SURVEY OF WATER USE IN THE CALIFORNIA FOOD PROCESSING INDUSTRY

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ABSTRACT

Recent droughts in California and increased awareness of pollution from processing plants has renewed the interest in water management in the food industry. To assess the opportunities for improved water management, a survey of water use within the food processing industry in California was conducted. The survey included mailing a questionnaire to 453 food processing plants.

The requested information included quantity and cost of fresh water supply and wastewater disposal, seasonal water use pattern, commodity specific statistics for quantity and quality of water use, and treatment plant rates. A total of 71 plants responded to the survey. Responses from product groups were, fruit and vegetable (52), wine and beverages (9), seafood (4), meat (3), dairy (2), and oils (1).

The total water use by the responding industries was 12 billion gallons per year. The total cost was $ 18 million of which 23% was for fresh water supply and 77% was for wastewater disposal. There were 5 plants spending over one million dollars for water annually. More than half of the plants spent over $1000 per million gallons of water while 15 plants exceeded $5000 per million gallons of water. At these costs, membrane treatment of wastewater for reuse becomes an attractive alternative. Cost of freshwater supply and wastewater disposal varied widely among plants.

Specific water consumption rates of tomato, peach, olive and wine industries were found to be 890, 2830,7250, and 1320 gallons per ton of raw materials processed. The variation within each sector was high. These water consumption rates were significantly lower than the rates reported in earlier surveys.

INTRODUCTION

Increasing demand for domestic water due to expanding urban population, increasing ago-industrial demand and diminishing supply of high quality water have contributed to make high quality water a costly commodity. Recent droughts in California highlighted the gravity of the water crisis.

Wastewater discharge is becoming increasingly expensive due to stricter regulations resulting from environmental issues. The overall cost of water use in the industry is rising at an alarming rate due to the net result of these events. The food industry has responded to this situation with a renewed the interest in water conservation.

The Industry Advisory Technical Committee (IATC) formed by the National Food Processors Association (NFPA) and California League of Food Processors (CLFP) initiated a survey of water use within the food processing industry in California as a step towards finding means for water conservation.

METHODOLOGY

The survey was conducted by mailing a questionnaire to the food processing plants. Membership lists of NFPA and CLFP were the primary source of addresses for food plants. These plants were almost exclusively canneries belonging to the Standard Industry Classification (SIC) Code subgroup 203. The State Water Resources Control Board (SWRCB) maintains a computer database of all the industries in the state that are National Pollutant Discharge Elimination System (NPDES) permit holders. This database was searched for food processing industries (SIC code group 20) and crop preparation plants (SIC code 0723). This search resulted in 448 plants.

A master list of food plants was prepared by comparing the plants in California belonging to the membership of NFPA (48), plants belonging to membership of CLFP (133) and the NPDES permit holders (448) as listed by the SWRCB. The questionnaires were mailed to 449 plants contained in this master list.

The structure and contents of the survey form was prepared after many discussions of the IATC. The finalized two page form contained information requests for quantity and cost of fresh water supply and wastewater disposal, seasonal water use pattern, commodity specific statistics, and Publicly Owned Treatment Works (POTW) rates. It also provided space for additional comments.

The forms were mailed on July 10,1991 requesting that the completed forms be mailed to CLFP by July 31,1991. About 60 completed survey forms were received by the deadline. Then a reminder was sent to the parties that did not respond. When the final tally was taken at the end of August 1991, a total of 92 forms had been received. However, only 69 of these responses contained usable information.

The heaviest response was from the fruit and vegetable industry (SIC code subgroup 203). This is not surprising due the involvement in CLFP and NFPA in the survey, both with long association with this sector. Many of the industries that did not respond were insignificant water users.

The responses contained many inconsistencies and some inaccurate information. In such cases, the responders were contacted over the phone and the problems were discussed. The information was corrected based on the discussion.

The rates charged by water agencies and POTWs were furnished by the food plants as a part of this survey. However, when more than one food plant provided rates charged by the same agency the data rarely agreed with one another. Therefore, a large number of water agencies and POTWs were contacted by Phone and their rates were obtained verbally or by fax. These rates were then compared with data provided by food plants.

The information furnished by the food plants, water agencies and POTW's were compiled into five separate databases as follows.

1. Food Plants - Source, quantity and costs of fresh water supply and wastewater disposal.
2. Commodity - Flow, Biochemical Oxygen Demand(BOD), and solids generated by commodity.
3. Water Agency - Rates charged by water agencies for the supply of fresh water.
4. POTW - Rates charged by wastewater treatment plants.
5. Seasonality - Water use by food plants by the month.

The food plants database does not contain the identity of the food plant. The water supply and wastewater treatment databases contain name and telephone number of the contact person in the organization. This will help when these databases are updated.

RESULTS OF THE SURVEY

Fresh Water Supply

Of the 69 respondents, 33 obtained water from outside agencies alone and another 33 obtained fresh water from private wells alone, while 14 obtained water from outside agencies as well as from private wells. Table 1 is a summary of information on fresh water supply.

Table 1. Freshwater Supply - Quantity and Cost Statistics

Range	Quantity (million gallons per Year)			Cost ($1000 per year)			Specific Cost ($ per million gallons)		
	Private	Public	All	Private	Public	All	Private	Public	All
0-1	3	1	3	1	3	4	-	-	-
1-10	8	8	12	7	4	9	1	-	1
10-100	10	16	19	21	23	35	1	-	2
100-1000	25	11	34	4	7	13	27	16	36
1000 -10000	1	-	1	-	-	-	4	19	20
10000-	-	-	-	-	-	-		-	
No data	-	-	-	14	1	10	14	1	10
Total	47	36	69	47	36	69	47	36	69

The water use by 34 of the 69 plants was in the 100-1000 million gallon range and the median was 100 million gallons. The cost of water for 35 of the 69 plants was in the $10,000 to $100,000 range and the mean was $47,000. The specific cost of water of 36 of the 69 plants was in the $100 to $l000 per million gallon range and the median was $400 per million gallons.

All the 47 plants using own wells for fresh water reported the quantity but only 33 plants reported the cost. The 14 plants that did not track their cost included 7 plants that used over 100 million gallons per year. The largest quantity drawn by a well user was 1,800 million gallons and the highest cost was $325,000, both by the same plant.

The highest specific cost reported by a plant w`ith own well was $4,000 per million gallons. All four plants with specific costs over $1000 per million gallons for well water were users in the 1-10 million gallon range. The highest specific costs by well water users in the 10-100 and 100-1000 million gallon ranges were $810 and $540 per million gallons respectively. Both these were reported from Santa Clara - San Jose area..

All but one of the plants that obtained water from water agencies reported the quantity and all but one reported the cost. The largest quantity supplied by an outside water agency was 523 million gallons while the highest amount charged was $385,000. These two do not refer to the same food plant. The highest rate paid to a water agency was $5,000 per million gallons by a plant in San Francisco bay area. However, the quantity used by this plant was in 1-10 million gallon range. The highest rate paid by the users in the 10-100 million gallon range was $3,200 per million gallons by another plant in the same area. The lowest rate paid to an agency was $123 per million gallons by a food plant in Stockton East water district.

Wastewater Disposal

Of the 69 respondents, 30 disposed wastewater to private facilities and 32 disposed to POTW's. Another 7 plants used both means of disposal. All 69 plants reported the quantity of water disposed. However, 14 plants did not report the cost of private disposal and 3 plants did not report the cost of public disposal. Three plants that did not report cost of private disposal discharged over 100 million gallons. Table 2 is summary of the information collected on wastewater disposal in the form of a frequency table.

Table 2. Wastewater Disposal - Quantity and Cost Statistics

Range	Quantity (million gallons per Year)			Cost ($1000 per year)			Specific Cost ($ per million gallons)		
	Private	Public	Total	Private	Public	Total	Private	Public	Total
0-1	4	-	4	-	-	-	-	-	-
1-10	7	7	22	4	3	4	-	-	-
10-100	11	15	19	12	13	23	1	5	1
100-1000	15	16	33	7	18	25	11	7	15
1000 -10000	-	1	1	-	2	2	11	28	37
10000-	-	-	-	-	-	-	-	1	1
No data	-	-	-	14	3	15	14	3	15
Total	37	39	69	37	39	69	37	39	69

The quantity of water disposed by 33 out of 69 plants was in the range of 100 to 1000 million gallons of water and the median was 90 million gallons. The cost of disposal by 25 plants was in the $100,000 to $1,000,000 range and 23 plants was in the $10,000 to $100,000 range. The median cost of disposal was $100,000. The specific cost of disposal for 37 plants was in the $l000 to 10,000 range and the median was $1800 per million gallons of water.

The total quantity of disposed water was significantly less than the total quantity of fresh water inflow in some plants. This was mostly due to direct discharge of non contact cooling water which was not considered as wastewater. Fresh water ending up in cans and jars as brine and syrup also contributes to this difference. The cost of disposal to public treatment plants, in many cases, included capacity and demand charges for flow, BOD and suspended solids.

The largest quantity treated in a private facility was 700 million gallons at a cost of $210,000 in an aeration lagoon. However highest cost of treatment at a private facility was $350,000 to treat 175 million gallons by land disposal. The highest specific cost for private disposal of $8000 per million gallons was reported for an evaporation pond treating 450,000 gallons.

The highest quantity of water disposed by a single plant to a public facility was about 1,800 million gallons and the highest cost was 1.8 million dollars, both by the same plant. The highest specific cost for disposal through a public facility was over $17,000 per million gallons. This belonged to a plant that was

forced to transport wastewater by truck to a treatment plant. Besides this plant there were four other plants spending over $5000 per million gallons for wastewater disposal through public facilities.

Overall Cost of Water Use

The total cost of water is obtained by summing up the cost of fresh water supply and cost of wastewater disposal. When this statistic was compiled it was found that 14 plants spent over $5000 per million gallons of water use and another 33 spent between $1000 to $5000.

The cost of water use amounts to $0.26 to $4.50 per ton of tomatoes, $8.95 to $58.91 per ton of olives, and $0.84 to $11.38 per ton of peaches. The wide variation is due to differences in rates of the water agency and the POTW and also due to differences in conservation measures in the processing plant.

Product Specific Water Use and Effluent Strength

The largest number of responses received for a specific product was 23 for tomatoes. The specific water use for tomato processing ranged from 144 to 1870 gallons per ton of tomatoes and the median was 920, The biochemical oxygen demand (BOD) of the tomato processing effluent was reported by 17 plants. The reported values ranged from 0.3 to 32 lb/ton of tomatoes and median was 8. The total suspended solids (TSS) was reported by 13 plants. The values ranged from 0.55 to 20 lb/ton and the median was 6. The lower end of the ranges belong to bulk tomato paste plants while the higher end correspond to retail tomato sauce plants.

Table 3. Specific Water Use and Effluent Strength for Some Products

Product	Flow Gallons per ton	BOD lb per ton	TSS lb per ton
Apple Sauce	275		
Apricots	2,992	39.0	9.0
Artichokes	766	3.3	3.9
Asparagus	808		
Brussels Sprout	813		
Cheese	1,700	1000	29.0
Cherry	11,932	102	21.0
Frozen Fruits	1,780		
Garlic	2,800	1.8	
Meat	4,000		
Mushrooms	1,818	1.8	0.8
Mushrooms*	781		
Onions	1,000		
Pears	4,174	11.0	6.0
Pumpkins	3,690		
Raisins	2,000	75.0	15.0
Seafood	2,700	12.9	7.9
Seafood*	2,662		4.0
Specialty	3,514		12.7
Vegetable Oils	2,111	1.1	0.3
Yams	6,094	8	3.0
Yams*	4,186	39.8	22.3
Zucchini	7,975	340	104.0

* Data from two different plants

Six responses were received from the wine industry. The specific water use in wine production ranged from 625 to 2800 gallons per ton of grapes and the median was 1000-1250. None of the wine makers provided data on BOD or TSS in wastewater.

The peach industry also provided six responses. The specific water use ranged from 1800 to 3900 gallons per ton of peaches and the median was 2700-2900. The BOD was reported by only four plants and the values were 9, 38, 41 and 67 lb per ton of peaches. The TSS was reported by the same four plants and the values were 4, 10, 12, and 18 lb per ton of peaches.

The olive industry provided four responses with data on specific water use and effluent strength. The reported values of flow were 3000,7100, 8400 and 10400 gallons per ton of olives. Only two plants provided data on BOD and suspended solids. The values were 63 and 90 lb of BOD and 5 and 28 lb of TSS per ton of olives.

Another 24 plants provided specific water use and effluent strength data on 22 different products ranging from apple sauce to zucchini. Table 3 is a complete listing of these data.

Water Agency Rates

There were 38 food plants that obtained fresh water from 29 water agencies. The rate structure of these water agencies differed widely. Most water agencies had a service charge that varied with the size of the meter from about $5.00 per month for a half inch meter to about $200 per month for 12 inch meter. The rate for quantity of water use was usually in multiple steps. The unit of water use and the steps were in million gallons, hundred cubic feet and acre feet. Exact comparison of charges was made difficult by these discrepancies.

However, an approximate comparison done using the rate at the highest quantity step, is presented in Table 4 for 10 water agencies. These rates do not include service charges. This table indicates the wide differences in rates that exist among the water agencies. The rate structure of some agencies penalized the high users with higher rates while some others rewarded the high users with lower rates.

Table 5. Fresh Water Rates in Some California Communities

Community	Price of Water $ per million gallons
Turlock	160.00
Orland	250.00
Modesto	433.30
Hollister	784.00
King City	823.00
Oroville	1038.00
Los Angeles	1132.00
Santa Rosa	1570.00
Santa Cruz	1805.00
San Jose	1925.00

POTW Rates

There were 39 food plants that discharged water to 29 Publicly Owned Treatment Works. The rates as well as the rate structure varied widely among these POTW's. Most POTW's had wastewater loading rates based on quantities of wastewater, BOD and TSS. A small number had loading rates based only on quantity of wastewater. Another few plants paid lump sums irrespective of the quantity and quality of wastewater. Table 5 is a listing of wastewater loading charges by 16 POTW's. It could be seen that two plants charged for ammonia and one for fat content in wastewater. A number plants not included in this table based charges on chemical oxygen demand (COD) instead of BOD. This seems to be an increasing trend.

Table 5. Wastewater Loading Rates of Some POTW's

Community	Wastewater Loading Rates					Total Loading Charge for Median Plant
	Flow $ per MG	BOD $ per kp*	TSS $ per kp	Ammonia $ per kp	Fats $ per kp	
Stockton	165.04	13.56	20.56			38367.68
Watsonville	77.70	27.41	20.28			41244.40
Turlock	381.00	21.80	43.40			78532.00
Hollister	362.22	45.96	64.60			108852.24
Modesto	518.60	61.34	56.46			130659.00
Sacramento	360.96	96.72	53.15			142474.32
Visalia	281.58	71.00	104.00			145105.36
Oroville	270.00	146.00	42.00		38.00	166840.00
Atwater	459.00	142.00	83.00			205628.00
Fullerton	215.00	121.00	155.00			209580.00
San Jose	1470.00	74.00	98.00	771.00		253240.00
Merced	300.00	166.97	208.46			286252.00
Monterey	715.20	148.70	175.50			290058.40
Santa Cruz	3770.00					346840.00
Orland	6810.00					626520.00
Santa Rosa	4040.00	223.60	145.60	780.00		637920.00

* kp denotes kilopounds or a unit of 1000 lbs.

The differences in rate structures makes it difficult to compare the rates among POTW's. Therefore, Table 6 also contains a column listing the total wastewater loading charge for the median tomato processing plant which processes 100,000 tons of tomatoes in an year, discharging 920 gallons of water, 8 lb of BOD and 6 lb of TSS per ton of tomatoes. This comparison indicates that the loading charges between extremes vary by a factor of 16.

Table 6. Annual Capacity Charges by Some POTW's

Community	Annual Capacity Charges				Total Capacity Charge for Median Plant
	Flow $ per MGD	BOD $ per kpd	TSS $ per kpd	Ammonia $ per kpd	
Turlock	10261.00	1200.00	700.00		25259.70
San Jose	30678.00	8376.00	9744.00	771.00	167047.90
Stockton	55545.00	9400.00	6600.00		180316.60
Merced	40300.00	10680.00	8570.00		189047.60
Watsonville	77064.00	7800.00	23520.00		298258.90

A number of POTWs have an annual capacity charge. The basis for this usually, but not always, is the capacity utilization during the maximum month. Table 6 is a listing of annual capacity charges in five POTW's. This table also contains a column for the total capacity charge for the median tomato processing plant assuming that the processing was done in three months in equal quantities. As in the case of loading charges, the capacity charges also vary widely among the POTWs.

In addition to the loading and capacity charges some POTW's have a one time connection fee while some require new plants to make one time payments towards the repayment of capital investment of the POTW.

Seasonality of Water Use

The water use by most of the food plants showed seasonal trends. Table 8 shows the monthly water use as a percentage of the yearly sum for tomato, peach, olive and wine industries. Tomato and peach industries use most of the water during summer months with the peak in August. Water use in the olive industry is spread over seven months from October to April. The wine industry used more water in August, September and October months. Most of the fruit and vegetable industries followed trends similar to tomato and peach plants. Milk and meat processing industries did not show any seasonality in water use.

Table 7. Seasonal Water Use Patterns

Month	Monthly Water Use as a Percentage of Yearly Sum			
	Tomatoes	Peaches	Olives	Wine
January	3.4	1.3	11.4	8.4
February	2.9	2.1	12.3	8.3
March	3.5	2.1	12.2	6.0
April	2.6	2.1	10.5	6.1
May	3.5	2.9	4.8	6.0
June	6.3	2.7	3.6	6.1
July	20.7	19.0	2.0	6.0
August	25.1	35.3	2.4	11.9
September	19.7	22.6	6.8	12.2
October	4.6	7.5	13.7	12.0
November	3.2	1.8	11.7	8.4
December	4.5	0.7	8.7	8.5

SUMMARY AND CONCLUSIONS

This survey was successful in collecting a wealth of information on water use by the food industry in California. The water use by the fruit and vegetable processing industries has reduced significantly compared to the surveys conducted in 1970s. However, the large variation within each industry by itself is an indication of the potential for further reductions.

The cost of fresh water supplied by different water agencies and cost of wastewater treatment by POTW's varied widely among different communities. An inquiry into these variations may reveal valuable information. The contribution of cost of water towards the processing cost of commodities also varies from community to community. This should be taken into account when locating food processing industries.

The overall cost of water, including cost of fresh water and cost of wastewater treatment, was over $5000 per million gallons for 14 food plants. The current trend is for further increases in these rates. The cost of desalination of water is reported to be about $6000 per million gallons. Therefore, even the most Extraordinary treatments that enable reuse of water, may become feasible in the near future.

The responses received during this survey were very encouraging. Many responders complemented the effort and suggested that this survey be made an annual feature. Conducting the surveys of food plants, water agencies and POTWs on an annual basis with somewhat wider coverage is strongly recommended for the future. The experience gathered during this survey will help reduce the workload in the future surveys. Wide dissemination of the findings of the survey could help receive more and better responses in the future.

Acknowledgments

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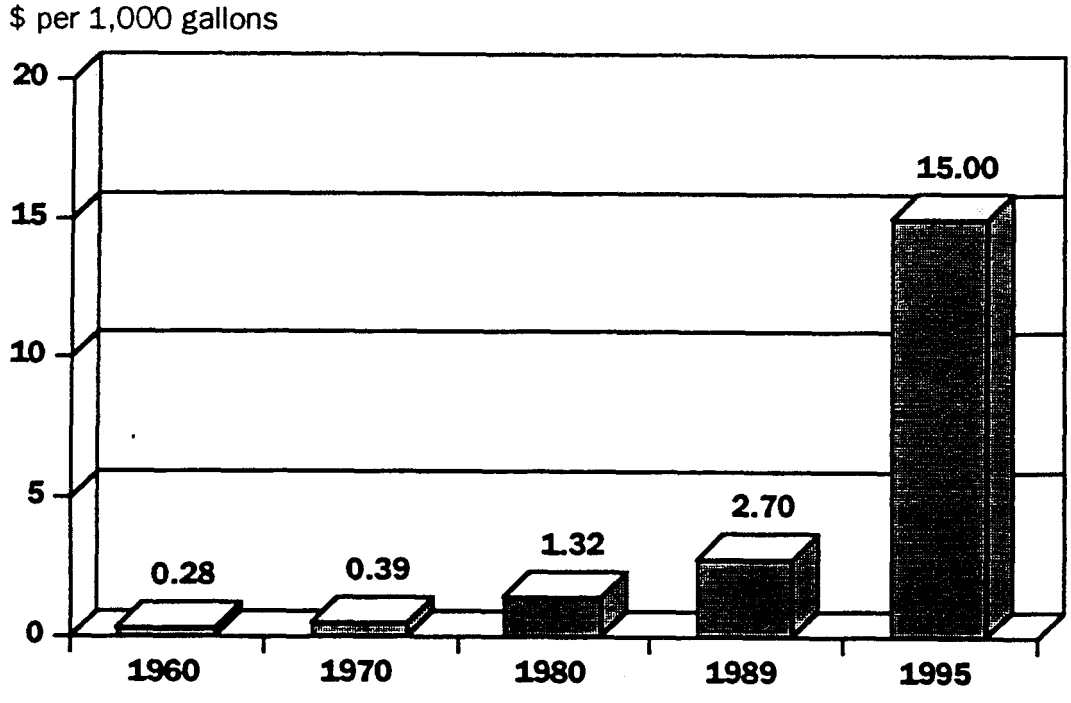

Figure 10. Water and Sewage Charge Summary ($/1000 Gal., Gainsville, GA)