Water Reuse for Agricultural Processing: A Community Case Study

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Prepared for Agricultural Utilization Research Institute

1.0 Abstract

Water sustainable solutions require communities to broaden planning boundaries and look toward partnerships to achieve economic and resource protection goals. This case study looks specifically at one Midwest rural community. This community, like many rural communities, has more industrial than domestic water demand and wastewater discharges. While each community has a unique composition of municipal and industrial water and wastewater systems, there are common elements that can be summarized to serve as a model for planning future improvements to meet private and public entity economic goals and provide for the community's sustainability.

The approach taken in this study was to evaluate the water balance for the community and identify opportunities for water reuse. The case study community is represented by a municipality providing water supply and wastewater treatment services and two nearby industries. Water-sustainable opportunities include process changes that reduce and reuse water at industrial facilities, modifications at municipal wastewater treatment facilities, and use of treated municipal wastewater for non-potable water uses at the industries or in the community.

Based on the conceptual costs developed for six water sustainability practices, the most feasible alternative for this community is for one of the industries to maximize use of reclaimed process water within their own facility. This will reduce the wastewater discharged to the municipal wastewater treatment plant, which provides the municipality capacity that can be allocated to other customers. The additional capacity can be used to attract new industries to the area or allow other expansion. To avoid rate increases and possibly offset the industry's savings through water reuse, the municipal revenue lost from potable water sales and reduced treatment services must be replaced with new customers.

This community case study involves a municipality with a low-cost, groundwater supply and adequate capacity in their water infrastructure systems. The two industries are dairy-based and net water producers with high-quality water requirements. For other communities and industries looking to implement water sustainability practices, the following circumstances would improve the economic viability: limited supply of adequate quality water, infrastructure capacity limitations, water demands that do not need a high-degree of treatment, inclusion of other existing or future industries with a year-round consistent source of water, and a longer planning horizon to account for future infrastructure replacement costs and water regulations.

2.0 Introduction

The Agricultural Utilization Research Institute (AURI) recognizes the value of reclaimed water for the agricultural processing industry. AURI has directed funding to study reclaimed water use for industry and this case study is a continuation of this effort to understand and explore the possibilities and potential benefits of water reuse at industrial facilities.

This case study looks specifically at one rural community in Minnesota. This community, like many rural Minnesota communities, has more industrial than domestic water demand and wastewater discharges. While each community has a unique composition of municipal and industrial water and wastewater systems, there are common elements that can be summarized to serve as a model for planning future improvements to meet overall economic goals for the community as a whole, both private and public entities.

These common elements, and the focus of this case study, involve water sustainability practices. For this community and others like it, it is important to evaluate the water balance for the community, rather than plan water supply and wastewater systems separately for municipal and industrial facilities. Opportunities include process changes that reduce and reuse water and pollutant loads at industrial facilities, modifications at municipal wastewater treatment facilities, and use of treated municipal wastewater for non-potable water uses at the industries or in the community.

2.1 Study Objective

The purpose of the study is to determine alternatives to reduce overall water use at multiple facilities while achieving a cost-effective plan for overall wastewater treatment and water supply. The study is intended to provide:

- List of information required to evaluate water sustainability practices.
- Documentation of questions and planning activities for water sustainability projects.
- Concept plan for water sustainability for two case-study industries.
- Evaluation of proposed water sustainability improvements for the municipal wastewater treatment facility in terms of capacity and costs.
- Industry return on investment and related benefits from a water sustainability plan.

This study utilizes a case-study approach to demonstrate the potential synergy between public and private entities related to water resources. The study is focused on a specific rural community in Minnesota, which is presented as a “generic” community with local agricultural processing industries.

2.2 Background

AURI has partnered with a specific rural community, herein referred to as "City", to conduct the study and use data specific to the City and its local industries. The City has a population of approximately 3,500. The City provides wastewater treatment for the residential/commercial sector, and also provides treatment for three significant industries, including dairy industries. This community was selected because its industries contribute approximately 80 percent of the wastewater volume and portions of the City's Wastewater Treatment Facility (WWTF) are approaching hydraulic capacity.

The City is completing a wastewater treatment facility (WWTF) planning process to evaluate the facility's capacity. This is an opportune time to evaluate water use and pollutant loadings at the municipal and industrial facilities to identify reduced water use practices and the most cost-effective treatment for the collective facilities.

This study evaluates water use at two of the three significant industries, herein referred to as Industry #1 and Industry #2, with the objective to determine if water sustainability practices could alleviate some of the municipality's capacity concerns. This report describes the water sustainability opportunities identified and describes how the changes could benefit the industries, as well as the City.

2.3 Related Project Studies

AURI contacted the Metropolitan Council Environmental Services (MCES), St. Paul, Minnesota, to coordinate efforts for a water reuse study focused on the agricultural processing community. MCES completed a study on the feasibility of industrial water reuse in Minnesota [MCES, 2007] and AURI was looking to build on the efforts in this study. MCES and AURI funded two studies completed by Craddock Consulting Engineers in June 2009.

- Reclaimed Water for Agricultural Processing, Technical Memorandum 1
- Ethanol Facility Water Reuse Case Study, Technical Memorandum 2

The first document provides an overview of water reuse in Minnesota with specific applications and considerations for agricultural processing facilities. The second document provides a planning level analysis of facilities and operation and maintenance (O&M) requirements to supply reclaimed water to an ethanol facility for cooling water use. The analysis identifies the basic project elements that need to be evaluated to technically implement a project.

3.0 Water Use Evaluation Approach

There are four main steps to implement a water conservation/reuse plan and water sustainability projects:

1. Establish support, goals, and resources.
2. Conduct water audit.
3. Prepare plan of action and implementation.
4. Track results and publicize success.

This study was intended to focus on the steps 1, 2 and part of 3.

The first step in a water use evaluation involves establishing support, goals, and resources. This first step has been completed with AURI's assistance and the participation of willing industries.

3.1 Conduct Water Audit

The second step in a water conservation/reuse plan is to complete a water audit. The purpose of the water audit is to understand where water enters the facility, where it leaves the facility, what water quality is required, and what water quality is discharged. The water audit also documents locations where water efficiency practices are already in place. To complete the water audit, SEH met with staff at each of the two industries to learn about the industrial process and water use within the facility. Following the initial meeting, an email summarizing a list of water needs was submitted to each industry. This was followed up with several conversations and emails with additional information.

For most industrial water use evaluations, it is important to obtain the following information:

- Process schematic.
- Water balance schematic identifying all water-using equipment and demands.
- Wastewater discharge permits and significant industrial agreements.
- Pretreatment reports showing average, minimum, and maximum flows.
- Pretreatment reports showing effluent water quality, possibly including biological oxygen demand (BOD), total suspended solids (TSS), total phosphorus (P), ammonia, total kjeldahl nitrogen (TKN), metals, total dissolved solids (TDS), chlorides, sulfate, hardness, anions/cations, and total coliform/E.coli.
- Future flow projections.
- Historic records of water use.
- Potable water quality.
- Potable water supply and treatment process.
- Information on water use including locations of water meters and wastewater meters.
- Utility rates (water, wastewater, electricity, natural gas).
- Staffing information (number of employees, number of shifts).

After reviewing the available information, a facility survey should be completed. For this study, plant staff were consulted to answer questions that would typically be answered with a facility survey. The facility survey objectives are to observe how water is used, where it may be used excessively, calibrate flow meters, note hours of operation for all water-using equipment, and consult with employees using equipment.

After the facility survey, an audit summary can be compiled. The audit summary serves as the baseline for water use. It summarizes the primary water uses and is compiled in such a way that can be viewed annually or monthly for comparison. The audit summary should include water costs. Depending on the industry, it may be useful to calculate the water used per unit of production.

3.2 Prepare Plan of Action and Implementation

The plan of action should summarize opportunities to implement water conservation measures and describe the benefits, challenges, cost savings, and implementation costs of each measure. The actions should be prioritized, and key staff identified to lead the implementation.

3.3 Track Results and Publicize Success

Results of implemented water conservation measures should be compared back with the baseline audit results to quantify savings. The successes should be acknowledged and awarded.

4.0 Public Resources and Utilities

To consider water use and the impact sustainable water practices can have on the industry and the City, it is important to understand the public resources and utilities and any capacity issues that may exist. For this particular case study, the City provides water and wastewater services to its 3,500 residents, commercial entities, and three significant industrial users.

4.1 Water Utility

Important questions to ask a municipality about its potable water system when looking at water sustainability opportunities at a community level include:

1. Are there any water supply limitations?
2. Are there any capacity concerns with the potable water treatment, distribution, or storage systems?
3. What are the treatment costs per 1,000 gallons of water? Would a reduction in water use have a significant impact on operations and maintenance costs of the water system?

The City's water supply comes from five groundwater wells and is stored in two 1-million gallon water towers. The City pumps an average of 1.7 to 2.5 million gallons of water per day. The City distinguishes water users as residential, commercial, or industrial customers. Approximately 80 percent of the water used within the City is for industrial customers, as shown in Table 1.

Table 1
Summary of Water Use

Customer Type	Annual Volume Used (MG)	Percent of Total	Number of connections	Average Daily Use per Connection (gpd)
Residential	79.5	13%	984	221
Commercial	31.3	5%	140	613
Industrial	504.3	80%	8	NA[a]
Total	615.1			

Notes:
a) Eight metered industrial connections serve three industries. The smallest industry has one metered connection and an average daily potable water use of 3,175 gpd. The largest industry has four metered connections with an average daily use of 1,026,000 gpd.

Minimal treatment of the groundwater is required for the City's supply, and as such the water rates charged to the City's water customers is relatively low. Water rates are comprised of a monthly customer charge that varies from $10 to $233, depending on the water meter size, and commodity output charges that vary seasonally (for residential customers) and with the volume of water used. For industries, the commodity output charge is $1.25/1,000 gallons.

The potable water storage and distribution systems are also part of the City's water utility. In this instance, the City did not identify any storage or distribution capacity limitations; however this may not be the case for all communities. In other communities, water supply, treatment, or distribution may be capacity limited, and water sustainability strategies implemented at an industry may provide the municipality with more available treatment capacity, may reduce operations costs, or may reduce future capital expenditures needed to increase capacity.

4.2 Wastewater Utility

Important questions to ask a municipality about its wastewater system when looking at water sustainability opportunities at a community level include:

1. Are there any sewer collection system capacity limitations – either sewer or lift stations?
2. Are there any capacity concerns with the wastewater treatment system – hydraulic, organic, nutrient, or solids-related?
3. If flows are reduced, but loads remain the same, will the wastewater become too concentrated in any given parameter and inhibit treatment?
4. What are the treatment costs per 1,000 gallons of water? Would a reduction in water use have a significant impact on operations and maintenance costs of the wastewater treatment or collection systems?
5. Are there upcoming discharge regulations that require a significant capital investment - an investment which could be reduced if flows or loads are reduced?
6. Are there upcoming discharge regulations that could drive decisions? For example, biological phosphorus removal typically requires a certain ratio of BOD to phosphorus. Decisions, either to provide pretreatment at the industry or not, can impact this ratio in and result in different levels of performance.

The City has a wastewater treatment facility with a rated average wet weather flow capacity of 3.0 million gallons per day (MGD) and an average dry weather capacity of 2.65 MGD. Equipment at the facility lacks treatment capacity for peak conditions. In 2011, the average daily flow to the treatment facility was 2.08 MGD. Approximately 75% of this flow, or 1.56 MGD, is attributed to the three significant industrial users (SIUs). The wastewater treatment facility has an organic treatment capacity of 10,383 pounds per day (lb/d) of CBOD, but in 2011 saw an actual load of only 2,323 lb/d, as shown in Table 2. Table 2 notes that the combined industrial CBOD contribution is greater than the actual load measured at the facility. This is likely due to treatment that occurs in the sewer collection system prior to influent sampling at the wastewater treatment facility, and errors inherent in sample collection and characterization.

Table 2
Summary of Wastewater Flows and Loads

Parameter	Flow (MGD)	CBOD (lb/d)
Design Capacity[a]	3.0	10,383
2011 Actual Flow/Load	2.08	2,323
Estimated Municipal/Commercial[b]	0.36	612
Industry #1	0.61	54
Industry #2	0.056	662
Industry #3[c]	0.89	2,219
Industrial Contribution[d]	75%	126%

Notes:

a) Average wet weather design flow.
b) Estimated based on 100 gallons per person per day and 0.17 lb BOD/person/day.
c) Industry #3 has a rated flow (average flow during peak production days) of 1.25 MGD.
d) Industrial organic loadings measured at the industries are greater than the loadings measured in the facility influent, which is indicative of treatment in the collection system and sample characterization error.

The City's wastewater treatment facility (WWTF) is hydraulically limited and not organically limited. While most of the organic loading is associated with the industries, overall the facility is organically under-loaded in comparison to the flow. The influent organic concentrations at the WWTF (120 mg/L CBOD) are lower than typical domestic sewage (190 mg/L BOD). This can result in higher treatment cost per pound of organic load. Based on this, the best focus for this study, given the partnered approach between the City and the industries, is on volume reduction.

Water conservation at an industry often results in more concentrated discharges to the WWTF. For some communities that have organic treatment limitations in addition to hydraulic limitations, it may be important to address both the quantity and quality of the industrial discharges, but this is not the case for this particular community.

The three SIUs in this community each have agreements with the City that prescribe wastewater discharge allocations. In 2011, the industries paid a base monthly fee and paid for flow, BOD, suspended solids, phosphorous and ammonia-nitrogen based on a tiered system. Industry #1 has implemented a number of water reuse strategies to reduce its wastewater discharge by an average of 160,000 gallons per day over the last two years. However, the peak day loads from the industry remain high and, therefore, this reduction has not had a positive impact at the City's WWTF.

Also part of the wastewater utility is the sewer collection system which conveys the wastewater from the industries to the municipal wastewater treatment facility. The City has studied the capacity of sewer lines throughout the City and has identified that the sewer line from the two industries has limited capacity. Therefore, reducing the wastewater volume has the potential to prevent a future capital investment to replace the sewer line with a larger diameter pipe. However, further investigation is required to determine the condition and remaining useful life of the sewer, as replacement may be warranted for non-capacity reasons as well.

4.3 Recycled Water Utility

Most Minnesota communities do not have a recycled water utility, but there are many examples of communities with recycled water utilities within the United States. In this report "recycled water" specifically refers to treated effluent from a municipal wastewater treatment facility. Recycled water can be reused to reduce potable water demands. Important questions to ask when considering the potential for recycled water use include:

1. Are there water demands at industries that can be served with recycled water from the municipal wastewater treatment facility? Industrial uses could include cooling water or rinse water. It is important to remember that industries, particularly food and beverage industries, may be subject to stringent health and safety regulations that may limit recycled water use. As a follow up: what quality of water is needed for the reuse locations?

2. Are there demands at the wastewater treatment facility that can be served with treated effluent?

3. Are there water demands within the community that can be served with recycled water from the wastewater treatment facility or reclaimed water from industry? These demands could include irrigation of parks, ball fields, or street sweeping. As a follow up: What quality of water is needed for the reuse locations? Are there separate irrigation water meters? Where are the use locations with respect to the recycled water supply?

4. Are there future effluent discharge regulations that are more easily achieved if effluent is reused rather than discharged to a surface water?

5. What level of wastewater treatment is currently provided?

6. Is there available space at the wastewater treatment facility for additional treatment/pumping systems?

Use of recycled water from a wastewater treatment facility in Minnesota requires a permit that includes routine monitoring of the water, conformance to water quality limits, treatment process requirements, and adherence to specific construction codes and possibly local ordinances. Minnesota is one of several states that have not developed state water reuse criteria. Currently Minnesota uses California's *Water Recycling Criteria*. Additional treatment of the wastewater at the wastewater treatment facility may be needed to comply with the *Water Recycling Criteria* depending upon the end use of the recycled water.

The City does not have a recycled water utility. The industries that opted to participate in the study are wet industries, meaning that they produce more wastewater than the potable water they consume, which is described further in a following section. For this reason, using recycled water from the City's WWTF in the wet industries is not practical when the industries can reclaim their own water for reuse.

City potable water billing records were reviewed to assess the potential for recycled water use within the City. The WWTF uses on average approximately 28,000 gallons of potable water per day. A portion of this water demand can be offset by using recycled water. At a wastewater treatment facility recycled water can be used at hose bibs, seal water for pumps, spray/rinse water for solids thickening and dewatering applications, spray water for foam control, and other locations. Section 4 discusses some of the costs associated with an in-plant recycled water system.

The City's potable water use records are also useful to determine water demands for irrigation uses. Comparing the water use during the summer months with that of the winter months is one way to estimate how much water is used for irrigation purposes. There are a small number of users within the City that have separate irrigation water meters, but most users have only one meter. There is a City park located near the WWTF which could be a potential recycled water use location. Costs associated with a recycled water distribution system are presented in Section 4.

One of the two industries participating in the study currently uses the pretreated industrial wastewater for irrigation. While this reduces the wastewater volume to the municipal WWTF, it only provides a seasonal reduction and does not alleviate the municipal wastewater treatment facility of its capacity limitations during the winter months.

4.4 Electric Utility

The City also provides electrical service to the community and industries. While energy is not a focus of this study, often reducing water use results in reduced energy consumption. A complete economic evaluation of reduction or reuse options would consider associated energy savings/costs and, therefore, it is important to consider energy costs when evaluating water reuse and reduction opportunities. Reduced electricity demands may also provide benefits to the electrical utility in the form of grid capacity.

Industrial electric service has the following rates for 2011:

- Customer Charge: $30.00/month
- Demand Charge: $11.48/kW
- Energy Charge: $0.0386/kWh
- Franchise Fee: 5% in addition to the above rates

5.0 Water Sustainability Opportunities

Municipalities and industries alike invest significantly in water infrastructure and the operation of water systems. Pumping, treating, and distributing potable water is costly. On the back end, collecting, pumping and treating wastewater is costly. Implementing water sustainability strategies, including reducing demand and using reclaimed water, can positively impact both the municipality's costs, as well as industry's costs.

The following sections describe water sustainability opportunities for the community, focusing on the two participating industries and typical recycled water uses. Conceptual-level implementation costs are provided. These conceptual-level cost estimates are developed from assumptions and have an accuracy range of +40 to -20 percent. Further development of a given water reduction/reuse strategy is necessary to more accurately define implementation costs.

5.1 Industrial Water Sustainability

The City is home to three significant industries, two of which have opted to be involved with this study. These two industries contribute to the water demand and flows/loads at the wastewater treatment facility. Table 3 summarizes the water and wastewater uses and average unit water/wastewater costs for these two industries. The wastewater costs per 1,000 gallons are significantly different between the two industries. This is because Industry #1 provides pretreatment, while Industry #2 does not.

Table 3
Summary of Water-Related Demands and Costs

Industry	Average Potable Water Purchased (gpd)	Average Potable Water Unit Cost ($/1,000 gal)[a]	Average Wastewater Produced (gal/d)	Average Wastewater Unit Cost ($/1,000 gal)[c,d]
Industry #1	424,780	$1.90	608,310	$1.16
Industry #2	3,176	$1.25[b]	56,032	$5.21

Notes:

a) Cost excludes monthly meter charges (which would not change with water reduction)
b) Cost excludes onsite water softening, which is expected to be minimal for Industry #2 based on the volume of water used.
c) Costs present net average costs including all surcharges.
d) Costs exclude wastewater pretreatment costs at the industry.

5.1.1 Understanding the Industries

The two participating industries are dairy-processing industries. It is important to be familiar with the specific industry(s) under consideration for water reuse to understand the water use areas to target and also to understand the regulations that apply.

Dairies are unique industries because the wastewater volume discharged is often greater than the volume of potable water used. This is because the raw material, or milk, is approximately 80 percent water. At dairies, the raw milk is pasteurized and placed in cooking vats for setting. After setting, the product may be heated, dried, or filtered (depending on the location) to separate the solids and proteins from the liquid. This liquid is sometimes called condensate of whey (COW) water because it is the water that condenses when the raw milk is heated, which is the case for Industry #2. Industry #1 uses filtration to separate the solids and refers to the liquid as polished water, RO water, or permeate.

Not all industries are net water producers like dairies. For many other types of industries, the wastewater volume produced is less than or equal to the volume of potable water used. Because a large portion of the wastewater volume is from the raw input material (milk), the wastewater volume is directly related to the volume of raw material/product. This leaves only the potable water fraction of the effluent wastewater (refer to Table 3) that can be targeted for reduction. This narrows the focus of the study to the potable portion of the wastewater volume.

Appendices A and B describe in further detail the two industries participating in the study and the potential water use reduction and/or reuse potential and the associated costs. Table 4 below summarizes the potential water reductions identified in the Appendices for the different levels of investment described above.

Dairy processing industries are regulated by the United States Food and Drug Administration (FDA) and by state rules and regulations. Most industries producing a product consumed by humans (food or beverage) are regulated by the FDA, and it is critical to understand the applicable regulations (both federal and state) when considering water reuse. For Minnesota dairies, there are specific rules governing water sources used in the industry set forth in the FDA Pasteurized Milk Ordinance (PMO). The most recent PMO is from 2009. Appendix D of the PMO identifies the standards for water sources. The PMO states that water reclaimed from Grade "A" milk and milk products may be reused in a milk plant and identifies three general categories of water reuse:

- Category I: Reclaimed water used for potable water purposes, including the production of culinary stream.
- Category II: Reclaimed water used for limited purposes, including the production of culinary steam, pre-rinsing of product surfaces, and cleaning solution make-up water.
- Category III: Reclaimed water used as feed-water for boilers not used for generating culinary steam, or in a thick, double-walled, enclosed heat exchanger.

Each of the above use categories has associated water quality requirements. These water quality requirements restrict the reuse and define the treatment requirements.

5.1.2 Industrial Water Sustainability Strategies

In general, three levels of investment are identified to reduce potable water demands and use water more sustainably at the two industries:

(1) Conservation and education.

(2) Using polished or industrial reclaimed water in place of City potable water for PMO Category II and III uses.

(3) Treating polished water to potable water quality standards and using the treated water in place of City potable water for Category I uses.

Conservation and education require investment in monitoring equipment, control systems, database development and annual costs for operating and maintaining equipment and practices. Reduction through conservation and education may be considered the low-hanging fruit, but in some cases conservation and education strategies require investment in more efficient fixtures or equipment.

Polished water can be used in some locations, but not all, and there will likely be capital costs associated with new piping for polished water. Process potable water demands could be offset if polished water is further treated to potable water quality standards. It would be beneficial to reduce water use through conservation/education and use of polished water prior to implementing a potable-quality treatment system to minimize the size of the treatment system. However, there becomes a point at which the cost to increase the size of the treatment system is less expensive than cost to implement conservation or increase the use of polished water.

Table 4
Summary of Industrial Water-Sustainability Strategies and Costs

Water Reduction Strategy	Industry #1	Industry #2
Conservation/Education		
Reduced Potable Water Demand (gpd)	36,000	600
Estimated Capital Cost of Implementation	$80,000	$5,300
Estimated Annual O&M Cost of Implementation	$15,000	$300
Estimated Annual Utility Cost Reduction[a]	$28,000	$315
Estimated Simple Payback Period (years)	6.2	NA[b]
Category II & III Uses		
Reduced Potable Water Demand (gpd)	94,000	2,000
Estimated Capital Cost of Implementation	$160,000	$16,000
Estimated Annual O&M Cost of Implementation	$26,000	$3,000
Estimated Annual Utility Cost Reduction[a]	$72,000	$1,000
Estimated Simple Payback Period (years)	3.5	NA[b]
Category I (Potable-Quality) Uses		
Reduced Potable Water Demand (gpd)	100,000	3,000
Estimated Capital Cost of Implementation	$565,000	$292,000
Estimated Annual O&M Cost of Implementation	$56,000	$29,000
Estimated Annual Utility Cost Reduction[c]	$76,000	$10,400
Estimated Simple Payback Period (years)	27.6	NA[b]

Notes:

a) Cost reductions assume wastewater volume reduction, but no change in wastewater loadings.
b) Not applicable: Utility cost reductions do not offset the annual O&M costs for there to be any returns on investment.
c) Conservatively assumes that WW discharge can be eliminated by diverting the potable-quality water from the sewer (i.e. selling or giving away) and the concentrate from the treatment process can be converted to product.

There may be some opportunities for water sustainability for Industry #1, as summarized in Table 4. However, for Industry #2, given its small potable water demands, the opportunities that exist are not economically viable.

The costs associated with conservation/education include monitoring equipment to optimize water use and staff time to optimize controls. O&M costs include maintaining the monitoring equipment. For Industry #1, implementing these conservation strategies are expected to reduce water use by 36,000 gpd, resulting in a utility savings of approximately $27,000. This utility savings assumes savings from potable water purchases and wastewater volume surcharges. The simple payback for these water sustainability strategies associated with conservation/education is approximately 6 years for Industry #1. For the City, this would mean less revenue for water and wastewater utilities, but would also result in less potable water pumping, less wastewater pumping, and more available hydraulic treatment capacity at the WWTF.

The costs associated with increased use of polished water for Category I and II include piping to serve more processes with polished water and costs for chemical addition to increase the storage time of the polished water for Industry #1. For Industry #2 the costs consist of a condensate of whey (COW) water storage tank. The O&M costs include staff time for assumed increased cleaning and maintenance of the cooling system, chemicals to increase storage time, and/or additional chemicals for the cooling system. Implementing increased use of polished water has the potential to reduce the potable water demand of Industry #1 by 94,000 gpd and can save the industry approximately $72,000 per year. The simple payback for the water sustainability strategies associated with increased use of polished water is approximately 3.4 years. For the City, this would have a more notable impact on the availability of excess WWTF capacity.

The costs associated with produced potable-quality water from polished water include new reverse osmosis membranes, disinfection, and storage. The O&M costs, estimated from a specific installation example, include electricity, maintenance, and membrane replacement. For Industry #1, based on a 100,000-gpd system, the utility savings covers the estimated annual O&M costs, but has a long payback. The 100,000-gpd capacity was an estimate for this system. A smaller capacity system will cost less; however, the utility savings would also be less. Typically, the unit cost (i.e. $/gal) for a treatment system will decrease as the capacity increases; this is a result of economies of scale. With this in mind, if a 100,000-gpd system has an unfavorable economic return, it is expected that a smaller capacity system would have an even more unfavorable economic return. For the City, were Industry #1 to implement treatment for Category I uses, this would result in some increased revenue for the electrical utility, additional WWTF treatment capacity, but smaller water and wastewater revenues.

Industry #2 is a unique case. The industry's potable water demand is small and the industry pays only $1.25 per 1,000 gallons or $4,000 per year for potable water. With this low cost, it is difficult to identify a project that will ever result in an economic return for the industry. The industry could treat the condensate of whey (COW) water/effluent to potable water standards, but it could only use a very small portion of this water onsite. The remainder of the water could be sold to another user. To make this investment worthwhile, the industry would have to sell this excess potable-quality water for nearly $2.50/1,000 gallons. Another option may be for Industry #1 and Industry #2 to combine efforts and further offset the potable demands of Industry #1. However, this cooperation between industries could be difficult due to liability (especially for food/beverage industries) and/or perception issues.

5.2 Recycled Water Use within the City

Aside from the opportunity for industries to reclaim their own water, the effluent from the City's WWTF can also be reclaimed for reuse. Recycled water from municipal WWTPs can be used at industries for cooling water or other purposes, at parks and ball fields for irrigation, and at the WWTF for in-plant uses such as rinse water.

To produce effluent that meets the *Water Recycling Criteria*, the WWTF will need to add additional treatment. The type of treatment required is dependent upon the specific end-use water quality requirements and the degree of human exposure at the end-use location. The WWTF produces what would likely be classified as *Disinfected Secondary-23* recycled water during part of the year when disinfection is required. Disinfected Secondary-23 water, according to the California *Water Recycling Criteria,* can be used for the following applications:

- Surface irrigation of cemeteries, freeway landscaping, restricted-access golf courses, ornamental nursery stock and sod farms, pasture for animals producing milk for human consumption, and any nonedible vegetation where access is controlled so that the irrigated area cannot be used as if it were a park or yard
- Surface irrigation of non food-bearing trees
- Surface irrigation of fodder and fiber crops and pasture for animals not producing milk for human consumption
- Industrial or commercial cooling not involving the use of a cooling tower, evaporative condenser, spraying or any mechanism that creates a mist
- Industrial boiler feed
- Non-structural fire fighting
- Backfill consolidation around nonpotable piping
- Soil compaction
- Mixing concrete
- Dust control on roads and streets
- Cleaning roads, sidewalks, and outdoor areas
- Industrial process water that will not come into contact with workers
- Flushing sanitary sewers

5.2.1 Industrial Recycled Water Use

Industrial "recycled water use" is differentiated from "industrial reuse". Within this report, "recycled water" means treated effluent from the municipal wastewater treatment facility. "Industrial reuse" involves reclaiming and reusing industrial process water within the industry. As stated previously, industries can often use recycled water from a wastewater treatment facility for cooling or other industrial uses. However, for this specific community with "wet" industries, providing the piping and pumping needed from the WWTF approximately 0.5 miles to the industries is difficult to justify when the industries can recycle industrial effluent for reuse. Another challenge is that food and beverage industries have very limited locations where municipal recycled water effluent can be used due to health and safety concerns.

While industrial reuse of recycled water is not likely for the two industries involved in this case study, the third significant industry in the community or other future industries may be better candidates for recycled water. Making an assumption that a potential or future industrial recycled water application is for cooling with a cooling tower, the recycled water will need to meet *disinfected tertiary* recycled water criteria. Disinfected tertiary recycled water is a water that has been filtered and disinfected to meet a specified contact time or demonstrates a specific virus inactivation percentage. For the City's WWTF to meet disinfected tertiary criteria, a filtration system and expanded disinfection system would be required. Additional treatment may also be required depending upon the specific cooling system needs and material.

There are four main components of a recycled water system: treatment, storage, pumping, and piping/transmission. The following conditions have been assumed:

- The recycled water demand is 250,000 gallons per day.
- Tertiary treatment is via gravity filtration (as opposed to more advanced filtration by membranes).

- A one-mile recycled water distribution pipeline is needed.

Based on the above assumptions, producing disinfected tertiary recycled water for an industrial cooling tower application is expected to cost approximately $3.9 million, with an annual operations and maintenance (O&M) cost of $270,000 (MCES, 2007).

The City and industry would need to work together to determine the balance between the recycled water use rate and the capital cost investment. Using 250,000 gallons of recycled water per day instead of potable water would result in a potable water bill for the industry that is reduced by approximately $325,000 each year. But this also could reduce the City's potable water revenue. The City can sell the recycled water, offsetting some of the revenue lost from the sale of potable water. Also, the potential or future industry could be driven by sustainability goals and may be willing to invest capital to make this feasible.

5.2.2 Other Recycled Water Uses

There are other potential recycled water use areas within the community, including irrigation of parks and ball fields. Most non-industrial recycled water use locations are seasonal. Given the low cost of potable water treatment, the availability of groundwater, and the seasonal demand at potential use locations, it is unlikely that it is in the City's best interest to provide recycled water to these other reuse locations.

As a frame of reference, if a system were to be provided, the distribution cost for a 1-mile pipeline providing 250,000 gpd of *Disinfected Secondary-23* recycled water would cost approximately $860,000, with an annual O&M cost of approximately $70,000 (MCES, 2007). These costs include increased disinfection (year-round), transmission system residual disinfection, and transmission pumping and piping.

5.2.3 Wastewater Treatment Facility In-Plant Uses

Sustainable water use may also include reusing effluent from the wastewater treatment facility within the facility. Potable water is currently used for spray water to control foam, for pump seal water, and rinse water. Treated effluent can be used for these purposes. To reuse the effluent, an effluent reuse distribution system is needed. This would consist of small-diameter piping and a pump station including pumps, a pressure tank, and controls. It is assumed that the pump station would draw directly from the chlorine contact basin.

It is estimated that approximately 25 percent (7,000 gallons per day) of the total potable water demand at the WWTF (28,000 gallons per day) can be eliminated with use of treated effluent. This 7,000 gallons of potable water used per day costs approximately $3,300 per year at a cost of $1.25 per 1,000 gallons. For comparison purposes, an effluent reuse system is expected to cost approximately $90,000, with an annual operations and maintenance cost of approximately $300 per year. Looking at this over a 20-year planning period, continued use of the City's potable water system is more cost effective than installing an effluent reuse system. In this particular case, it becomes favorable to install an effluent reuse system if the non-potable water demands at the WWTF are approximately 50 percent of the current average daily potable water demand (or 14,000 gallons per day). It could also become favorable if the potable water rates increased from $1.25 per 1,000 gallons to $2.50 per 1,000 gallons. The City has low potable water rates due to a low level of water treatment required and low electric rates.

6.0 Summary and Outcomes

6.1 Sustainability Options

The following six water sustainability options were identified as possible options for this case study community:

1. Industrial conservation/education
2. Industrial reuse of process water
3. Industrial treatment of process water to potable-quality water
4. Wastewater treatment facility effluent use at industry
5. Wastewater treatment facility effluent use within the City
6. Wastewater treatment facility effluent use at the WWTF

The additional treatment, storage, and transmission necessary for options 4, 5, and 6 combined with the low potable water costs, make these options nonviable from an economic perspective. Options 1, 2, and 3 offer potential benefits for Industry #1, with the most viable option being increased use of process (polished) water for other uses by the industry. Unfortunately, for this case study, while internal reuse of process water will reduce the overall volume of wastewater discharged, additional evaluation and capital and operational changes are required to reduce the peak flows to the municipal WWTF. The municipality's goal to provide more hydraulic capacity will not be achieved until Industry #1 can guarantee a maximum peak wastewater discharge.

For this case study and similar community water reuse applications, the reuse initiatives must factor in the change in revenue to the municipality with the change in industrial waste flows and loads and potable water use. The municipality must generate enough revenue to cover annual base costs. Base costs include asset maintenance, labor, and debt service, which do not change with the volume of water processed. A significant reduction in industrial wastewater discharges and potable water use may result in an increase in the utility's residential and/or industrial rates and possibly offset industrial cost savings.

By pursuing water sustainability projects together, industries and municipalities can work to realize benefits for the overall community, both economic and longer-term sustainability goals.

From the industries perspective, the expected benefits may include:

- Decreased potable water costs* to the City.
- Decreased wastewater treatment costs* to the City.
- Decreased onsite potable water treatment (i.e. softening) costs.
- Decreased onsite wastewater treatment costs.
- Decreased electrical and natural gas utility costs* (i.e. pumping, heating, and/or cooling less water).
- Improved customer and community perceptions due to increased sustainability.

*These benefits may not be realized. If the flow/loading/utility reductions do not result in an O&M reduction for the City, the City may need to redistribute costs or increase rates to cover their expenses and negate the savings the industry expected. Also, the benefit may not materialize if only the average water or utility demand or wastewater flow is changed but not the peak demand/flow. If the City still needs to provide for peak demands/flows it cannot take advantage of additional capacity that can be allocated to another industry that provides a source of revenue. The City would need to increase unit rates to cover annual costs. In this case study, the City's WWTF is organically under loaded, and a reduction in load and higher fluctuations can also lead to less efficient treatment and potentially higher O&M costs.

From the City's perspective, the expected benefits may include:

- Increased potable water treatment, storage, and/or transmission capacity that can eliminate or delay a planned capital improvement project.
- Increased wastewater treatment and/or transmission capacity* that can eliminate or delay a planned capital improvement project.
- Reduced O&M costs for potable water system (reduced chemical demand, reduced electrical demand).
- Reduced O&M costs for wastewater system (reduced chemical demand, reduced sludge hauling, reduced electrical demand).
- Increased potable water treatment, storage, and/or transmission capacity that can allow the City's residential, commercial, or industrial base to grow, which can increase the tax base and bring more jobs to the City.
- Increased wastewater treatment and/or transmission capacity* that can allow the City to accept another significant industry, generating more revenue and bringing jobs to the City.

*These benefits will not be achieved if the industrial peak wastewater flows are not reduced. The City will still need to provide capacity for peak flows even if the total volume of wastewater discharged by the industries is reduced.

6.2 Driver Summary

Determining the value of the potential benefits is necessary to come to a solution on a fair rate structure. For this particular case study, the City expressed a desire to reduce wastewater flow to provide 100,000 to 200,000 gpd of wastewater treatment capacity for additional industries. Industry #1 has specific goals to use water more sustainably. Industry #2 would be interested in implementing water sustainability strategies if they make economic sense.

6.3 Optimum Option

Based on the conceptual costs developed for the six water sustainability practices, the most optimum outcome is for Industry #1 to maximize use of reclaimed process water. This will reduce Industry #1's potable and wastewater costs by approximately $72,000 per year. It will reduce the City revenue by the same amount, but will free up a portion (estimated to be 94,000 gpd) of the desired WWTF capacity that the City could allocate to other customers. The municipality's benefit will only occur if Industry #1 is able to reduce the peak wastewater flow. Additional evaluation and likely additional costs will be required for Industry #1 to manage their discharge fluctuations to meet a maximum peak flow to provide the capacity the City is seeking. If the City is not able to allocate capacity to other customers and Industry #1 reduces its purchase of potable water supply from the City and reduces its wastewater discharges to the City's WWTF, the City will need to evaluate their utility rate structure and may need to increase their rates to make up the lost revenue.

Given the small water/wastewater volumes of Industry #2, not many options are economically viable. However, it was noted that there may be a wastewater flow monitoring inaccuracy, which may be worthwhile to explore further.

6.4 Outcomes

This study outlines the steps involved in a water reuse evaluation and identifies information to compile and preliminary questions to address. In communities, like this case study community, where industry has a larger water demand and wastewater loading than the residential/commercial sector, it is important to evaluate water sustainability practices from all perspectives. For this particular community, only one of the six potential water sustainability options was considered economically feasible. For other communities and industries looking to implement water sustainability practices, the following circumstances would improve the economic viability:

- **Limited supply of adequate quality water.** When water supply is limited or of poor quality requiring significant treatment for potable use, the potable water rates will increase. With higher potable water rates, the payback for reuse options will decrease. This case study involved a municipality with an adequate aquifer supply and sufficient water infrastructure capacity.
- **Infrastructure capacity limitations.** If the municipality needs to invest to increase capacity of potable water, wastewater, or electrical infrastructure, this investment can be compared to the implementation of water sustainability practices. While there are infrastructure limitations driving this particular case study community, an important conclusion is to distinguish between average daily requirements and peak requirements.
- **Water demands that do not need a high-degree of treatment.** The industries in this case study needed potable-quality water for many different uses. If less stringent treatment is acceptable for a particular industry or use location, economics will improve.
- **Inclusion of other existing or future industries in the analysis that require a year-round consistent source of water.** Only two industries were considered in this case study, both of which have their own process water that can be reclaimed. The inclusion of other industries in the community could impact the economics of a community recycled water system.
- **A longer planning horizon**
  - To account for future infrastructure replacement costs even if capacity increases are not forecasted.
  - To account for future regulations of water infrastructure systems. For example, future wastewater effluent discharge regulations for the City could require treatment equivalent to recycled water quality criteria.

7.0 References

Environmental Protection Agency (EPA), 2011. Energy Efficiency Improvement and Cost Saving Opportunities for the Dairy Processing Industry. October, 2011.

Metropolitan Council Environmental Services (MCES), 2007. Recycling Treated Municipal Wastewater for Industrial Water Use. November, 2007.

Industry #1 Analysis

Water Reuse for Agricultural Processing

Agricultural Utilization Research Institute

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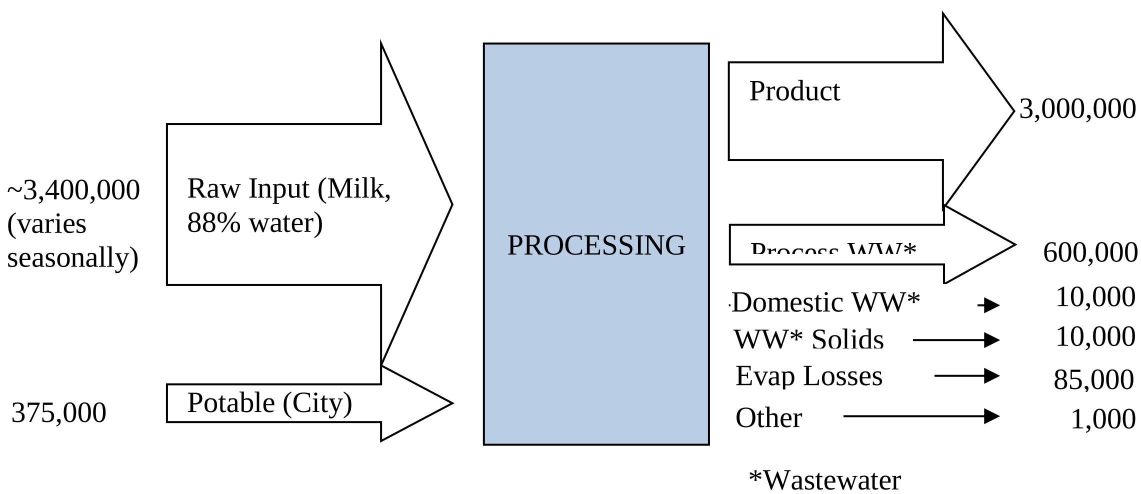
8.0 Introduction

One of the three significant industries in the City is a dairy facility. The dairy produces various dairy products including cheeses, whey, and a byproduct that is further processed by Industry #2. Water inputs into Industry #1 include raw material, or milk, which contains 80 percent water. The industry also purchases approximately 425,000 gallons of potable water from the City per day. The City's potable water supply is hard, with a hardness of approximately 38 grains. Due to the hardness, Industry #1 utilizes several water softeners to reduce the hardness.

Industry #1 discharged an average of 0.6 million gallons per day (MGD) of wastewater to the City's wastewater treatment facility (WWTF) at a cost of approximately $21,000 per month, or $250,000 per year. The discharged effluent volume comes from the raw product (milk) and potable water. A simple balance is shown in Figure 1A. As shown in Figure 1A, the volume of wastewater produced is greater than the volume of potable water the industry purchases from the City. This is because a portion of the raw product contains excess liquid that is wasted. A wastewater discharge volume that is greater than the potable water purchased is not typical of all industries. Other types of industries are likely to have the wastewater discharge volume less than or approximately equal to the potable water purchased.

Figure 1 –
Industry#1 Water Balance for Nov. 2011 (Volumes in gallons per day)



9.0 Wastewater Volumes

Industry #1 has been investing effort and money over the last two years to reduce its potable water demands and the amount of wastewater generated. Figure 2A shows the wastewater volumes from Industry #1 over the last two years (2010 and 2011). Industry #1 has reduced its wastewater volume by approximately 22 percent, or an average of 160,000 gallons per day (gpd), over the last 24 months. This reduction has resulted from increased staff education related to water conservation practices, process optimization, and increased reuse of treated process water or "polished water". It is important to note that this reduction has resulted in a lower average daily discharge, but the peak day discharge has remained unchanged and, therefore, has not necessarily had a positive impact at the City's

WWTF. In 2011 there were two peak wastewater flow events that occurred. If these events could be attributed to a single cause, effort could focus on reducing that problem. However, these peak occurrences were not attributable to any known cause.

The potable water uses have been quantified by the industry. Table 1A summarizes the potable water demands. To reduce the BOD and TSS concentration and the wastewater treatment surcharges, Industry #1 implements onsite pretreatment.

Figure 2 –
Summary of Wastewater Discharge Volume

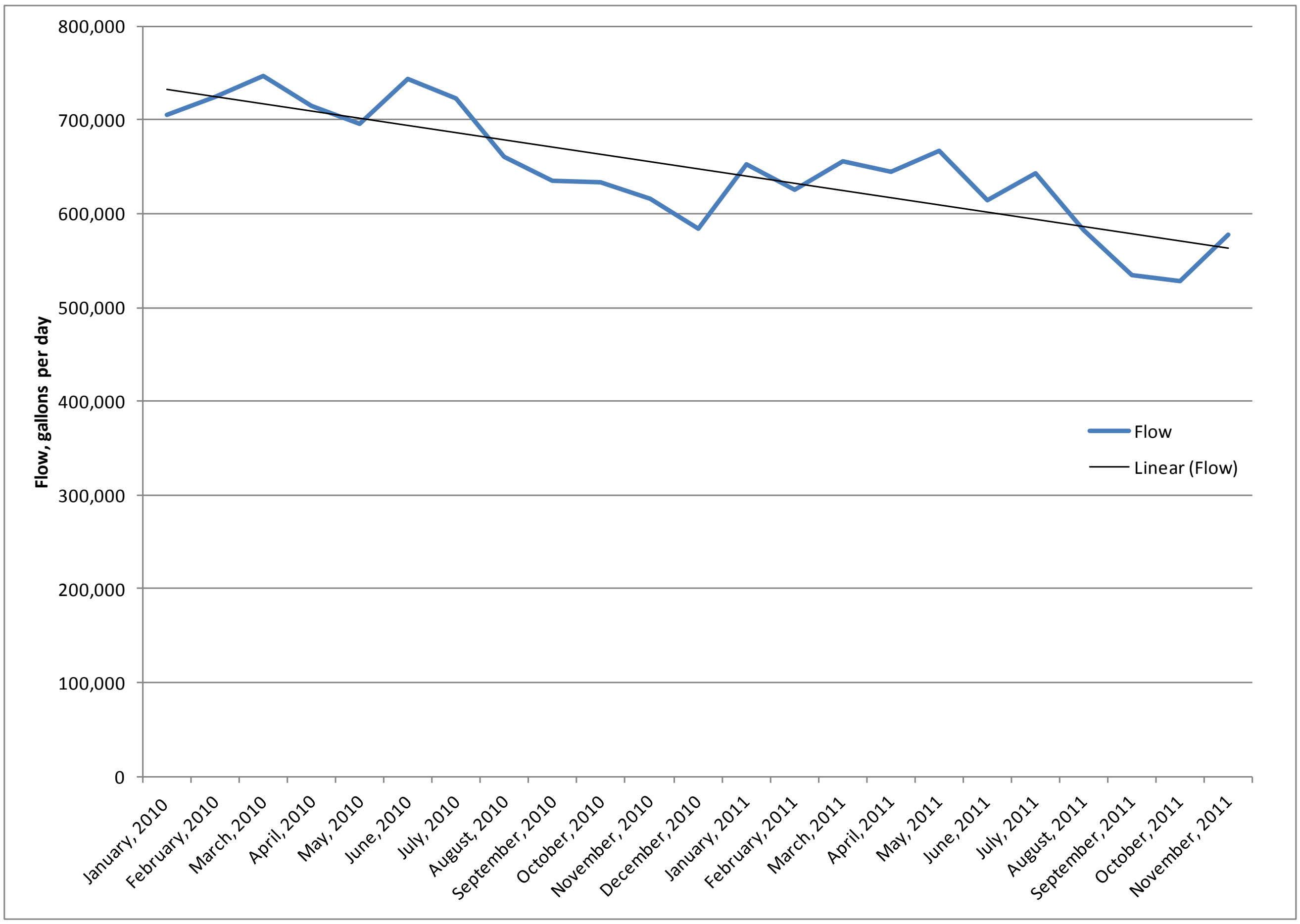


Table 5
Industry #1 Summary of Potable Water Uses

Potable Water Use Area	Estimated Potable Volume Used (gpd)
Clean-in-place (CIP) systems	180,000
Cooling tower and condenser make-up water	85,000
Water softener regeneration	62,000
Hose drops	20,000
Pump seal water	16,000

Foamer/Sanitizer	1,700
Lavatory, sinks, fountains	60
Defiltration rinse water[a]	
Total Quantified	364,760

Notes:

a) Upon reviewing the industries flow diagrams and water balance, defiltration rinse water was found to be omitted from the water balance. No estimate of the volume was available.

10.0 Water Reduction Opportunities

A large portion of the wastewater volume is from the raw input material (milk). This volume is tied directly to the volume of raw material/product and can only be reduced by finding ways to reuse the waste product or reducing production. Within the dairy process, there are locations where condensate of whey (COW) water can be reused in lieu of potable water. Therefore, the evaluation of water sustainability strategies needs to focus on the uses of approximately 375,000 gpd of City-purchased potable water. Volumes of potable water can be reduced through the following methods:

(1) Conservation and education.

(2) Using polished or reclaimed water in place of City potable water. Using polished water or reclaimed water at a dairy is subject to standards established by the U.S. Food and Drug Administration Pasteurized Milk Ordinance (PMO).

(3) Treating polished water to potable water quality standards and using the treated water in place of City potable water. This is also subject to the PMO requirements.

Conservation and education require investment in monitoring equipment, control systems, database development and annual costs for operating and maintaining equipment and practices. Reduction through conservation and education may be considered the low-hanging fruit, but in some cases conservation and education strategies require investment in more efficient fixtures or equipment.

Polished water can be used in some locations, but not all, and there will be capital costs for new piping for polished water. Process potable water demands could be offset if polished water is further treated to potable water quality standards. It would be beneficial to reduce water use through conservation/education and reuse the polished water prior to implementing a potable-quality treatment system to minimize the size of the treatment system. However, there becomes a point at which the cost to increase the size of the treatment system is less expensive than cost to implement conservation or increase the use of polished water.

10.1 Clean-in-Place Water Use

Federal law requires dairy processors and other food processers to follow certain practices for cleaning equipment and clean-in-place (CIP) systems. CIP systems require several rinse cycles and are a significant source of water use in a dairy. Industry #1 has 13 CIP systems that operate on over 110 individual CIP circuits that use an estimated 180,000 gpd of potable water, and this is after significant reductions have been made to the CIP system over the last two years. Clean-in-place systems typically involve the following cycles (EPA, 2011):

- Equipment is drained of all milk/product.
- An initial rinse with water is used to remove much of the milk/produce residue.
- A hot alkaline detergent solution is circulated through the equipment, and then drained. The alkaline solution is used to remove organics and soil not removed through the initial rinse.
- A water rinse is used to remove much of the residual alkaline solution.
- An acid solution is circulated through the equipment, and then drained. The acid removes mineral deposits and also neutralizes any leftover base.
- A water rinse is used to remove the residual acid solution.
- A final sanitize solution prepared with potable-quality water is used on the equipment. This step is the final antimicrobial step in the cleaning process.
- Optional – often, air is blown through the equipment to remove residual water to push sanitizer through the system more efficiently.

There are several ways in which potable-quality water used in CIP can be reduced. Industry #1 has implemented some of these strategies already. The Energy Efficiency Improvement and Cost Saving Opportunities for the Dairy Processing Industry report (EPA, 2011) provides a number of suggestions to reduce CIP water use, which are summarized below.

- Reuse or recovery distribution systems to reclaim the alkaline detergent solution and reuse it for future cleaning (*Conservation*). The final rinse water can also be captured and used for the next CIP cycle's initial rinse (EPA, 2011). Industry #1 is currently reusing rinses on some of the CIP circuits.
- Pulse rinses can be more effective at rinsing, while also reducing water demand (*Conservation)*. Industry #1 uses slug or pulse rinses and recaptures the slug for use as a pre-rinse.
- RO or evaporative water use involves diverting RO reject water for use in the CIP system (*Offset with Polished Water*). Industry #1 uses polished water for many intermediate post rinses and also for chemical make-up.
- Optimize CIP final flush cycle times (*Conservation*). An effective flush requires a velocity of 5 feet per second. Based on the volume of the piping and equipment (which is different for the 110+ circuits), the actual required rinse time can be determined. This would require programming changes to the 100+ circuits. It is very difficult to quantify the water reduction that could be realized by customizing all 110+ circuits because some circuits may operate closer to the ideal time than others. It is estimated that this would roughly reduce the post rinse water demand by 10 percent, resulting in an overall potable water reduction of approximately 1 percent or 2,000 gpd.
- Replace prerinse water with polished water or eliminate the prerinse altogether (*Offset with Polished Water*). The prerinse water accounts for approximately 5 percent of the

potable water used for the CIP system at Industry #1, or approximately 9,000 gallons per day.

- Optimize reuse or recovery distribution systems by installing inline conductivity or turbidity meters to determine when a rinse is too contaminated for use and needs to be disposed (*Conservation*). This may reduce CIP water use for Industry #1 by approximately 5 percent, or 9,000 gpd.
- Implement an over-ride procedure where instead of separate alkaline and acid wash steps, the first step (alkaline step) is kept circulating while acid is added to the required concentration (*Conservation*). This procedure requires more chemical use, but has been estimated to reduce water demands by 10 percent, or for Industry #1 this equates to 18,000 gpd.
- Implement single-phase cleaning where a single cleaning solution that acts as both the alkaline and the acid to remove both the organics and the mineral deposits is used (*Conservation*). This technique saves water associated with the interim rinse step and second wash and can result in an estimated 15 percent reduction in water use, or for Industry #1 27,000 gpd. However, there is a chance the chemical costs could change significantly.

Industry #1 has already implemented some of the suggested CIP water reduction strategies. Additional conservation/education opportunities could reduce the potable water by up to 29,000 gallons per day (assuming over-ride is implemented and not single-phase cleaning). Increased utilization of polished water could further reduce the potable water demand by approximately 9,000 gallons per day. The remaining CIP potable water use (142,000 gpd) can be offset with potable-quality treated polished water.

10.2 Cooling

Reducing water use in cooling applications requires a careful balance between bleed-off water and make-up water quality (called the concentration ratio). Water is bled from the system and new water added to reduce the concentrations of suspended and dissolved solids. The presence of suspended and dissolved solids can lead to scaling and/or corrosion, which can negatively affect the efficiency of the system. Constituents that are of specific concern in cooling tower water include (1) pathogenic microorganisms; (2) calcium and magnesium salts that produce scale; and (3) ammonia, chlorides, and heavy metals that can cause corrosion that promote biological growth and the formation of slime (MCES, 2007). Optimizing this balance can result in water savings as high as 20 percent (EPA, 2011).

Industry #1 uses potable water for make-up water in the cooling towers and ammonia condensers. The industry has implemented improvements to reduce the potable water demands from the cooling towers and has planned projects for the next year which will replace the majority of the potable demands with reverse osmosis (RO) water or polished water. Installing conductivity meters and flow meters on the make-up and bleed off lines can provide the necessary information to fully understand the cooling tower operation and the concentration ratio.

Industry #1 uses approximately 35,000 gallons per day of potable water in three cooling towers and approximately 50,000 gallons per day in five ammonia condensers. It is assumed that 100 percent of the cooling potable water demands can be eliminated by using process RO water and optimizing the concentration ratio.

10.3 Water Softener Regeneration

The City's potable water supply is hard. To prevent mineral scale, the water is softened. Industry #1 has a total of six softeners, four with a capacity of 32,000 gallons and two with a capacity of 36,000 gallons. Each softener is regenerated 3 times per day, for a total of 18 regenerations per day. The softeners typically use approximately 62,000 gallons per day of potable water.

There are two measures of softener efficiency – brine efficiency and water efficiency, where brine efficiency is a measure of how much salt is needed to soften the water and water efficiency is a measure of how much water is needed to regenerate the softener. Water efficiency-rated softeners use 5 gallons of regeneration water per 1,000 grains of hardness removed (Pentair, 2011). Assuming all of the potable water is softened and that the softener removes roughly 90 percent of the hardness, the estimated water use for regeneration of 62,000 gallons per day seems reasonable and not excessive.

There are ways to optimize water efficiency in a softening system. It is best to work with the manufacturer of the softening system to determine the optimum solution, but options include optimizing the backwash and rinse cycles and using upflow (as opposed to downflow) brining (Pentair, 2011). There are also alternatives to water softeners that claim to reduce scaling through electronic or magnetic means, without the use of salts and regeneration water. These systems may or may not meet the desired water quality requirements and their effectiveness is uncertain. Other treatment systems, such as membrane filtration, can also serve as a substitute for water softening.

10.4 Hosedrops

Throughout the facility there are a number of hose drops where staff use a sprayer connected to a hose to wash down equipment or the floor. While polished water could possibly be used for some of the floor rinses, Industry #1 would prefer to keep all hose drops on potable-quality water. Options to reduce hosedrop demand include using smaller diameter hoses, checking frequently for leaks, and educating employees on proper spray down procedures. Using smaller diameter hoses results in a low flow, high pressure condition and can result in less water use.

10.5 Pump Seal Water

The facility has hundreds of pumps. These pumps require a constant small flow of water to flush the seals of the pumps. This water must be of potable water quality. It was observed during the site visit that the seal water on some pumps was flowing at unnecessarily high flow rates. The seal water rate was set by a manual quarter-turn ball valve. Employees can be educated on the proper seal water flow rate and the importance of not bumping the valves. There are also seal water measuring devices that make the water use clear. Also, locking-style valves can be used to prevent inadvertent adjustments of the valve and seal water flush rates.

10.6 Lavatory, Sinks, and Fountains

Sinks and fountains must be served with potable quality water. These fixtures can be replaced with water-efficient fixtures. As an example, water-efficient toilets now use 1.6 gallons of water per flush, as opposed to 3.5 gallons per flush used in older toilets. Using a water-efficient toilet could reduce water use by 200 to 300 gallons per day (assuming current toilets use 3.5 gallons per flush and there are 140 flushes per day). Reducing these potable water demands will reduce the potable water use, but it will not impact the industry's wastewater fees because the domestic wastewater is sewered separately.

10.7 Summary

Table 2A summarizes the primary areas in which potable water is used and the estimated daily volume of water. Also indicated are the potential water reductions associated with the three water sustainability strategies.

Table 6
Summary of Potable Water Use Reduction Strategies

Potable Water Use Area	Estimated Potable Volume Used (gpd)	Reduction Potential from Conservation/Education (gpd)	Reduction Potential from Additional Polished Water Use (gpd)	Reduction Potential Assuming Potable-Quality Water Production (gpd)
Clean-in-place (CIP) systems	180,000	29,000	9,000	142,000
Cooling tower and condenser make-up water	85,000	7,000	85,000	(assumes demand is met with polished water)
Water softener regeneration	62,000	Yes, assumed negligible	No	62,000
Filter rinse water	NA[b]	No	No	Yes
Hose drops	20,000	Possible, but not quantified.	No	20,000
Pump seal water	16,000	Possible, but not quantified.	No	16,000
Foamer/Sanitizer	1,700	No	No	1,700
Lavatory, sinks, fountains	60	Possible, but not quantified.	No	30
Total Quantified	364,760	36,000	94,000	241,730[a]

Notes:

a) The amount of COW water available for treatment is limited by the volume of milk processed on a given day. The actual amount of available COW water for further treatment may be of only 100,000 gallons per day.

b) NA – not available.

11.0 Costs to Implement Reduction Opportunities

The costs associated with implementing the water sustainability strategies are summarized in Table 3A and described in the following sections.

Table 7
Summary of Water Sustainability Strategies

Water Reduction Strategy	Industry #1
Conservation/Education	
Reduced Demand (gpd)[a]	36,000
Estimated Capital Cost of Implementation	$80,000
Estimated Annual O&M Cost of Implementation	$15,000
Estimated Annual Utility Cost Reduction[b]	$28,000
Estimated Simple Payback Period (years)	6.2
Category II & III Uses	
Reduced Demand (gpd)[a]	94,000
Estimated Capital Cost of Implementation	$160,000
Estimated Annual O&M Cost of Implementation	$26,000
Estimated Annual Utility Cost Reduction[b]	$72,000
Estimated Simple Payback Period (years)	3.5
Category I (Potable-Quality) Uses	
Reduced Demand (gpd)[a]	100,000
Estimated Capital Cost of Implementation	$565,000
Estimated Annual O&M Cost of Implementation	$56,000
Estimated Annual Utility Cost Reduction[b]	$76,000
Estimated Simple Payback Period (years)	27.6

Notes:
a) Refer to Table 2A.
b) Cost reductions assume wastewater volume reduction, but no change in wastewater loadings.

11.1 Conservation and Education

While conservation and education are often considered the “low-hanging fruit”, there are implementation and training costs to consider. For example, reducing water use in the cooling towers requires monitoring bleed off volumes, make-up water volumes, and conductivity. Flow meters and conductivity meters need to be connected to a readout location and staff need to monitor this information frequently until the optimum operational strategy is identified. Capital costs include equipment procurement and installation and annual costs will be incurred for equipment maintenance (labor and materials, data management, and reporting.

It has been estimated to cost approximately $80,000 to implement conservation/education strategies, with an additional annual recurring cost of $15,000. The capital cost includes one-time staff hours to optimize the CIP cycles. The annual cost is associated with maintenance/replacement of turbidity meters, additional chemical that may be needed (for the CIP override procedure), and staff time. Data management and reporting was not considered an added cost for Industry #1 because they already have the infrastructure in place with current practices.

These costs are offset by the reduced water purchases and reduced wastewater discharges. Reducing the potable water demand by 36,000 gallons per day results in a savings of approximately $25,000 per year. Reducing the wastewater discharged to the City by 36,000 gallons per day results in a savings of approximately $3,000. The total savings is approximately $28,000. This neglects any additional chemical savings that may result from the optimized CIP cycle times. This also neglects savings associated with a reduction in the volume of wastewater that requires pretreatment. The simple payback for the conservation/education strategies is approximately 6.2 years.

11.2 Additional Polished Water Use

Industry #1 is already using polished water in several areas. Increased use of polished water over the last two years has contributed to the reduced wastewater discharges as shown previously in Figure 2A. Currently approximately 250,000 gallons of polished water is used for boiler water and within the CIP cycles. It was estimated that an additional 94,000 gallons per day of potable water demand could be replaced with polished water. However the use of the polished water is limited by the supply available, the storage available, and the regulations in the PMO.

The PMO does not allow carryover of Category II water from one day to the next and requires that water collected be used promptly, unless the temperature of the storage and distribution system is automatically maintained below 45 degrees Fahrenheit (F) or above 145 deg F or unless the water is automatically treated with a chemical to suppress bacterial propagation. Currently, the polished/Category II water is not cooled, heated, or chemically treated. Staff reports that volumes of stored polished water are discharged to the drain at the end of the day, only to draw significant water from the potable supply early the next morning.

Providing storage could help improve polished water use and is likely necessary to fully capitalize on the polished water supply. The industry has existing storage silos. Additional monitoring is needed to determine if this storage capacity is sufficient as processes continue to convert to polished water. Unfortunately, there are costs associated with cooling, heating, or chemically treating the polished water. Cooling the water is expected to be inefficient because the polished water is warm already (96 deg F to 112 deg F) and some of the polished water use locations require hot water. Heating the water would be more energy efficient; however, at 145 deg F, the water becomes a safety/scalding concern. This leaves chemical treatment as an option. A chemical treatment system would consist of a chemical storage tank, chemical feed pumps, and automated controls. Approximately 16 gallons of 12.5 percent sodium hypochlorite (bleach) would be needed daily to chemically treat all 342,000 gallons of COW water produced per day.

Another challenge associated with use of polished water is that the polished water volume is not constant. The volume of polished water generated correlates with the volume of raw input material and does not correlate with the water demands. The solution to this challenge is to have equipment piped for either polished water use or potable water use, with the appropriate separation devices.

It has been estimated to cost approximately $160,000 to implement additional polished water use, with an additional annual recurring cost of $16,000. The annual cost is associated with the chemical disinfection system.

These costs are offset by the reduced water purchases and reduced wastewater discharges. Reducing the potable water demand by 94,000 gallons per day results in a savings of approximately $65,000 per year. Reducing the wastewater discharged to the City by 44,500 gallons per day results in a savings of approximately $8,000. The total savings is approximately $72,000. This neglects savings associated with a reduction in the volume of wastewater that requires pretreatment. The payback for the additional use of polished water is approximately 3.5 years.

11.3 Polished Water Treatment to Potable-Quality Water

Any excess polished water could be treated to potable water quality. Because of economies of scale, there is a tradeoff between the effort/cost to maximize the use of polished water and the cost to provide a larger polished water treatment system.

Additional treatment of the polished water is necessary to meet the Category I criteria as required by the PMO. The additional treatment requires passing the polished water through another RO system to remove more organic material and then disinfection. In the past, chlorination was the primary means of disinfection, but the 2009 Revision of the PMO was expanded to include ultraviolet (UV) disinfection. The UV disinfection systems must be PMO-compliant, with a sealed control box controlling the flow diversion. In addition to the treatment, storage is needed for the potable-quality water. A detailed understanding of the supply of polished water and demand for potable-quality water is required to determine the storage volume.

To roughly estimate the costs to produce potable-quality water, a treatment system was sized for 100,000 gallons per day. This volume roughly represents the current excess polished water available, or the difference between the current polished water supply and the current volume used. For the basis of this evaluation, two 50,000-gallon storage silos have been assumed. Two silos allow one to be taken down and washed.

It has been estimated to cost approximately $565,000 to implement the treatment system necessary to produce potable-quality water (including equipment, engineering, and installation). This assumes that building space is available for the indoor equipment and land is available for new storage silos. The treatment system will require replacement bulbs for the UV system, replacement membranes for the RO system, staffing, and energy. These recurring O&M costs are expected to total approximately $56,000.

These costs are offset by the reduced water purchases and reduced wastewater discharges. Reducing the potable water demand by 100,000 gallons per day results in a savings of approximately $69,000 per year. Reducing the wastewater discharged to the City by 100,000 gallons per day results in a savings of approximately $9,000. The total savings is approximately $76,000. This neglects savings associated with a reduction in the volume of wastewater that requires pretreatment. The payback for production of potable-quality water is approximately 28 years.

Another way to look at the potable-quality water production is the cost per 1,000 gallons. Based solely on the annual O&M costs, it is estimated to cost approximately $1.53/1,000 gallons to produce potable-quality water from COW/polished water. However, when the capital cost is included for a 10-year planning period, the cost of production increases to $2.70/1,000 gallons. In comparison, the City's potable (softened) supply is $1.90/1,000 gallons. If the industry could identify funding to offset the initial capital costs, producing potable-quality water could be more economical than softening purchased City water.

The capacity estimate of 100,000 gallons per day is more than Industry #1 requires if they choose to increase use of polished water. With the principle of economies of scale, the treatment costs per unit will tend to increase as the capacity decreases. For this reason, it is unlikely that the return on investment will improve if a smaller capacity were assumed.

11.4 Summary

Based upon the three levels of water sustainability strategies available to Industry #1, increased use of polished water provides the greatest return on investment. Part of these improvements include addition of a chemical feed system to increase the storage time of the polished water. This should increase the use polished water and reduce the occurrences of discharging polished water to the sewer due to the carryover from one day to the next. This capital investment for a chemical system could be avoided assuming there is some flexibility in the timing of the demand of water at the cooling towers. Polished water use in the CIP cycles does not have much flexibility with respect to timing. The water use demands in the cooling towers could perhaps offer timing flexibility to maximize polished water use each day to avoid discharge to the sewer because of carryover.

12.0 References

Environmental Protection Agency (EPA), 2011. Energy Efficiency Improvement and Cost Saving Opportunities for the Dairy Processing Industry. October, 2011.

Metropolitan Council Environmental Services (MCES), 2007. Recycling Treated Municipal Wastewater for Industrial Water Use. November, 2007.

Pentair Water Solutions. Water Treatment Guide: Achieving Brine Efficiency in Softening. http://www.watertreatmentguide.com/achieving_brine_efficiency_in_softening.htm. Accessed 11 April 2012.

Appendix B

Industry #2 Analysis

Water Reuse for Agricultural Processing

Agricultural Utilization Research Institute

AURI Project No. AIC-052

December 6, 2012

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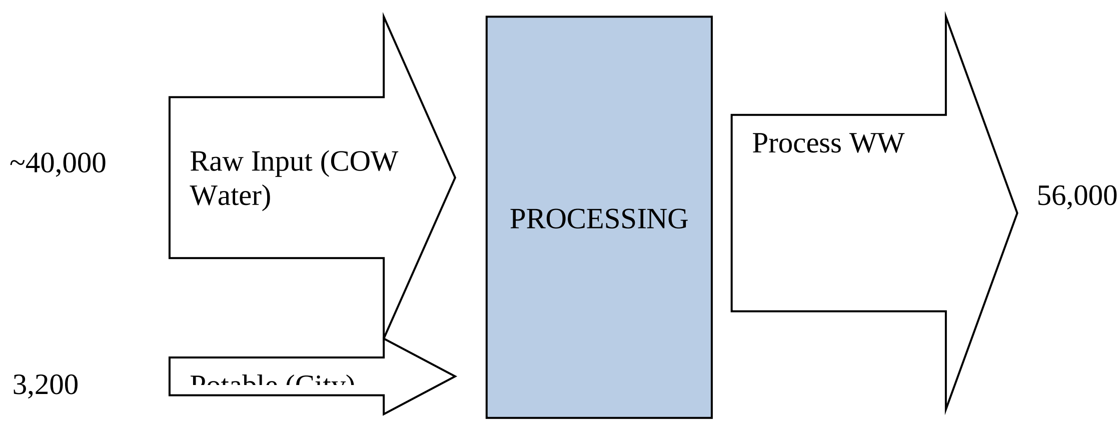
13.0 Introduction

Industry #2 is one of the City's three significant industrial users. Like Industry #1, this industry is also a dairy processing industry. The industry further dries the condensate of whey (COW) water from Industry #1 to produce a dry supplement. Similar to Industry #1, the facility is a net water producer (i.e. produces more wastewater than potable water consumed) because of the liquid contained in the raw input material. This industry operates 24 hours per day, 7 days per week.

Industry #2 purchases approximately 3,200 gallons of potable water from the City per day at an annual cost of approximately $4,000. Due to the hardness of the potable water supply, Industry #2 uses water softeners to reduce the hardness and potential for scaling. Industry #2 discharged an average of 56,000 gallons per day of wastewater to the City's treatment facility at a cost of approximately $9,000 per month, or $106,000 per year. Given the daily potable water use and the daily wastewater discharge volumes, it is clear that a large portion of the wastewater volume generated is from the raw input material.

Looking at the basic water balance of water in versus water out, the volume of outputs appears to be greater than the volume of inputs. It seems that some input water is not accounted for or the output water is not correctly measured.

Figure 3 –
Industry#2 Water Balance (Volumes in gallons per day)



14.0 Water Reduction Opportunities

Industry #2 has many of the same potable water uses as Industry #1 and can implement many of the same water sustainability practices:

(1) Conservation and education.

(2) Using polished or reclaimed water in place of City potable water. Using polished water or reclaimed water at a dairy is subject to standards established by the U.S. Food and Drug Administration Pasteurized Milk Ordinance (PMO).

(3) Treating polished water to potable water quality standards and using the treated water in place of City potable water.

One of the main differences between Industry #1 and Industry #2 is the potable water demands. If Industry #2 completely eliminated potable water demands, the water reduction would total only 3,200 gallons per day. This equates to an annual cost savings of $4,000 for potable water supplies. Also, because the majority of the wastewater charges are loading related, this reduction in potable water will have a small effect on the wastewater charges; reducing only approximately $225 annually (assuming the mass loading does not change). With a return-on-investment in mind, the potential options are limited.

14.1 Clean-in-Place Water Use

Industry #2 has two CIP systems. The CIP systems clean equipment approximately two times per day. Many of the same measures suggested for Industry #1 can also be implemented for Industry #2; however, the cost to implement any approach can quickly surpass the potential economic benefits. Options that require little investment include:

- A reuse or recovery distribution system to reclaim the alkaline detergent solution and reuse it for future cleaning (Conservation) is already practiced by the industry.
- Pulse rinses can be more effective at rinsing, while also reducing water demand (*Conservation)*. Assuming a 10 percent reduction, this could reduce Industry #2's potable water demand by approximately 300 gallons per day.
- Optimize reuse or recovery distribution systems by installing inline conductivity or turbidity meters to determine when a rinse is too contaminated for use and needs to be disposed (*Conservation*). Assuming a 10 percent reduction, this could reduce Industry #2's potable water demand by approximately 300 gallons per day.
- Implement an over-ride procedure where instead of separate alkaline and acid wash steps, the first step (alkaline step) is kept circulating while acid is added to the required concentration (*Conservation*). This procedure requires more chemical use, but has been estimated to reduce water demands by 10 percent, which equates to less than 300 gallons per day.
- In lieu of over-ride, a single-phase cleaning approached could be implemented. This is where a single cleaning solution that acts as both the alkaline and the acid to remove both the organics and the mineral deposits is used (*Conservation*). This technique saves water associated with the interim rinse step and second wash and can result in an estimated 15 percent reduction in water use, which equates to less than 480 gallons per day.

Some of the above strategies may already be implemented at Industry #1.

14.2 Cooling

Majority of the potable water used by Industry #2 that is not used for cleaning is used for cooling. Reducing water use in cooling applications requires a careful balance between bleed-off water and make-up water quality (called the concentration ratio). Water is bled from the system and new water added to reduce the concentrations of suspended and dissolved solids. The presence of suspended and dissolved solids can lead to scaling, which can negatively affect the efficiency of the system. Optimizing this balance can result in water savings as high as 20 percent (EPA, 2011).

Installing conductivity meters and flow meters on the make-up and bleed off lines can provide the necessary information to fully understand the cooling tower operation and the concentration ratio. It is estimated that it would cost approximately $10,000 to install flow meters and conductivity meters. With a potential reduction of only 20 percent (or at most 640 gallons per day), the additional staff time to maintain and monitor the new instrumentation makes this not worthwhile.

In some instances cooling water can be discharged in the storm sewer/surface instead of the sanitary sewer. Bleed off from cooling towers is not eligible for coverage under the non-contact cooling water general permit. These non-storm water discharges may be covered by an individual NPDES permit. However, the NPDES permit fees and required sampling may make this option undesirable. To determine if the cooling water blow down can be discharged to other than the sanitary sewer, MCPA would need to review some information about the discharge quality, volume, and rate of discharge.

14.3 Other Uses

Approximately 90 to 95 percent of the potable water demand is used for cleaning and cooling. Other uses of potable water include water softener regeneration, hose drops, pump seal water, bathroom/break room uses. Responsible for a small portion of the total demand, optimizing these uses will not have a significant impact on the Industry or the City.

14.4 Summary

Table 1B summarizes the primary areas in which potable water is used and the estimated daily volume of water. Also indicated are areas in which conservation or reuse could be implemented to reduce potable water demands.

Table 8
Summary of Potable Water Uses

Potable Water Use Area	Estimated Potable Volume Used (gpd)	Reduction Potential from Conservation/Education (gpd)	Reduction Potential from Additional Polished Water Use (gpd)	Reduction Potential Assuming Potable-Quality Water Production (gpd)
Clean-in-place (CIP) systems	1,500	300	500	1,500
Cooling tower and condenser make-up water	1,500	300	1,500	1,500
Misc (water softener regeneration, fixtures, hose drops)	160	Yes, assumed negligible	No	No
Total Quantified	3,200	600	2,000	3,000

15.0 Costs to Implement Reduction Opportunities

There are costs associated with implementing the water sustainability strategies summarized in Table 2B.

Table 9
Summary of Water Sustainability Strategies Costs

Water Reduction Strategy	Industry #2
Conservation/Education	
Reduced Demand (gpd)	600
Estimated Capital Cost of Implementation	$5,300
Estimated Annual O&M Cost of Implementation	$300
Estimated Annual Utility Cost Reduction[a]	$315
Estimated Simple Payback Period (years)	NA[b]
Category II & III Uses	
Reduced Demand (gpd)	2,000
Estimated Capital Cost of Implementation	$16,000
Estimated Annual O&M Cost of Implementation	$3,000
Estimated Annual Utility Cost Reduction[a]	$1,000
Estimated Simple Payback Period (years)	NA[b]
Category I (Potable-Quality) Uses	
Reduced Demand (gpd)	3,000
Estimated Capital Cost of Implementation	$292,000
Estimated Annual O&M Cost of Implementation	$29,000
Estimated Annual Utility Cost Reduction[c]	$10,400
Estimated Simple Payback Period (years)	NA[b]

Notes:

d) Cost reductions assume wastewater volume reduction, but no change in wastewater loadings.

e) Not applicable: Utility cost reductions do not offset the annual O&M costs for there to be any returns on investment.

f) Conservatively assumes that WW discharge can be eliminated by diverting the potable-quality water from the sewer (i.e. selling or giving away) and the concentrate from the treatment process can be converted to product.

15.1 Conservation and Education

While conservation and education are often considered the "low-hanging fruit", there are implementation and training costs to consider. For example, reducing water use in the cooling towers requires monitoring bleed off and make up water volumes and conductivity. Flow meters and conductivity meters need to be connected to a readout location and staff need to monitor this information frequently until the optimum operational strategy is identified. There are equipment costs and staff time is needed to implement conservation/education water sustainability strategies.

It has been estimated to cost approximately $5,300 to implement conservation/education strategies, with an additional annual recurring cost of $300. The capital cost includes one-time staff hours to optimize the CIP cycles. The annual cost is associated with maintenance/replacement of turbidity meters.

These costs are offset by the reduced water purchases and reduced wastewater discharges. Reducing the potable water demand by 36,000 gallons per day results in a savings of approximately $315 per year. The annual savings just barely covers the added expense of the maintaining the monitoring equipment and, therefore, these strategies do not have a reasonable payback.

15.2 Additional Process Water Reuse

Industry #2 could use COW water for the first CIP rinse and in the cooling towers. It has been estimated to cost approximately $16,000 to implement additional polished water use (tankage), with an additional annual recurring cost of $3,000 (increased cooling tower cleaning and increase cooling tower chemical).

These costs are offset by the reduced water purchases and reduced wastewater discharges. Reducing the potable water demand by 2,000 gallons per day results in a savings of approximately $1,000 per year. Again, the potential savings does not cover the expected increase to the O&M costs.

15.3 Polished Water Treatment to Potable-Quality Water

Additional treatment of the COW water is necessary to meet the Category I criteria as required by the PMO. The additional treatment requires passing the polished water through an RO system to remove more organic material and then disinfection.

To estimate the costs to produce potable-quality water, a treatment system was sized for 50,000 gallons per day. While this is significantly larger than the water demand at Industry #2, producing only 3,200 gallons per day of potable-quality water will most certainly cost more than the $1.25 that the industry currently pays for potable water. By producing 50,000 gallons of potable water per day, the industry could sell the excess potable to a nearby industry or farmer. This would certainly reduce the wastewater volume sent to the City's WWTF. Assuming the reject from the treatment system could be further dried and made into product, the Industry could potentially eliminate the bulk of its wastewater discharge.

It has been estimated to cost approximately $292,000 to implement the treatment system necessary to produce potable-quality water. This assumes that building space is available for the indoor equipment and space is available for new storage silos. The treatment system will require replacement bulbs for the UV system, replacement membranes for the RO, staffing, and energy. These recurring O&M costs are expected to total approximately $29,000.

These costs are offset by the reduced water purchases and reduced wastewater discharges. Reducing the potable water demand by 3,000 gallons per day results in a savings of approximately $1,400 per year. Assuming the volume and load to the WWTF could be reduced, this could result in an annual savings up to $9,000. The total savings could be approximately $10,400. Yet this savings does not cover the estimated annual O&M costs for the system. For the project to pay for itself in 10 years, the industry would have to charge approximately $2.50 for the excess water it sells.

15.4 Summary

Given the small water demand of Industry #2, there are not many water sustainability strategies that are cost-effective to implement. There may be some potential for collaboration with Industry #1 to make the best use of the COW water.

16.0 References

Environmental Protection Agency (EPA), 2011. Energy Efficiency Improvement and Cost Saving Opportunities for the Dairy Processing Industry. October, 2011.

Metropolitan Council Environmental Services (MCES), 2007. Recycling Treated Municipal Wastewater for Industrial Water Use. November, 2007.