Two of the respondents discharged to a sewer system, and the remainder discharged to a land application system or through irrigation.

Kennedy/Jenks believes that use of more advanced biological treatment, including anaerobic treatment, may grow as both CRWQCB permitting requirements for discharging effluent to land and POTW discharge limitations become more stringent. Anaerobic treatment can be more costly than other types of treatment and has yet to be widely adopted in the food and beverage industry; however, we are aware of a number of larger fruit and vegetable processors, dairy processors, wineries and beverage processors that have opted for this approach.

A typical low-rate anaerobic system, such as a covered lagoon, does not consume a large amount of power for operation. With relatively small power needs, therefore, there are not significant opportunities for energy efficiency improvement with this technology, other than biogas generation and use. There may be a need to upgrade application pumps and motors used for fluid transfer for optimal efficiency. Although low-rate anaerobic systems can have significant excess storage capacity, considering their low energy use, they are not likely to benefit from demand side management.

High-rate anaerobic systems are more complicated and energy intensive than low-rate systems. A number of pumps and motors are used for fluid transfer, the influent wastewater may require heating, and advanced control systems are used. The pumps and motors offer the most significant opportunities to optimize energy use in anaerobic systems. High-rate anaerobic systems can be very efficient at converting waste to energy, and typically generate more biogas than other treatment technologies. Because high-rate anaerobic systems can have both excess storage capacity and significant energy demands, these systems may be appropriate candidates for demand side management programs.

9.5 Activated Sludge Treatment

Activated sludge treatment was employed by only two of the 39 survey respondents: one was a poultry processor and one was a winery. Both respondents discharged the treated water to a land application system. The survey results may reflect food processor's knowledge that other treatment technologies are often more energy-efficient than activated sludge treatment. For example, if space is available, an aerated pond is often less complicated and can be as effective. If space is limited, and discharge to a POTW is an option, membrane biotreatment may be preferable. Anaerobic treatment is also often less energy intensive than activated sludge treatment, and generates biogas.

The most significant energy demand for activated sludge systems is typically aeration, followed by pumping. Energy efficiency measures, such as fine bubble aerators, efficient motors, pumps, and blowers, VFDs for pumps, as well as automated aeration control with DO sensors can yield significant energy savings.

9.6 Membrane Bioreactor Treatment

Membrane bioreactor (MBR) treatment was employed by only two of the 39 survey respondents: one was a large poultry processor with a multistage wastewater treatment system discharging to a land application system, and the other was a large dairy processor that discharges to a POTW. Although this is a very small percentage of the survey responses, as regulatory requirements for effluent quality are tightened over time, use of this technology or other related membrane treatment methods may become more prevalent.

Important benefits of MBRs are that they can treat high-strength wastewater to relatively stringent discharge standards or can provide nutrient removal; they typically require a small footprint; and they have fewer processing steps than conventional activated sludge treatment. However, membranes can become blocked by grease, so the application of MBRs in the food and beverage industry may be limited. The technology is rapidly evolving, as indicated by the decreasing costs to install and maintain these systems, and use of membranes for a wider range of applications.

The amount of energy used by a MBR system is typically higher than more conventional activated sludge systems because additional pumping and aeration are typically required. The most significant energy demand for MBRs is still typically aeration, followed by pumping. As with activated sludge systems, energy efficiency measures, such as fine bubble aerators, efficient motors, pumps, and blowers, VFDs for pumps, as well as automated aeration control with DO sensors can yield significant energy savings.

Section 10: Energy Efficiency Opportunities by Sector

Results of the study for each of the food processing sectors were evaluated to identify key factors that would be pertinent to determining high-impact opportunities for energy efficiency improvement. These factors are presented below and summarized on Table 10.

10.1 Fruit, Vegetable, and Nut Processing

Due to the diversity of food processing activity in this sector, it is difficult to draw general conclusions about the potential for energy efficiency improvements that will be valid across the entire sector. Additionally, the number of survey respondents from this sector was very low. Therefore, survey results were supplemented with information available in literature sources, such as the Manual of Good Practice for Land Application of Food Processing/Rinse Water (CLFP, 2007) and from Kennedy/Jenks' direct experience assisting processors with wastewater treatment.

The PG&E customer list for the sector is large, and included 58 accounts with greater than $250,000 revenue for electricity; this is more than any other sector. The largest facilities included 11 different NAICS codes. In decreasing order of annual energy costs, the five largest codes were: Fruit and Vegetable Canning (311421), Frozen Fruit, Juice, and Vegetable Manufacturing (311411), Perishable Prepared Foods (311991), the general category of Food Manufacturing (311000), and Dried and Dehydrated Food Manufacturing (311423).

In the survey, three of the four respondents were from the same company, but representing different facilities. Three respondents reported using solids separation or screening as a treatment technology. Three of the respondents discharged to a POTW, which ultimately used land application for discharge of their treated effluent. In fact, One of the respondents added an explanatory note confirming that the POTW they discharge to uses land application for treatment. One respondent used an aerated pond combined with a low-rate anaerobic system and discharged to a POTW.

In addition to significant energy costs, other factors that suggest there may be opportunities for energy efficiency improvements in this sector are as follows:

- There are a large number of fruit, vegetable and nut processing facilities in the sector located within the PG&E service area.
- The sector includes processing classifications that are known to produce significant amounts of high-strength wastewater, including tomato processors and fresh-packed fruit and vegetables.
- A number of the facilities in this sector use heat as part of their manufacturing process. Facilities with combined heat and power plants may be able to harvest excess heat for their processes or to optimize wastewater treatment. Additionally, treated water, depending upon the degree of treatment, can sometimes be used for boiler make-up water, which can reduce water use.

Table 10: Energy Efficiency Potential by Sector

Sector	Energy Intensity Factors	Energy Efficiency Potential
Fruit, Vegetable, and Nut Processing	• Large number of facilities • 58 accounts >$250,000 • May have high-strength wastewater • Processing often requires heat • Regulatory scrutiny could result in more pretreatment requirements for land application • Sector diversity poses implementation and measurement challenge; further research would be needed	• High potential impact due number and size of facilities • Opportunities for technology upgrades identified • Benchmarking energy for wastewater treatment may be feasible and desirable for select portions of subsector
Wineries	• Largest sector: 1,222 accounts of all sizes • Many use aerated pond treatment; efficiency can be improved • Regulatory scrutiny could result in more pretreatment requirements • Sector is relatively homogeneous	• High potential impact due number and size of facilities • Opportunities for technology upgrades identified • Benchmarking energy for WWT is feasible and desirable; may be developed by others
Dairy Processing	• High energy use by small number of large facilities • High-strength wastewater • Processing requires heat	• High potential impact due to the size of largest users • Opportunities identified • Benchmarking energy for wastewater treatment WWT is feasible and may be desirable
Beverage manufacturing	• High total energy use, but not attributable to wastewater treatment	• Moderate potential impact • Opportunities identified where pretreatment is required • Benchmarking is feasible and possibly desirable; may be developed by others
Poultry Processing	• Treatment requires significant energy • Not a significant number of facilities • Slaughtering facilities produce higher strength wastewater • Processing requires heat	• Low potential impact due to smaller number of facilities • Opportunities for technology upgrades identified • Benchmarking not recommended
Dairy Farms	• Many farms in PG&E area (1,500?) • Energy use unknown • High potential for biogas generation	• Low potential impact estimated • Benchmarking not recommended

Sector	Energy Intensity Factors	Energy Efficiency Potential
Meat Processing	• One of the smallest sectors for total energy use • High-strength wastewater • Processing requires heat • Sector is not projected to grow	• Low potential impact due to small number of facilities • Opportunities for technology upgrades identified • Benchmarking not recommended

- Although 3 of the 4 survey respondents discharged to a POTW, a significant number of the facilities in this sector appear to be rural, and presumably without access to a POTW connection. Increasing regulatory scrutiny of land application permits could drive these facilities to use more intensive pretreatment.

10.2 Poultry Processing

There were 16 poultry processors on the PG&E customer list, and the survey captured responses from eight processors (but two indicated they were not served by PG&E). Three of the facilities are owned by the same corporation. Results of the poultry industry survey (Section 7) were also considered in evaluating energy efficiency opportunities.

Seven of the eight respondents indicated use of solids separation or screening as a treatment technology, and all of the other treatment technologies studied were reportedly used in this sector as well. The relatively high incidence of use of anaerobic treatment and aerated ponds is indicative of the strength of the wastewater produced. Two of the eight respondents employed land application for discharge of treated wastewater, and five respondents discharged to a POTW.

The average electrical use per customer in this sector was high, and there are proportionally more large customers (with annual electric revenue greater than $250,000) than any other sector. In short, the sector has a small number of relatively large customers, but total energy use is low compared to other sectors. Factors that indicate the potential for energy efficiency improvements are as follows:

- The range of treatment technologies used in this sector suggests that energy use required for wastewater treatment at these facilities should be significant.
- Poultry facilities that perform slaughtering generate more wastewater, and wastewater with higher strength, than facilities that exclude this operation.
- A number of the facilities in this sector use heat in their manufacturing process. Facilities with combined heat and power plants may be able to harvest excess heat for their processes or to optimize wastewater treatment. Additionally, treated water, depending upon the degree of treatment, can sometimes be used for boiler make up water, which can reduce water use.

10.3 Wineries

PG&E's customer list contains 1,222 winery accounts, which makes it the largest sector - nearly four times the size of the next largest sector. The survey provided responses from seven wineries, which were considered along with available literature and Kennedy/Jenks' significant direct experience with winery wastewater treatment to assess energy efficiency potential.

In the survey, two of the seven respondents from this sector reported use of solids separation or screening as a treatment technology, and four of the respondents employed aerated ponds. Use of ponds may be attributable to wastewater characteristics, their relatively low cost, effectiveness, and the rural locations of the wineries. Only one respondent discharged to a POTW. Many of the respondents reported using land application and/or irrigation to discharge treated effluent, consistent with rural locations.

The total electrical use in this sector was large, but less than fruit and vegetables and dairy processing, and significantly less on a per-account basis. Still, there were a significant number of large customers (with annual electric revenue greater than $250,000). Based on the information gathered for this study and our experience, the following factors indicate the potential for energy efficiency improvements in this sector:

- There are a large number of wineries within the PG&E service area.
- Aerated pond treatment is commonly used in this sector, and there are a number of proven approaches to modify these systems to improve energy efficiency, which are generally relatively simple and inexpensive to implement.
- Increasing regulatory scrutiny of land application permits could drive these facilities to use more intensive pretreatment.
- Unlike the fruit and vegetable sector, wineries are relatively homogenous in terms of processing operations and wastewater characteristics, though facility sizes vary widely. The homogeneity and industry cohesion make the sector easier to reach through industry outreach programs.

10.4 Dairy Farms

Two dairy farms responded to the survey. The size of PG&E's customer base of dairy farms is not known, but estimated at more than 1,500. California has approximately 2,200 dairies, including about 1,650 in the Central Valley Region, according to the RWQCB. Information pertaining to the energy intensity of the facilities in the sector was not available.

Both of the survey respondents reported using solids separation or screening as a treatment technology. One farm reported using an aerated facultative pond for treatment, and the other indicated it used a low-rate anaerobic system with capacity for biogas capture. As described previously in Section 5.3, use of lagoons is typical for treatment of dairy farm wastewater, and treated effluent is generally discharged via land application or irrigation. This technology is not very energy intensive, unless the ponds are aerated.

Dairy farms have significant potential to produce biogas via anaerobic treatment of manure and wastewater from milking, offsetting operational energy needs and potentially providing surplus electricity. A number of industry groups are actively promoting this opportunity, primarily using anaerobic digestion. Although the technology for anaerobic digestion is well established, it is capital intensive, which may partially explain why it has not more widely adopted by dairy farm owners to date. Recent installations have faced air emissions permitting challenges, as noted in Section 6.6 above.

Dairy farms that are co-located with dairy processing facilities using heat may find opportunities to improve energy efficiency by harvesting excess heat for reuse in their processes or to optimize wastewater treatment. Additionally, treated water, depending upon the degree of treatment, can sometimes be used for boiler make up water, which can reduce water use.

10.5 Dairy Processing

Eight dairy processors responded to the survey, out of a customer base of 85 accounts in this sector, although four of the surveys were only partially completed. One respondent from this sector uses solids separation or screening as a treatment technology, and two respondents employed aerated ponds. Four respondents discharged to a POTW. One respondent discharged using irrigation and constructed wetlands, and one discharged to treatment lagoons and land application. Considering the small number of respondents and the number of incomplete surveys, results cannot be assumed to be a representative sample of the industry.

With respect to PG&E customers, the dairy processing sector is the second largest by total electrical use, but is the second smallest in terms of number of customer accounts, with a total of 85. This suggests the customers are each significant energy users. Indeed, there are 14 accounts with annual electric revenue greater than $250,000.

In addition to size, other factors that indicate the potential for energy efficiency improvement in this sector:

- Dairy processing facilities typically generate large quantities of wastewater, including high-strength streams, which means that biological wastewater treatment is often needed before land application or discharge to a POTW.

- If the dairy processes whey, the volume of wastewater that will need to be managed will be much greater than the volume of source water used for sanitation and other activities.

- Dairy processing facilities often have significant energy requirements for heating during their processes, particularly those that produce powdered whey. These facilities may present significant opportunities to improve energy efficiency through harvesting excess heat for wastewater treatment and reuse for boiler make up water and other non-contact operations.

10.6 Meat Processing

Three meat processors responded to the survey. PG&E has 137 accounts in this sector. All three respondents reported use of solids separation or screening as a treatment technology. Two of the respondents included in this category were seafood processing facilities that discharged to POTWs. The remaining respondent discharges to land using irrigation. One of the seafood processors used a DAF intermittently (when shrimp were processed). The small number of respondents coupled with limited literature and direct experience indicate this sector may warrant further research. However, this is one of the smallest sectors by total electrical use; PG&E has 18 accounts with annual electric revenue greater than $250,000.

Although the energy use in this sector is relatively small, the following factors indicate the potential for energy efficiency improvements:

- Meat processing facilities can generate high-strength wastewater, which would indicate biological wastewater treatment may often be needed whether or not the facility discharges to a POTW.
- Meat processing facilities that perform cooking can present significant opportunities for energy efficiency measures through harvesting excess heat for wastewater treatment and water reuse for boiler make up water and other non-contact operations, for example.
- Due to the challenges of siting new meat processing facilities in California, the growth of this industry is uncertain and may not warrant significant investment to improve energy efficiency associated with wastewater treatment.

10.7 Beverage Processing

PG&E's customer base for beverage processing includes 161 accounts, which is the third largest of the sectors studied. Six beverage manufacturers responded to the survey, including four breweries and two soft drink manufacturers. Four of the respondents reported using solids separation or screening as a treatment technology, and two used simple pH adjustment systems for pretreatment before discharge to a POTW. One respondent employed aerated pond treatment and discharged to a land application system, while the other five respondents discharged to a POTW. The soft drink manufacturer respondents used only pH adjustment before discharging to a POTW.

The small number of respondents is not necessarily representative of the industry, but the brewery responses generally correlated with the larger survey conducted by the Brewers Association (refer to Section 7). The Brewers Association survey had a total of 76 respondents, and 91 percent reported discharging to a POTW. Solids separation was used by almost a third of respondents; anaerobic treatment was used by 7 percent, and aerobic treatment was used by 9 percent of respondents. Based on the larger sample size of the Brewers Association survey, these results can be interpreted with relatively greater certainty.

This is PG&E's second largest sector by total electrical use, and the second smallest in terms of number of accounts, indicating that usage is concentrated among large customers. There were 14 accounts with annual electric revenue greater than $250,000. However, the majority of energy use is projected to be associated with heating operations during processing, rather than wastewater management. Due to the high percentage of facilities in this sector that discharge to POTWs, the potential for improving the energy efficiency of wastewater treatment operations is considered relatively low. Breweries that must pretreat their wastewater prior to sewer discharge afford the most significant opportunities for energy efficiency improvement in this sector.

Section 11: Basis for Benchmark Development

11.1 Evaluation of Benchmarking Feasibility

Benchmarking an aspect of an industrial process can be useful if:

- There are clear drivers for improving this process, and improvements would yield significant benefits (potentially economic, environmental and/or social);
- More efficient ways to complete the process exist, or are anticipated;
- Appropriate metrics have been identified, and sufficient data is available or can be obtained to describe the typical process, as currently implemented in the industry;
- The process is widely used, ideally with consistent objectives;
- The industry itself believes this is a useful exercise and accepts/owns the proposed benchmarks as valid; and
- Resources to develop benchmarks are available, and this is considered a priority.

For benchmarks of energy required for wastewater treatment, one appropriate metric may be direct measurements of electrical use per volume of wastewater treated. Other metrics would likely be based on removal of targeted constituents (e.g., kWh per pound BOD removed) or on production basis (e.g., kWh per ton of product). Some metrics will be sector-specific and may depend on how well water needed for production and/or wastewater generation have been characterized. Such information can be coupled with sector-specific wastewater treatment process efficiency and energy use estimates to provide rough metrics. However, there are many variables inherent in production processes, including water use, wastewater chemistry, and wastewater treatment technologies, and this is likely to introduce significant uncertainty in metric estimates. This suggests that further research will be needed to confirm the appropriate metrics for individual sectors.

Considering the factors listed above and the findings from the study, each of the food and beverage processing sectors were evaluated to assess whether development of benchmarks for energy use in wastewater treatment would be feasible and desirable. The evaluation is summarized below.

11.1.1 Fruit, Vegetable and Nut Processing

For certain subsectors and processes of the diverse fruit, vegetable and nut processing sector, development of benchmarks may be both feasible and desirable; however, additional research would be needed to narrow the scope and prioritize these efforts. Justification for benchmarks is summarized below:

- The sector includes a large number of facilities within the PG&E service area that are known to have high water use, coupled with significant energy use;

- Wastewater management in the sector typically includes biological wastewater treatment and/or more advanced treatment methods that present opportunities to improve energy efficiency;

- Many facilities reuse treated effluent for land application or irrigation, therefore their treatment objectives would be relatively similar, depending on their location and the CRWQCB with jurisdiction;

- Methods for improving the energy efficiency of these treatment processes are established;

- Efforts to develop water use metrics are underway by industry groups, including the Stewardship Index for Specialty Crops, but results are not yet published;

- Regulatory pressures on the quality of land application discharges may drive processors in this sector to invest in more sophisticated treatment systems with potential to be more efficient; and

- There are active industry groups for the sector that could potentially facilitate consensus-building for benchmarks and subsequent outreach.

The challenges inherent in benchmark development for this sector stem from the variety of processing methods and products, each of which may result in wastewater with different characteristics. Metrics would need to be commodity-specific, for best results. For example, representative subsectors could be selected to focus on, such as frozen fruit or fresh-pack spinach, in order to examine the resulting effluent from processing and wastewater management practices in detail.

11.1.2 Poultry Processing

Although development of benchmarks may be feasible for the poultry processing sector, given the small number of these facilities within the PG&E service area, this may be a lower priority. The sector could be well served by programs that target improvements for specific treatment technologies, such as DAFs. Key considerations for development of benchmarks in this sector include the following:

- Facilities in this sector have relatively high energy use individually, though the impact of the sector is low due to the small number of plants;

- Wastewater management in the sector typically includes biological wastewater treatment and/or more advanced treatment methods that present opportunities to improve energy efficiency;

- Most facilities discharge treated effluent onsite for land application or reuse as irrigation, therefore they may have similar treatment objectives, contingent on their location;

- One prior study indicated a metric for slaughtering operations of 5 to 10 gallons of wastewater per bird (CAST, 1995).This could be coupled to metrics for energy use per gallon of wastewater treated by applicable technologies to meet PG&E's needs;

- Methods for improving the energy efficiency of these treatment processes are established;
- Regulatory pressures on the quality of land application discharges may drive processors in this sector to invest in more sophisticated treatment systems with potential be more efficient;
- There is an active industry groups for the sector that could potentially facilitate consensus-building for benchmarks and subsequent outreach; and
- Future growth of the sector is may be limited.

The prior research conducted for this industry nationwide (Kiepper, 2003) may provide sufficient guidance on industry practices for PG&E's purposes without investing in benchmark development.

11.1.3 Wineries

Development of energy benchmarks for wineries appears to be both feasible and desirable, particularly for aerated pond treatment. Key considerations for development of benchmarks for this sector are summarized below:

- There are more winery facilities within PG&E's service area than any other kind of food processing, and they are among the highest energy users within the study group;
- Many of these facilities treat their wastewater onsite in aerated ponds, rather than discharging to a POTW;
- There are well-established methods to improve the energy efficiency of pond treatment, particularly when mechanical aerators are used;
- Facilities that discharge treated effluent onsite for land application or reuse as irrigation may have similar treatment objectives, depending on their location. Facilities that discharge to a sewer system would have different objectives.
- Regulatory pressures on the quality of land application discharges may drive processors in this sector to invest in more sophisticated treatment systems with potential be more efficient;
- Metrics for water use and wastewater generation are contingent on the specific set of operations performed at a given winery. There are a range of values in the literature which are typically normalized as gallons of water used per gallon of wine or case of wine produced. These numbers can range from as low as 1.5 gallons of water per 1 gallon of wine, to as high as 20 gallons of water or more per 1 gallon of wine; and
- There are active industry groups for the sector that could potentially facilitate consensus-building for benchmarks and subsequent outreach.

An important consideration for benchmark development for this sector is that several industry groups, including California Sustainable Winegrowing Alliance, are currently pursuing metrics and/or benchmarks for various aspects of the winemaking process, including water and wastewater management. We anticipate that PG&E would obtain results at the least cost by partnering directly with the wine industry.

11.1.4 Dairy Farms

Although data on the size and relative energy use of this sector was not available for this study, and the number of survey responses was small, existing information suggests that certain technologies or processes used in this sector would be feasible and potentially desirable to benchmark. The rationale for benchmarks for this sector is summarized below:

- The sector is estimated to include a large number of large facilities within the PG&E service area;
- Wastewater management in the sector typically includes biological wastewater treatment and/or more advanced treatment methods that present opportunities to improve energy efficiency;
- Methods for improving the energy efficiency of these treatment processes are well established;
- Most facilities in this sector discharge treated effluent onsite for land application or reuse as irrigation, therefore they should have similar treatment objectives, depending on their location;
- There is significant opportunity to generate biogas that would offset energy used for wastewater treatment in this sector;
- Regulatory controls that are being implemented for dairy effluent management in the Central Valley are expected to result in greater use of more advanced treatment technologies in this sector, with the potential for energy efficiency improvements; and
- There are active industry groups for the sector that may be willing to facilitate consensus-building for benchmarks and subsequent outreach. This would require confirmation.

Prior to initiating plans for benchmarks, the market potential of the sector to PG&E should be verified. The industry should also be consulted to gauge their willingness to participate in the process.

11.1.5 Dairy Processing

For the dairy processing sector, development of energy benchmarks for wastewater management appears to be both feasible and desirable, although the available data about the industry was limited. Justification for development of benchmarks in this sector is summarized below:

- The sector consists of a relatively small number of large facilities with high energy use;

- Facilities in this sector generally produce large volumes of high-strength wastewater, such that biological wastewater treatment and/or more advanced treatment is needed prior to discharge to land or a POTW. These types of technologies may present opportunities to improve energy efficiency;
- Methods for improving the energy efficiency of these treatment processes are well established;
- Facilities that discharge to a sewer system may have relatively similar treatment objectives; and
- Metrics for water use and wastewater generation are normalized to production output, such as gallons of water per gallon of milk, or an equivalent mass basis. Literature citations vary, but one reference indicated that U.S. dairies generate an average of 3.25 kilograms (kg) of wastewater to produce 1 kg of milk, and an average of 3.14 kg of wastewater per 1 kg of cheese. (North Carolina Division of Pollution Prevention, 2009).

11.1.6 Meat Processing

Although development of benchmarks may be feasible for the meat processing sector, given the small number of these facilities within the PG&E service area, this may be a lower priority. One subsector, slaughter houses, produces higher strength wastewater that may present significant energy efficiency opportunities on a limited scale. However, the sector as a whole may be well served by programs that target improvements for specific treatment technologies, such as DAFs. Key considerations for development of benchmarks in this sector include the following:

- The number of facilities in the sector is small, although there is a high proportion of relatively large facilities, based on energy use;
- A subset of the facilities in this sector, slaughter houses, generate high-strength wastewater that requires biological wastewater treatment and/or more advanced treatment that includes energy efficiency opportunities;
- There are established methods to improve the energy efficiency of these processes;
- Most facilities in this sector discharge treated effluent onsite for land application or reuse as irrigation, therefore they should have similar treatment objectives, depending on their location;
- Regulatory pressures on the quality of land application discharges may drive processors in this sector to invest in more sophisticated treatment systems with potential be more efficient, particularly at slaughter houses; and
- Future growth of the sector in California may be limited.

11.1.7 Beverage Processing

The beverage processing sector includes a relatively small number of facilities within the PG&E service area, most of which minimize their wastewater management effort by discharging to a POTW. Breweries, in particular, tend to have high energy use, but it is generally not attributed to wastewater management, with the possible exception of pretreatment systems. Accordingly, benchmarking may be feasible, but is potentially a lower priority than sectors where full, onsite treatment systems is typically employed.

Nonetheless, treatment systems used by beverage processors may offer potential for energy efficiency improvement. As such, the sector may be suited for energy efficiency programs that target improvements for specific treatment technologies. Further, there are several industry groups for this sector, including the Beverage Industry Environmental Roundtable, that are actively developing performance metrics and benchmarks. They may be willing to partner with PG&E in this process.

11.2 Benchmark Development Process

Benchmarks for energy use associated with wastewater treatment in the food and beverage industry, if considered feasible and desirable, could be developed through the following general steps:

- Determine appropriate metrics;
- Gather pertinent data on water use, wastewater generation, and energy performance during treatment, including when energy is used and for what purpose;
- Establish baselines at individual facilities by measuring performance of the subject technology over a specified time interval, relative to the treatment goals at the facility;
- Propose tentative benchmarks for energy use for specific treatment applications and objectives; and
- Seek validation and concurrence from industry that the benchmarks are appropriate.

The resulting benchmarks would allow facilities to compare their energy performance against other similar facilities that employ the same treatment processes, and may be the basis for PG&E to set goals for improvement. EPA used this approach in developing Energy Performance Indicators for the food processing industry, which are analogous to benchmarks (EPA, 2008). However, the overall benchmarking process requires considerable effort as well as commitment from the subject industry; therefore targets for benchmarking should be very carefully selected. The steps outlined above are discussed in more detail as follows.

11.2.1 Data Gathering

In addition to information summarized in this study, other existing sources of information that will be useful to support benchmark development include audits that have already been performed, published data for related industries, customer records for any facilities that meter the energy use of their wastewater treatment systems separately, and other sector-specific studies. As noted above, some sectors have already made progress toward developing water use metrics and standards of practice for wastewater management.

After existing data is compiled, it is likely that additional data will still need to be collected in most (or all) sectors. Few records of unit-process energy sub-metering were identified in the course of this study, and this represents a fundamental data gap for benchmarking energy use associated with current treatment practices.

11.2.2 Establishing Baselines

After appropriate monitoring systems have been installed at individual facilities, baselines can be established for these facilities by tracking energy use for wastewater treatment relative to treatment objectives, wastewater flows, and other characteristics such as corresponding product output. Baselines are generally defined over a certain period of time, ideally when output is consistent and reliable data is available, and they allow the facility to track progress once improvements are made.

11.2.3 Establishing Tentative Benchmarks

To develop tentative benchmarks, performance baselines from individual facilities are aggregated for consideration, along with historical performance information, and other available industry performance metrics. Interpretation of baselines and other data from diverse sources, where different monitoring methods were employed and treatment objectives varied, can be difficult and relies on best professional judgment. Benchmarks can be set to represent an average industry level of performance or an aspirational level, depending on intended use.

11.2.4 Industry Validation and Acceptance

For benchmarks to be useful to processors as well as PG&E, the development process must include review and validation by industry leaders. Therefore the pre-existence of active, sector-specific industry associations that can provide a forum for this process is considered imperative to the success and resolution of a benchmarking project. The industry may request that additional data be provided or other modifications made to the benchmark in order to ascertain that it is representative of their activities.

Section 12: Summary and Conclusions

Information was compiled on five standard wastewater treatment technologies and applicable energy efficiency improvements that can be used in the food and beverage processing sector. To gage the current state of implementation in the industry within PG&E's service area, online and telephone surveys were administered on behalf of PG&E. Information was collected on operations and wastewater management practices used by food and beverage processors in seven sectors. Although the number of responses that could be gathered from each of the targeted sectors was insufficient to allow statistical evaluation by sector, based on the aggregate of the results, as supported by literature review and Kennedy/Jenks' related experience, a number of conclusions were substantiated.

- Most facilities already employ some best practices for energy efficient wastewater treatment using the subject technologies, but additional measures could be implemented. The highest-impact opportunities identified to improve energy efficiency in wastewater treatment are in the following areas:
- Upgrades for DAFs, which are widely used by food processors for solids separation;
- Optimal management of aerobic ponds using DO sensors and timers;
- Anaerobic treatment for high-strength waste to avoid aeration energy demand and generate biogas;
- Energy-efficient pumps and motors, including VFDs; and
- Sector-specific opportunities, where energy use and the volume of wastewater generated are highest:
    - Dairy processing facilities in general, where both energy use and the volume of wastewater generated are among the highest in the food processing industry;
    - Fruit, vegetable, and nut processing facilities, where energy use is relatively high, but specific areas for improvement may warrant further investigation; and
    - Wineries, which constitute the sector with the largest number of facilities and the second highest energy use within the PG&E territory and offer opportunities with respect to improving aerobic pond treatment.

Study results suggest that poultry and meat processing sectors may be lower priorities for efforts to achieve energy efficiency improvements due to relatively smaller numbers of facilities within the PG&E service area. Although dairy farms may also have limited potential for energy efficiency improvement, they have significant potential with respect to wastewater digestion for energy generation, offsetting energy use for treatment.

Development of benchmarks is potentially feasible and desirable for dairy processing and wineries. Benchmarks may also be appropriate for portions of the fruit and vegetable sector, but this would be complicated by the diversity of processing operations and commodities. Both the wine industry and beverage industry have associations that are actively working on metrics and benchmarks related to water use and wastewater generation; these groups may welcome collaboration with PG&E.

Section 13: Areas for Further Research

13.1 Data Gaps

The principal data gap identified during the course of research for this study, relative to developing benchmarks for energy use in wastewater treatment, was an absence of sub-metering data on energy use for wastewater treatment systems. Additional data gaps were identified relative to wastewater characteristics and wastewater treatment practices in individual sectors. If benchmarks are to be pursued, or a greater understanding of energy use for wastewater treatment is needed to refine energy efficiency improvement programs, the following data gaps may warrant further research:

Fruit, Vegetable, and Nut Processing. Due to the diversity of facilities in this sector, more information is needed on the energy requirements for wastewater treatment correlate with different types of processing, different commodities/products, and different size facilities. This information would allow identification of the most significant opportunities to improve the energy efficiency of treatment.

Poultry Processing. Based on existing information, treatment processes for the sector are relatively uniform and well understood, however energy use for treatment has not been directly monitored.

Wineries. The wastewater treatment processes used in this sector are well understood, however direct monitoring of energy use for treatment is needed to develop benchmarks and allow measurement of efficiency improvements. Industry groups are actively pursuing metrics and benchmarks, and may be amenable to partnering with PG&E to obtain this data.

Dairy Farms. Wastewater treatment practices used in this sector are relatively well understood, but energy use has not been directly monitored. Research related to digestion of wastewater and biogas generation may be more promising than efforts to reduce energy associated with treatment processes.

Dairy Processors. Characteristics of this sector and current wastewater treatment practices are generally well understood, however direct measurement of energy use for treatment is needed to facilitate benchmark development.

Meat Processors. Data gaps in this sector include identifying the number of facilities that perform slaughtering operations, which produce higher-strength wastewater and present the sector's most significant opportunities to improve treatment energy efficiency. Characteristics of wastewater from facilities that do not include slaughtering (and associated treatment requirements) are also unknown, but less imperative.

Beverages. While breweries use the most energy of the facilities in this sector and have the highest potential for energy efficiency improvements, there are not a significant number of breweries with large wastewater treatment systems onsite; most discharge to city sewers. This finding, considered along with the active research efforts by the industry groups, suggests this sector is a lower priority for additional PG&E research.

13.2 Recommendations for Next Steps

To address the data gaps cited above, the following approach is suggested:

1. Obtain direct measurements of energy use by implementing a pilot program to test application of the top treatment technologies in the highest priority sectors, identified as:
   - Fruit and vegetable processing – solids separation, aerobic technologies
   - Wineries – aerobic technologies, anaerobic treatment
   - Dairy processors – aerobic technologies, anaerobic treatment

2. Using results of pilot testing as facility-specific baselines, measure the energy savings that can be achieved by implementing selected treatment system improvements that were identified in this study.

Where the currently available technologies and/or best practices for treatment are considered insufficient to achieve desired improvements in energy efficiency, further research into innovative new or emerging technologies may be warranted. Specifically, new technologies in membrane treatment, sludge management, and aeration promise substantial savings in wastewater treatment energy use. There may also be emerging technology options that are not yet widely distributed or commercialized that warrant evaluation.

With results of this study and subsequent efforts to address identified data gaps, PG&E will be able to prioritize industry sectors where energy use for wastewater treatment is greatest, and can develop appropriate incentive and outreach programs to maximize adoption of known energy efficiency improvement options.

References

BASE Energy, Inc. September 2006. Energy Baseline Study for Municipal Wastewater Treatment Plants.

California Energy Commission. 2009. California Electric Utility Service Areas. 3 December.

California League of Food Processors, 2007. Manual of Good Practice for Land Application of Food Processing/Rinse Water.

California Public Utilities Commission, 2008. Long-Term Energy Efficiency Strategic Plan.

CAST, 1995. Waste Management and Utilization in Food Production and Processing. Task Force Report No. 124. Council for Agricultural Science and Technology, Ames, Iowa.

Electric Power Research Institute (EPRI), 1999. Energy Audit Manual for Water/Wastewater Facilities.

Kiepper, Brian Harry, 2003. Characterization of Poultry Processing Operations, Wastewater Generation, and Wastewater Treatment Using Mail Survey and Nutrient Discharge Monitoring Methods. The University of Georgia, Athens, Georgia.

Lawrence Berkeley National Laboratory, 2008. Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry (http://www.energystar.gov/ia/business/industry/Food-Guide.pdf).

Metcalf & Eddy, Inc., 2003. Wastewater engineering: treatment, disposal, and reuse. 4th ed. McGraw-Hill, Boston.

M/J Industrial Solutions, June 2003. Municipal Wastewater Treatment Plant Energy Baseline Study.

North Carolina Division of Pollution Prevention and Environmental Assistance, 2009. Water Efficiency, Industrial Processes, Dairy Processing.

San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel, December 2005. An Assessment of Technologies for Management and Treatment of Dairy Manure in California's San Joaquin Valley.

SBW Consulting, Inc., 2002. Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various Municipal Wastewater Treatment Facilities.

SWRCB, 2009. Water Quality Enforcement Policy.

U.S. Environmental Protection Agency (EPA), 1999. Feedlots Point Source Category Study (http://www.epa.gov/guide/feedlots/).

Wang, Lawrence K., et al., 2006. Waste Treatment in the Food Processing Industry.

Water Environment Foundation (WEF), 2009. Energy Conservation in Water and Wastewater Treatment Facilities. WEF Manual of Practice No. 32.

WEF Task Force on Pretreatment of Industrial Wastes. Pretreatment of Industrial Wastes, 1994. WEF Manual of Practice No. FD-3.

(This Page Intentionally Blank)

Appendix A

Survey of Wastewater Management Practices

Survey of Wastewater Management Practices

1. Introduction

Dear Customer,

Thank you for your valuable time in completing this survey. Please allow approximately 15 to 30 minutes to respond. The objective of the study is to collect information about standard practices and best practices, with respect to energy management, in treatment of agricultural and food processing wastewater. These practices will be considered in the context of regulatory agency expectations and discharge requirements that can vary regionally. Results of the study will be used to help customers reduce wastewater treatment and energy costs by taking advantage of financial incentives to optimize system design and operations, while still maintaining regulatory compliance. PG&E will develop a study report that infers best practices, and this will be shared with participating companies and industry associations. For more detailed background information on the specific objectives and methods for the study, please click here.

The survey is completely confidential, and all questions are optional. Results will be aggregated and reported by subsector, without identification of individual facilities. However, we would appreciate your contact information for survey tracking purposes, and to allow us to reach you for clarifications or follow-up questions. We will also send a copy of the final study results and guidance to respondents who provide contact information.

We recommend you refer to your facility's treatment system design criteria and any annual monitoring reports for wastewater discharge when completing the survey. If you would like to preview/print the survey questions to gather information before responding online, click here.

Please help us ensure the the accuracy of our results by submitting only one survey from your company per facility location.

Thanks in advance for your participation. Any questions or comments on the survey can be directed to:

Mr. Tsosie Reyhner
PG&E
(415) 973-0216
TDRb@pge.com

Ms. Sharon Melmon
Kennedy/Jenks Consultants
(415) 243-2430
sharonmelmon@kennedyjenks.com

2. About Your Facility

1. Does your company operate facilities at more than one location?

◯ Yes

◯ No

If yes, please respond to the survey considering only one location at a time. Optionally, please indicate where the subject facility is located:

Survey of Wastewater Management Practices

2. Please indicate your product type

- ◯ Fruits and/or vegetables
- ◯ Raw milk (dairy farm)
- ◯ Dairy products
- ◯ Meat
- ◯ Poultry
- ◯ Beverages
- ◯ Wine
- ◯ Other (please specify):

3. Fruits and Vegetables

1. Please indicate your main product processing/packaging steps (check all that apply):

- ☐ Peeling
- ☐ Acidifying
- ☐ Cooking/blanching
- ☐ Freezing
- ☐ Drying/dehydrating
- ☐ Brining
- ☐ Canning
- ☐ Fresh pack
- ☐ Other (please specify):

4. Dairy Products

Survey of Wastewater Management Practices

1. Please check the main products produced at this facility:

- [ ] Milk
- [ ] Cheese
- [ ] Butter
- [ ] Ice Cream
- [ ] Other (please specify):

5. Meat Processing

1. Please check the activities at this facility:

- [ ] Meat processing
- [ ] Rendering and by-product processing
- [ ] Other (please specify):

6. Beverages

1. Please check the beverage produced at this facility:

- [ ] Soft drinks
- [ ] Water
- [ ] Beer
- [ ] Juice
- [ ] Other (please specify):

7. About Your Facility (Continued)

1. Please list your top three products (by volume) at this facility, and indicate average volume produced per year
(for example, Chardonnay - 50,000 cases/year):

1:

2:

3:

2. How do you expect production volume to change over the next 3 to 5 years?

- ◯ Down 50% or more
- ◯ Down 25-50%
- ◯ Down 10-25%
- ◯ Down 0-10%
- ◯ Up 0-10%
- ◯ Up 10-25%
- ◯ Up 25-50%
- ◯ Up 50% or more
- ◯ No change expected
- ◯ Don't know

8. Water Use

1. What is the source of your water supply (check all that apply)?

- ☐ Onsite well(s)
- ☐ Municipal supply
- ☐ Other (please specify):

2. Do you have chemistry data for your source water?

- ◯ Yes
- ◯ No
- ◯ Don't know

3. Do you know how much source water is used per year for processing activities (e.g., excluding irrigation and residential uses)?

- ◯ Yes
- ◯ No
- ◯ Don't know

If known, please enter the average volume used (gallons/year):

4. Do you meter your water use?

- ◯ Yes
- ◯ No
- ◯ Don't know

If yes, please describe where the meter(s) are located (e.g., the wellhead, cooling tower makeup line, etc.)

5. Do you have water use records from your water provider?

- ◯ Yes
- ◯ No
- ◯ Don't know

6. How would you describe the water uses for your operations? (check all that apply)

- ☐ Continuous, 24 hours per day, 7 days per week
- ☐ Continuous, during operating hours
- ☐ Variable daily
- ☐ Variable seasonally

Specify largest uses:

9. Water Conservation

Survey of Wastewater Management Practices

1. Are you seeking to reduce water use (and wastewater generation) in response to any of the following? (check all that apply)

- [ ] Regulatory compliance requirements
- [ ] Limited discharge area and/or loading capacity
- [ ] Water shortage pressures
- [ ] Sewer surcharge
- [ ] Corporate sustainability initiative
- [ ] Don't know
- [ ] Other (please specify):

2. Have you voluntarily conducted a water audit in your facility to identify opportunities to conserve water and reduce the loading (chemical concentrations) in wastewater to be treated?

- ◯ Yes
- ◯ No

3. Do you use recycled water to offset a portion of source water use in the facility?

- ◯ Yes
- ◯ No

If yes, please indicate sources of recycled water and approximate volumes, if known:

4. Have you installed technologies or implemented practices to reduce water use?

- ◯ Yes
- ◯ No

If yes, please provide a brief description:

10. Wastewater Management

Survey of Wastewater Management Practices

1. Do you monitor the volume of wastewater effluent from the facility?

- ○ Yes
- ○ No
- ○ Don't know

If so, please indicate the average number of gallons per year:

2. Please indicate how process wastewater effluent is discharged:

- ☐ Irrigation
- ☐ Land application system
- ☐ Onsite septic system
- ☐ Sewer
- ☐ Constructed wetlands
- ☐ Surface water
- ☐ Groundwater
- ☐ Other (please specify):

11. Irrigation Details

1. Please enter number of irrigated acres:

2. Please list crops:

12. Wastewater Management (Continued)

1. Which of the following wastewater treatment or pretreatment strategies do you employ? (check all that apply)

- [ ] Solids separation/screening
- [ ] Aerated pond/tank
- [ ] Anaerobic system - low-rate
- [ ] Anaerobic system - high-rate
- [ ] Activated sludge system
- [ ] Membrane treatment
- [ ] Don't know
- [ ] None

Other (please specify):

13. Aerobic Pond Details

1. Please enter the capacity of your pond(s) in gallons, if known:

Pond 1

Pond 2

Pond 3

Pond 4

2. Please enter the number, type and size of aerators used in each pond, if known:
(for example, 2 brush @ 25Hp; 1 brush @ 10Hp)

Pond 1

Pond 2

Pond 3

Pond 4

3. Please indicate the total horsepower (Hp) of aerators in each pond(s), if known:

Pond 1 Hp

Pond 2 Hp

Pond 3 Hp

Pond 4 Hp

Survey of Wastewater Management Practices

14. Wastewater Management (Continued)

1. Do you manage stormwater runoff separately from process water?

- ◯ Yes
- ◯ No, some or all of the stormwater goes into the process water system
- ◯ Stormwater runoff is not significant at this location
- ◯ Don't know
- ◯ Other (please describe):

2. Do you manage domestic wastewater separately from process water?

- ◯ Yes
- ◯ No
- ◯ Not sure
- ◯ Other (please describe):

3. Do you use wastewater or other waste materials from your operations to generate biogas onsite?

- ◯ Yes
- ◯ No
- ◯ Don't know

If yes, please specify type:

4. Please rate the performance of your existing wastewater treatment system:

	Unsatisfactory	Satisfactory	Optimal
Energy efficiency	◯	◯	◯
Effectiveness	◯	◯	◯
Reliability	◯	◯	◯
Regulatory compliance	◯	◯	◯
Maintenance/operation effort	◯	◯	◯
Cost of operation	◯	◯	◯

Comments on treatment system performance:

5. Can your treatment system be operated in a PG&E demand-response or load-balancing program?

- ◯ Yes, we participate
- ◯ Possibly, but we have not enrolled
- ◯ No
- ◯ Don't know

6. Who is responsible for operating and maintaining your treatement system?

- ☐ Facility manager
- ☐ EH&S manager
- ☐ Staff operator
- ☐ Treatment system vendor
- ☐ Consultant
- ☐ Don't know
- ☐ Other (please specify):

7. Are you planning to make any changes to your treatment system?

	Yes	No	Don't know
In next 1-2 years	◯	◯	◯
In next 3-5 years	◯	◯	◯

15. Regulatory Agency Permits

1. Does your facility have Waste Discharge Requirements (WDRs) from the California Regional Water Quality Control Board (CRWQCB)?

- ◯ Yes, we have individual WDRs
- ◯ Yes, we have WDRs under a General Permit
- ◯ Yes, but not sure what kind
- ◯ No
- ◯ Don't know

2. If so, please indicate which Regional Board issued the WDRs:

- ◯ Region 1 - North Coast
- ◯ Region 2 - Bay Area
- ◯ Region 3 - Central Coast
- ◯ Region 5 - Central Valley
- ◯ Don't know
- ◯ Not applicable
- ◯ Other (please specify):

3. Do you have permits from other Federal, state, county or city agencies to discharge effluent to:

- ☐ Land (other than WDRs from CRWQCB)
- ☐ Surface water (e.g, National Pollutant Discharge Elimination System permit)
- ☐ Septic system
- ☐ Sewer
- ☐ Winery pond
- ☐ Don't know
- ☐ No, we don't have any of these permits

If yes, please list the agency that issued each permit:

4. What are your greatest challenges in meeting your discharge permit requirements?

16. Energy Efficiency

1. Is your electrical service provided by PG&E?

- Yes
- No

If not, please enter your provider:

2. Have you (or has your utility company) audited your facility to identify energy efficiency improvement opportunities?

- Yes
- No

3. Do you sub-meter the energy used by your wastewater treatment system, or any component of the system (for example, pond aerators)?

- Yes
- No
- Don't know

4. To your knowledge, what are the top uses of energy associated with your wastewater management practices?

1.
2.
3.

5. If you had to reduce the energy demand for your wastewater treatment system and cost was not a factor, do you have ideas for changes you would like to make? (for example, install variable frequency drives or high-efficiency motors, redesign aeration system, install a co-generation or methane recovery system, retrofit with newer technology, etc.)

17. Conclusion

1. Would you and/or your facility manager be willing to answer a few follow-up questions about your wastewater treatment system in a telephone conversation or meeting with a wastewater engineer? Your participation in the follow-up is voluntary but highly encouraged to ensure that PG&E's conclusions from the study are accurate and representative of industry. These conclusions may be the basis for future PG&E rebate and incentive programs. All information obtained will be strictly confidential.

- ◯ Yes
- ◯ No

18. Contact Info

1. If you are willing to be contacted, please provide your information:

Name: ______

Company: ______

Address: ______

Address 2: ______

City/Town: ______

State: ______

ZIP/Postal Code: ______

Email Address: ______

Phone Number: ______

19. Receive Results

1. If you prefer not to be contacted, but would like to receive a copy of the report from the study, please provide your company name and contact information below.

Name:

Company:

Address:

Address 2:

City/Town:

State:

ZIP/Postal Code:

Email Address:

Phone Number (optional):

20. Thanks

1. Thank you for participating in the survey. Results of the study and guidance on energy-efficient practices will be published and distributed by PG&E and industry associations in early 2010. Please provide any comments on the survey below.

If you would like to speak with someone about PG&E's free technical assistance, or rebates and incentives available to optimize your wastewater treatment system, please call your assigned Account Representative or the Business Customer Service Center at 1-800-468-4743.

Appendix B

Survey Responses

Appendix B: Survey Responses

Survey responses are summarized below, exclusive of open text fields. Indented questions indicate branches in the survey that were only shown when applicable.

Question 1.

Does your company operate facilities at more than one location?	
Answer Options	**Response Count**
Yes	18
No	18
If yes, please respond to the survey considering only one location at a time.	
Optionally, please indicate where the subject facility is located:	33
answered question	**36**
skipped question	**3**

Question 2.

Please indicate your product type	
Answer Options	**Response Count**
Fruits and/or vegetables	4
Raw milk (dairy farm)	2
Dairy products	8
Meat	4
Poultry	8
Beverages	6
Wine	7
Other (please specify):	0
answered question	**39**
skipped question	**0**

Question 3. Fruits and Vegetables

Please indicate your main product processing / packaging steps (check all that apply):	
Answer Options	**Response Count**
Peeling	3
Acidifying	1
Cooking/blanching	3
Freezing	0
Drying/dehydrating	0
Brining	0
Canning	4
Fresh pack	1
Other (please specify):	1
answered question	**4**
skipped question	**35**

Question 4. Dairy Products

Please check the main products produced at this facility:	
Answer Options	**Response Count**
Milk	1
Cheese	5
Butter	2
Ice Cream	0
Other (please specify):	2
answered question	**6**
skipped question	**33**

Question 5. Meat Processing

Please check the activities at this facility:	
Answer Options	**Response Count**
Meat processing	4
Rendering and by-product processing	0
Other (please specify):	2
answered question	**4**
skipped question	**35**

Question 6. Beverages

Please check the beverage produced at this facility:	
Answer Options	**Response Count**
Soft drinks	2
Water	0
Beer	4
Juice	0
Other (please specify):	0
answered question	**6**
skipped question	**33**

Question 7.

Please list your top three products (by volume) at this facility, and indicate average volume produced per year (for example, Chardonnay - 50,000 cases/year):	
Answer Options	**Response Count**
1:	37
2:	24
3:	17
answered question	**37**
skipped question	**2**

Question 8.

How do you expect production volume to change over the next 3 to 5 years?	
Answer Options	**Response Count**
Down 50% or more	0
Down 25-50%	0
Down 10-25%	0
Down 0-10%	0
Up 0-10%	12
Up 10-25%	6
Up 25-50%	2
Up 50% or more	2
No change expected	6
Don't know	4
answered question	**32**
skipped question	**7**

Question 9.

What is the source of your water supply (check all that apply)?	
Answer Options	**Response Count**
Onsite well(s)	19
Municipal supply	20
Other (please specify):	0
answered question	**34**
skipped question	**5**

Question 10.

Do you have chemistry data for your source water?	
Answer Options	**Response Count**
Yes	23
No	6
Don't know	0
answered question	**29**
skipped question	**10**

Question 11.

Do you know how much source water is used per year for processing activities (e.g., excluding irrigation and residential uses)?	
Answer Options	**Response Count**
Yes	22
No	4
Don't know	2
If known, please enter the average volume used (gallons/year):	
answered question	**28**
skipped question	**11**

Question 12.

Do you meter your water use?	
Answer Options	**Response Count**
Yes	22
No	7
Don't know	0
If yes, please describe where the meter(s) are located (e.g., the wellhead, cooling tower makeup line, etc.)	
answered question	**29**
skipped question	**10**

Question 13.

Do you have water use records from your water provider?		
Answer Options	**Response Percent**	**Response Count**
Yes		14
No		8
Don't know		0
	answered question	**23**
	skipped question	**16**

Question 14.

How would you describe the water uses for your operations? (check all that apply)	
Answer Options	**Response Count**
Continuous, 24 hours per day, 7 days per week	5
Continuous, during operating hours	20
Variable daily	10
Variable seasonally	10
Specify largest uses:	17
answered question	**31**
skipped question	**8**

Question 15.

Are you seeking to reduce water use (and wastewater generation) in response to any of the following? (check all that apply)	
Answer Options	**Response Count**
Regulatory compliance requirements	10
Limited discharge area and/or loading capacity	8
Water shortage pressures	9
Sewer surcharge	6
Corporate sustainability initiative	13
Don't know	1
Other (please specify):	8
answered question	**26**
skipped question	**15**

Question 16.

Have you voluntarily conducted a water audit in your facility to identify opportunities to conserve water and reduce the loading (chemical concentrations) in wastewater to be treated?	
Answer Options	**Response Count**
Yes	18
No	10
answered question	**28**
skipped question	**11**

Question 17.

Do you use recycled water to offset a portion of source water use in the facility?	
Answer Options	**Response Count**
Yes	12
No	19
If yes, please indicate sources of recycled water and approximate volumes, if known:	12
answered question	**31**
skipped question	**8**

Question 18.

Have you installed technologies or implemented practices to reduce water use?	
Answer Options	**Response Count**
Yes	26
No	5
If yes, please provide a brief description:	18
answered question	**31**
skipped question	**8**

Question 19.

Do you monitor the volume of wastewater effluent from the facility?	
Answer Options	**Response Count**
Yes	21
No	9
Don't know	0
If so, please indicate the average number of gallons per year:	19
answered question	**30**
skipped question	**9**

Question 20.

Please indicate how process wastewater effluent is discharged:	
Answer Options	**Response Count**
Irrigation	7
Land application system	12
Onsite septic system	2
Sewer	20
Constructed wetlands	1
Surface water	0
Groundwater	1
Other (please specify):	1
answered question	**33**
skipped question	**6**

Question 21.

Please enter number of irrigated acres (if applicable):	
Answer Options	**Response Count**
	10
answered question	**10**
skipped question	**29**

Question 22.

Please enter the number of acres for land application (if applicable):	
Answer Options	**Response Count**
	7
answered question	**7**
skipped question	**32**

Question 23.

Please list crops:	
Answer Options	**Response Count**
	12
answered question	**12**
skipped question	**27**

Question 24.

Which of the following wastewater treatment or pretreatment strategies do you employ? (check all that apply)	
Answer Options	**Response Count**
Solids separation/screening	20
Aerated pond/tank	12
Anaerobic system - low-rate	5
Anaerobic system - high-rate	1
Activated sludge system	2
Membrane treatment	2
Don't know	1
None	5
Other (please specify):	12
answered question	**33**
skipped question	**6**

Question 25.

Please enter the capacity of your pond(s) in gallons, if known:	
Answer Options	**Response Count**
Pond 1	8
Pond 2	3
Pond 3	2
Pond 4	0
answered question	**8**
skipped question	**31**

Question 26.

Please enter the number, type and size of aerators used in each pond, if known: (for example, 2 brush @ 25Hp; 1 brush @ 10Hp)	
Answer Options	**Response Count**
Pond 1	7
Pond 2	4
Pond 3	2
Pond 4	0
answered question	**7**
skipped question	**32**

Question 27.

Please indicate the total horsepower (Hp) of aerators in each pond(s), if known:	
Answer Options	**Response Count**
Pond 1 Hp	5
Pond 2 Hp	3
Pond 3 Hp	2
Pond 4 Hp	0
answered question	**5**
skipped question	**34**

Question 28.

Do you manage stormwater runoff separately from process water?	
Answer Options	**Response Count**
Yes	12
No, some or all of the stormwater goes into the process water system	1
Stormwater runoff is not significant at this location	8
Don't know	7
Other (please describe):	2
answered question	**28**
skipped question	**11**

Question 29.

Do you manage domestic wastewater separately from process water?	
Answer Options	**Response Count**
Yes	28
No	0
Not sure	0
Other (please describe):	1
answered question	**29**
skipped question	**10**

Question 30.

Do you use wastewater or other waste materials from your operations to generate biogas onsite?	
Answer Options	**Response Count**
Yes	2
No	27
Don't know	0
If yes, please specify type:	2
answered question	**31**
skipped question	**8**

Question 31.

Please rate the performance of your existing wastewater treatment system:				
Answer Options	**Unsatis-factory**	**Satisfactory**	**Optimal**	**Response Count**
Energy efficiency	4	18	1	23
Effectiveness	1	19	3	23
Reliability	2	16	4	22
Regulatory compliance	6	10	6	22
Maintenance/operation effort	3	17	3	23
Cost of operation	6	13	1	23
Comments on treatment system performance:				12
			answered question	**24**
			skipped question	**15**

Question 32.

Can your treatment system be operated in a PG&E demand-response or load-balancing program?	
Answer Options	**Response Count**
Yes, we participate	5
Possibly, but we have not enrolled	5
No	12
Don't know	8
answered question	**30**
skipped question	**9**

Question 33.

Who is responsible for operating and maintaining your treatement system?	
Answer Options	**Response Count**
Facility manager	14
EH&S manager	3
Staff operator	10
Treatment system vendor	2
Consultant	2
Don't know	0
Other (please specify):	5
answered question	**28**
skipped question	**11**

Question 34.

Are you planning to make any changes to your treatment system?				
Answer Options	**Yes**	**No**	**Don't know**	**Response Count**
In next 1-2 years	15	8	5	28
In next 3-5 years	6	8	4	18
			answered question	**28**
			skipped question	**11**

Question 35.

Does your facility have Waste Discharge Requirements (WDRs) from the California Regional Water Quality Control Board (CRWQCB)?	
Answer Options	**Response Count**
Yes, we have individual WDRs	9
Yes, we have WDRs under a General Permit	2
Yes, but not sure what kind	3
No	13
Don't know	2
answered question	**29**
skipped question	**10**

Question 36.

If so, please indicate which Regional Board issued the WDRs:	
Answer Options	**Response Count**
Region 1 - North Coast	3
Region 2 - Bay Area	0
Region 3 - Central Coast	1
Region 5 - Central Valley	9
Don't know	2
Not applicable	1
Other (please specify):	1
answered question	**15**
skipped question	**24**

Question 37.

Do you have permits from other Federal, state, county or city agencies to discharge effluent to:		
Answer Options		**Response Count**
Land (other than WDRs from CRWQCB)		2
Surface water (e.g., National Pollutant Discharge Elimination System permit)		0
Septic system		3
Sewer		13
Winery pond		2
Don't know		2
No, we don't have any of these permits		9
If yes, please list the agency that issued each permit:		10
	answered question	**29**
	skipped question	**10**

Question 38.

What are your greatest challenges in meeting your discharge permit requirements?	
Answer Options	**Response Count**
	19
answered question	**19**
skipped question	**20**

Question 39.

Is your electrical service provided by PG&E?	
Answer Options	**Response Count**
Yes	25
No	6
If not, please enter your provider:	2
answered question	**31**
skipped question	**8**

Question 40.

Have you (or has your utility company) audited your facility to identify energy efficiency improvement opportunities?	
Answer Options	**Response Count**
Yes	27
No	4
answered question	**31**
skipped question	**8**

Question 41.

Do you sub-meter the energy used by your wastewater treatment system, or any component of the system (for example, pond aerators)?	
Answer Options	**Response Count**
Yes	5
No	26
Don't know	0
answered question	**31**
skipped question	**8**

Question 42.

To your knowledge, what are the top uses of energy associated with your wastewater management practices?	
Answer Options	**Response Count**
1.	18
2.	8
3.	3
answered question	**18**
skipped question	**21**

Question 43.

If you had to reduce the energy demand for your wastewater treatment system and cost was not a factor, do you have ideas for changes you would like to make? (for example, install variable frequency drives or high-efficiency motors, redesign aeration system, install a co-generation or methane recovery system, retrofit with newer technology, etc.)	
Answer Options	**Response Count**
	13
answered question	**13**
skipped question	**26**

Question 44.

Would you and/or your facility manager be willing to answer a few follow-up questions about your wastewater treatment system in a telephone conversation or meeting with a wastewater engineer? Your participation in the follow-up is voluntary but highly encouraged to ensure that PG&E's conclusions from the study are accurate and representative of industry. These conclusions may be the basis for future PG&E rebate and incentive programs. All information obtained will be strictly confidential.	
Answer Options	**Response Count**
Yes	24
No	7
answered question	**31**
skipped question	**8**

Question 45.

If you are willing to be contacted, please provide your information:	
Answer Options	**Response Count**
Name:	23
Company:	22
Address:	9
Address 2:	2
City/Town:	20
State:	18
ZIP/Postal Code:	9
Email Address:	16
Phone Number:	21
answered question	**23**
skipped question	**16**

Question 46.

If you prefer not to be contacted, but would like to receive a copy of the report from the study, please provide your company name and contact information below.	
Answer Options	**Response Count**
Name:	6
Company:	6
Address:	4
Address 2:	0
City/Town:	4
State:	4
ZIP/Postal Code:	4
Email Address:	4
Phone Number (optional):	3
answered question	**6**
skipped question	**33**

Question 47.

Thank you for participating in the survey. Results of the study and guidance on energy-efficient practices will be published and distributed by PG&E and industry associations in early 2010. Please provide any comments on the survey below.	
Answer Options	**Response Count**
	1
answered question	**1**
skipped question	**38**

Appendix C

Overview of Applicable Regulatory Policies

Appendix C: Overview of Applicable Regulatory Policies

Federal and State of California water policies that are basis for current regulations that apply to food processors for wastewater management are outlined as follows.

Federal Clean Water Act

U.S. Congress enacted the Federal Clean Water Act (CWA) in 1972 to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Under the CWA, United States Environmental Protection Agency (USEPA) can delegate responsibility to states for the adoption and periodic review of water quality standards for all waters within their boundaries. Water quality standards consist of designated uses for state waters, water quality criteria (known as water quality objectives in California) to protect those uses, and an anti-degradation policy.

The CWA established the National Pollutant Discharge Elimination System (NPDES) permit program to regulate point source discharges of pollutants to navigable surface waters of the United States. The CWA and implementing federal regulations require NPDES permits to contain effluent limitations reflecting the pollution reduction that is achievable through technology (known as "technology-based effluent limitations"). The goal is to ensure that receiving waters meet water quality standards [known as "water quality-based effluent limitations" (WQBELs)].

To address indirect discharges to waterways that occur when industries discharge to publicly owned treatment works (POTWs), which in turn discharge to surface water, the NPDES program also includes the National Pretreatment Program. Under this program, all large POTWs (capacity of more than 5 MGD) and smaller POTWs receiving significant industrial discharges must establish a local pretreatment program. Local permits typically require industrial and commercial dischargers to pretreat or control pollutants in their wastewater prior to discharging to a POTW.

California Water Policy

In California, the Porter-Cologne Water Quality Control Act of 1969 authorized the State Water Resources Control Board (SWRCB) to develop statewide policies and regulations in close coordination with nine California Regional Water Quality Control Boards (CRWQCBs). State law addresses both point and nonpoint source discharges to navigable surface waters, land and groundwater. Each CRWQCB is charged with implementing policies in their own geographic area in a manner that accounts for local and regional priorities and environmental conditions, such as average rainfall, depth to groundwater, soil types and other factors. As a result, the specific requirements for food and beverage processors can vary depending on their facility location.

The Porter-Cologne Water Quality Control Act authorizes the CRWQCBs to regulate discharges through the issuance of Waste Discharge Requirements (WDRs), waivers of WDRs, or prohibitions. California is also one of the states authorized by USEPA to issue NPDES permits.

Porter-Cologne Water Quality Control Act and Basin Plans

Discharges that could affect beneficial uses of groundwater are regulated by the Porter-Cologne Water Quality Control Act (Porter-Cologne). Porter-Cologne and the Federal CWA mandated that the state prepare basin plans to ensure protection of waters in each region of the state. Each of the nine CRWQCBs operates in accordance with its own basin plan, which is accessible from the SWRCB site at: http://www.waterboards.ca.gov. Basin plans contain California's administrative policies and procedures for protecting state waters, including groundwater and surface water, for designated beneficial uses. According to the SWRCB:

> Each plan must contain water quality objectives, which in the judgment of the Regional Water Board will ensure the reasonable protection of beneficial uses and the prevention of nuisance, and a program of implementation for achieving those objectives, including a description of the nature of actions that are necessary to achieve the objectives, time schedules for the actions to be taken, and a description of surveillance to be undertaken to determine compliance with objectives.

Staff of the CRWQCBs cites the water quality standards and prohibitions of the basin plan for their region in permits issued to individual dischargers. The basin plans are reviewed in each region every three years through a process that includes identifying and prioritizing water quality issues in the basin.

Beneficial Uses and Water Quality Objectives

Each basin plan defines the beneficial uses of water that may include agricultural supply, drinking water supply, recreation involving water contact, and/or habitat of various types. The basin plans also define water quality objectives necessary to protect the beneficial uses in terms of threshold levels of chemicals and water quality characteristics. Water quality objectives may be applied region-wide or may be specified for individual water bodies or portions of water bodies.

Food processors that discharge wastewater to land may be required to meet water quality objectives that are protective of potential beneficial uses of groundwater, rather than just the existing and probable anticipated beneficial uses of underlying groundwater bodies. This translates to more stringent permit requirements that are intended to be protective of the "best and highest use" of groundwater, which is generally a drinking water supply or agricultural water supply suitable for the most salt-sensitive crops.

In the cases where basin plans do not dictate specific numerical objective values for particular beneficial uses or water bodies, permits have included limitations that CRWQCB staff believe are necessary to meet narrative standards. If groundwater is considered a potential drinking water supply, discharges must meet primary and/or secondary drinking water standards established by the Department of Public Health (DPH) as maximum contaminant levels (MCLs). Primary MCLs are the highest concentrations of certain constituents that drinking water is allowed to contain. Secondary standards are limits to protect water taste, odor, and appearance.

If natural conditions at a site make a particular beneficial use highly unlikely, it may be possible to de-designate that use at that location. For example, it is unlikely that an aquifer with excessive natural salinity (defined statewide as greater than 3,000 ppm TDS) or a low production rate (for example, less than 200 gallons/day, per the Central Valley Basin Plan) will be developed for a drinking water supply. In practice, however, an exemption is difficult to obtain because it requires an amendment to the basin plan. The burden of proof is on the entity seeking the de-designation. Both the CRWQCB and SWRCB must conduct public hearings, and then the Office of Administrative Law must approve the change. De-designation of surface water beneficial uses must also be approved by USEPA.

The Anti-Degradation Policy

The SWRCB issued Resolution 68-16 (Statement of Policy with Respect to Maintaining High Quality Waters in California), referred to as the “Anti-Degradation Policy”, to further protect both surface water and groundwater. It calls for use of best practicable treatment or control (BPTC) measures as a means to protect water quality, but does not specify practices that would be effective or approved for this purpose. Some aspects of this PG&E study may contribute to defining BPTC for future use by food processors.

The Anti-Degradation Policy applies when water quality characteristics are better than the basin plan requires for protection of beneficial uses. It establishes a goal to preserve that level of quality to the maximum extent possible. However, it is not a “no degradation” or zero-discharge policy. If existing water quality is better than the water quality objectives, reduction of water quality can be allowed (but never to the extent that water quality objectives would be exceeded) if the CRWQCB determines that: it will not unreasonably affect present and probable beneficial uses, it will be consistent with the maximum benefit to the people of the state, and it is consistent with other factors listed in the California Water Code.

Specifically, Water Code Section 13241 recognizes that it may be possible for the quality of water to be changed to some degree without unreasonably affecting beneficial uses, and requires a CRWQCB to consider a range of factors including past, present and probable future uses of water; environmental characteristics of the hydrographic unit; water quality conditions reasonably achievable through coordinated control of all factors; economic considerations; and the need for housing in the region. Section 13000 mandates that activities which may affect water quality shall be regulated to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved. It is important for food processors seeking new or revised permits to understand these provisions and how they may affect proposed permit conditions.

Best Practicable Treatment and Control

A food processor planning to discharge to land in an area where it could have an affect on high quality groundwater will be required to demonstrate use of best management practices and BPTC. As noted above, neither the Water Code nor the Anti-Degradation Policy defines BPTC explicitly. In their rationale for decisions on several WDR applications, the SWRCB has previously described BPTC (sometimes along with recognition of Section 13241 factors) as the level of treatment and control technically achievable using “best efforts”. In these cases, the SWRCB made it clear that to demonstrate use of BPTC, dischargers need to compare proposed methods with existing proven technology, evaluate performance data, compare alternative methods of treatment and control, consider methods used by similarly situated dischargers, and evaluate the potential impact of the discharge as well as the mitigating effects of BPTC on groundwater. For food processors, the umbrella of BPTC includes two general categories:

- Source reduction - eliminating or decreasing the generation volume or strength of process water from a given production process.
- Recycling - reusing process water that would otherwise have been discharged, including reuse facilitated by an interim treatment step to match a particular end use.

If a processor finds that source reduction and recycling are not sufficient to meet discharge objectives specified in their permit, they may need to implement a form of wastewater treatment at the source and/or at the end pipe. Alternatively, certain process waste streams may be segregated and hauled offsite for treatment or disposal, allowing the balance of wastewater to be more effectively managed onsite. In some cases, segregated waste streams can be evaporated, leaving a smaller volume of salts for offsite disposal.

Enforcement

In all of the regions, if a discharger violates the conditions of their WDRs, enforcement staff of the CRWQCB in that region may respond with a Cease & Desist Order (CDO), prescribing specific changes that must be made. If conditions of the CDO are not met, CRWQCB may issue an Administrative Civil Liability (ACL) Complaint with fines for the violation. The amount of the fine is determined by the CRWQCB using a formula that considers the potential for harm associated with the discharge, deviation from the requirement, and other factors. It may be assessed on a per-gallon or per-day basis. The full methodology is detailed in SWRCB's Water Quality Enforcement Policy, as revised on 19 November 2009 (SWRCB, 2009) The policy is consistent with the CWC language that provides some flexibility in determining the applicable fine:

> In determining the amount of civil liability, the regional board….shall take into consideration the nature, circumstances, extent, and gravity of the violation or violations, whether the discharge is susceptible to cleanup or abatement, the degree of toxicity of the discharge, and, with respect to the violator, the ability to pay, the effect on ability to continue in business, any voluntary cleanup efforts undertaken, any prior history of violations, the degree of culpability, economic benefit or savings, if any, resulting from the violations, and other matters as justice may require. (CWC Section 13327).

In some cases, a Special Environmental Project (SEP) can be completed to offset these fines. The fact that the fine structure allows consideration of individual circumstances and negotiation is one reason that WDRs and land discharge are preferred by food and beverage processors, in comparison to the more rigid NPDES program. Staff in each of the regions has some discretion over when to pursue enforcement activities, and this does vary.