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INDUSTRIAL WATER USE GUIDE BY SECTOR

Industrial Water Use Guide by Sector

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St. Johns River Water Management District

The St. Johns River Water Management District was created in 1972 by passage of the Florida Water Resources Act, which created five regional water management districts. The St. Johns District includes all or part of 18 counties in northeast and east-central Florida. Its mission is to preserve and manage the region's water resources, focusing on core missions of water supply, flood protection, water quality and natural systems protection and improvement. In its daily operations, the District conducts research, collects data, manages land, restores and protects water above and below the ground, and preserves natural areas.

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1.0: INTRODUCTION

The St. Johns River Water Management District (District) created the Water Conservation and Demand Management Program (the Program) in Fiscal Year 2008-2009 as a program to develop and implement innovative water conservation initiatives and to develop and analyze metrics to demonstrate the effectiveness of water conservation planned or implemented by the District.

As the District's population and economy grow, there will be increasing demands on our water resources. A commitment to more efficient and sustainable water use will help us meet the challenges this growth will bring. Water conservation, defined as the beneficial reduction of water use, water waste and water loss, can help ensure that we are able to continue to meet growing water demands. The ultimate goal of water conservation is not to discourage water use, but to maximize the benefit from each gallon used.

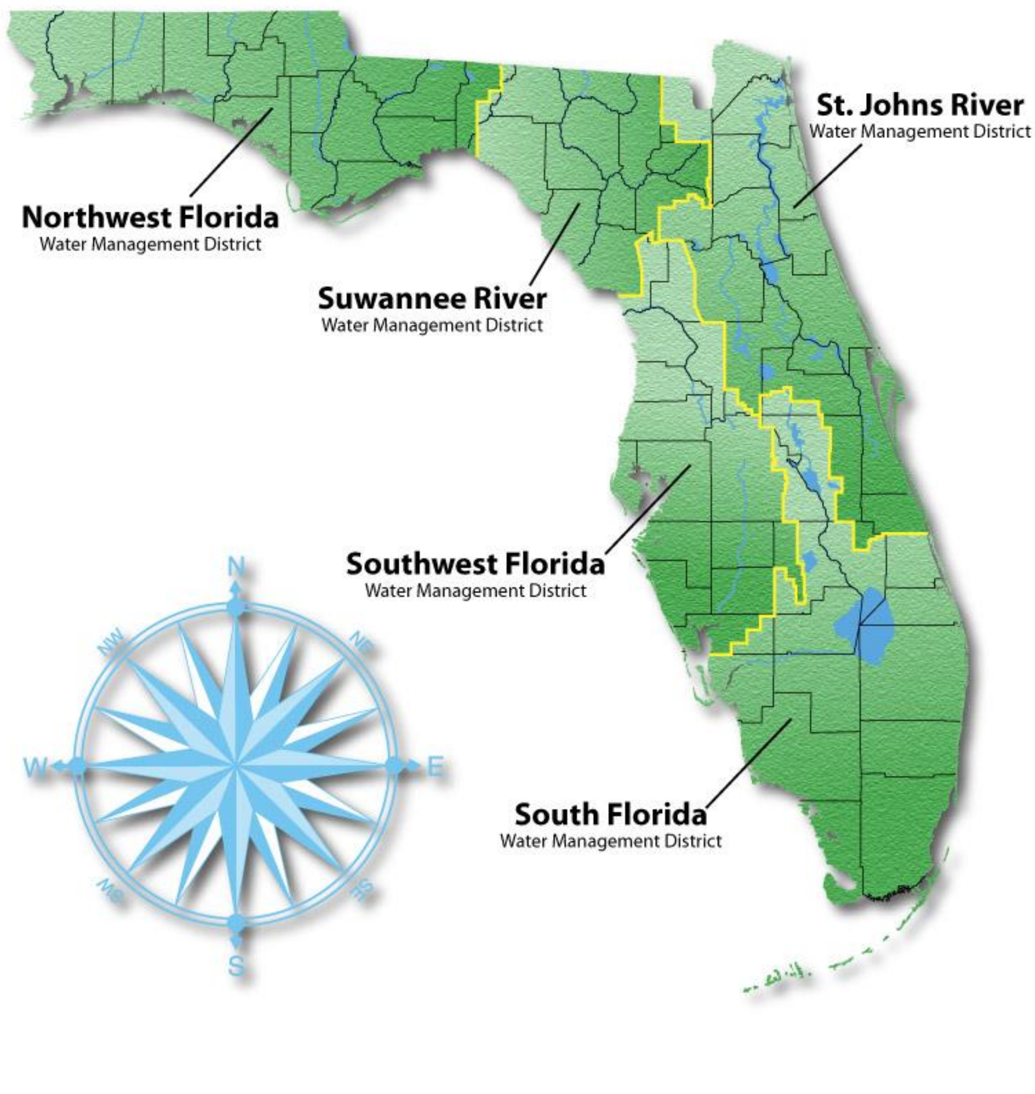
The purpose of this industrial end use guide is to supply users with best management practices in each industrial sector in order to evaluate water conservation potential. Each BMP structure has several elements that describe the efficiency measures, implementation techniques, schedule of implementation, scope, water savings estimating procedures and estimates, cost effectiveness considerations, and references to assist end-users in implementation.

This manual will cover the following industrial sectors:

- Light Industrial, Small Equipment Manufacturing, Small Machine Shop, Printing Plants
- Heavy Industrial, Heavy Equipment Manufacturing, Large Machine Shops, Foundries
- Lumber Yards, Sawmills, Planing Mills
- Packing, Fruit & Vegetables, Meat Packing Plants
- Canneries, Fruit & Vegetables, Bottles & Brewers
- Other Food Processing, Candy Factories, Bakery
- Mineral Processing, Phosphate Process, Cement Plants
- Warehousing, Distribution Terminals, Vans & Storage Warehousing

1.1: DISTRICT BACKGROUND

Management of water resources in Florida has been delegated to five Water Management Districts. The St. Johns River Water Management District (District) is located in Northeastern Florida. Major cities include Jacksonville, Gainesville, Daytona Beach and many smaller communities. The following map shows the location of the District. The District has a long history of promoting water efficiency. One of the most important recent developments are analytical tools to benchmark water use by type of end user based on several parameters including gallons of water used per square foot in commercial and institutional establishments. This analysis works well for the commercial and institutional sectors, but industrial water users (Florida Department of Revenue (DOR) Codes 41-48) proved problematic.



1.2: BMP GUIDE ORGANIZATION

In order to analyze each of the eight DOR categories to determine both the potential for water conservation and for the development of specific best management practices (BMP's) for water conservation, each of the sectors is analyzed separately. This analysis includes information from a variety of sources. Each sector analysis has the following format:

a) Description of the industry
b) Analysis of overall water use and benchmark parameters
c) Discussion of types of water use that may be present
d) Listing of BMP's that are unique to that industry

1.3: GUIDE DEVELOPMENT

The development of best management practices, identification of water conservation opportunities, and the description of water using characteristics of the various sectors requires a detailed analysis of existing data. In order to analyze water use by type of use and to develop metrics to describe use characteristics, several types of analysis were conducted:

1. For utility data, potable water use for DOR 41-48 were analyzed to determine gallons use annually per square foot of heated area, monthly to determine seasonal use patters;
2. Analysis of individual large water users processes where adequate information was available;
3. Analysis of wastewater permit information to determine types and volumes of wastewater produced;
4. Use of information available to WMI and from a review of literature to determine types of water use common to each type of user; and
5. Analysis of reuse and irrigation metered data from Lake Mary, Mount Dora, and Sanford.

The development of recommendations for use by the District to direct programs to the entities in the DOR sectors 41-48 and the development of the BMP Guide was based on three things:

1. The extensive experience of the staff of Water Management, Inc. over 30 of working with industrial, commercial and institutional (CII) entities to accomplish higher water efficiencies;
2. An extensive search of existing literature; and
3. The analysis of water use based on the data base and information from specific industries and industry trade groups.

1.4 APPLICABILITY

All BMP's described in this document are technically feasible and have been used in the past, AND are applicable to all commercial and institutional water users. Many are also applicable to industrial operations where a large number of people are employed. However, it does not mean that each BMP is applicable in all cases. Economic, structural and local water chemistry considerations all need to be taken into account.

Industrial operations, even more than commercial and institutional operations are each unique. Even though the processes are generally the same in a specific type of industry, the configuration or the actual facility layout and the unique design of equipment which is often proprietary to that specific plant or company make "cookie cutter" assumptions on payback or the implementation of a specific BMP not applicable to such facilities. The following three concepts should be the guiding principles when considering industrial facilities:

1. **One size does not fit all** – For any given industry, there may be a dozen potential BMP's. Not all will be applicable. In many cases establishing one BMP would mean that another will not be applicable because they will "be saving the same water."

2. **Every plant is unique** - Analysis of potential payback is unique to each plant and situation. Unlike many commercial situations, manufacturing plants, even in the same industry, vary in manufacturing techniques and design. For example, this means that what may work at one vegetable processing plant may not be applicable at another.

3. **The list should be used only as a guide** - The intent of the manufacturing BMP's is to provide a list of possible measures that plants can adopt for their specific situation.

Industrial and Commercial Water Use

In order to characterize industrial and mining water use and to develop a general approach to working with industrial customers, it is necessary to first divide overall use into categories of use. Industries can contain all the normal domestic water uses since they employee people. However, domestic uses are most often the smaller percent of total use. The table below summarizes the ways that water can be used in industrial operations (DOR 42 through 47).

FIGURE 1: EXAMPLES OF WHERE WATER CAN BE USED IN HEAVY INDUSTRY

Examples of Where Water can be Used in Heavy Industry						
	Food & Beverage	**Pulp & Paper**	**Minerals Mining**	**Chemicals**	**Wall Board**	**Electronics**
Process Cooling	X	X	X	X	X	X
AC Cooling	X	X		X	X	X
Refrigeration Cooling	X			X		
Employee sanitation	X	X	X	X	X	X
Landscape irrigation	X	X	X	X	X	X
Air Pollution	X	X	X	X	X	X
Equipment cleaning	X	X	X	X	X	X
Process	X	X	X	X	X	X
Inclusion in product	X		X	X	X	
Dust Control	X	X	X	X	X	X
Area wash-down	X	X	X	X	X	X
Transport of materials	X	X	X	X	X	X
Separations processes	X	X	X	X		
Humidification	?	X		X		
Boilers	X	X	X	X	X	X

Light industrial and warehouse operations more closely represent commercial operations.

2.0: OVERALL FINDINGS

Based on the information provided and information obtained from reports, conversations and web based information, an analysis of water use within each of the eight sectors (DOR Sectors 41 through 48) this guide was made to explain total water use, proportions of end uses, and best management practices in specific industrial uses in St. Johns River Water Management District.

The goal was to determine broad scope potential water savings. The findings are divided into three sections:

- Summary of Water Use;
- Findings for Each Sector;
- Development of Best Management Practices Guidelines; and
- Discussion of Water Saving Potential.

The DOR codes and industries covered are as follows:

- DOR 41: Light Industrial, Small Equipment Manufacturing, Small Machine Shop, Printing Plants
- DOR 42: Heavy Industrial, Heavy Equipment Manufacturing, Large Machine Shops, Foundries
- DOR 43: Lumber Yards, Sawmills, Planing Mills
- DOR 44: Packing, Fruit & Vegetables, Meat Packing Plants
- DOR 45: Canneries, Fruit & Vegetables, Bottles & Brewers
- DOR 46: Other Food Processing, Candy Factories, Bakery
- DOR 47: Mineral Processing, Phosphate Process, Cement Plants
- DOR 48: Warehousing, Distribution Terminals, Vans & Storage Warehousing

2.1: SUMMARY OF WATER USE

Water use in the eight sectors was analyzed for magnitude of total use, identification of dominant sectors and for seasonal variations. These findings include:

1. Self-supplied water makes up most of the DOR 41-48 water use**:** The most significant finding on sheer magnitude of use is that the majority of water use for these sectors (DOR Sectors 41 through 48) is from self-supplied water. Potable water use for all eight DOR sectors averaged (2008 and 2009) as reported by the participating utilities only 348 million gallons a year or just 0.95 million gallons a day (0.95 MGD). By contrast, water use for the same sectors reported in the EN - 50 form for self-supplied water was in the range 75 MGD to 80 MGD and for all commercial use was 95 MGD to 100 MGD. Reclaimed water and irrigation water uses were in the range of 0.1 MGD.

   The implication of the majority of water use being self-supplied is that the value of that water is low. This does not help promote water use efficiency. Other ways to encourage conservation are needed to help promote efficiency in the self-supplied sectors.

2. Data Limits**:** The data provided by the District was the basis for much of the analysis. There were some limits to the data's usefulness. For example, several of the potable water data sets did not have the entity name or address. The water use volumes from those data sets where names and addresses that were missing could be used for in the statistical analysis, but not for examination of specific operations. Some data sets would report negative use for a month and in the case of Daytona Beach *South Daytona Storage and Offices located at 2090 S Nova Road accounted for 94 percent of all water use for DOR 48 in Daytona Beach* total water use for that one storage facility accounted for 137 million of the 156 million gallons of water use in Sector 48 in Daytona Beach. Therefore, the Daytona Storage water use was removed from the water use analysis.

   Another limitation was the Department of Revenue classification system. It was designed to divide industries into categories for taxing purposes and not dividing industries by specific product or type of process. These DOR codes do provide a significant segregation of industrial operations, but the use of something like the North American Industrial Classification System would offer clear segmentation.

3. Seasonal Use: DOR 41 and 48 show some slightly seasonal use patterns. DOR 44 shows variation, but it appears to be based more on harvesting seasons for various crops. Conservation programs that focus in process and indoor use will address the majority of use in most sectors. The exception may be industrial complexes in sector 41 or 48 that want to have a well groomed landscape around their facilities.

2.2: DOR WATER USE CHARACTERISTIC SECTOR ANALYSIS

The following is a summary of the most pertinent findings for each of the eight DOR sectors analyzed.

1. DOR 41(Light Industrial, Small Equipment Manufacturing, Small Machine Shops and Printing Plant) showed that about 85 percent of the data points for individual users were at or below that normally expected for a domestic dwelling. The lower 85 percent of entities used below 50,000 gallons a month. In a similar manner, the gallons of use per year per square foot of heated area did vary. For very small users below 30,000 gallons a month and for those with low gallons per square foot use, programs aimed at normal plumbing fixture, irrigation and other domestic uses would be appropriate. For those entities with use over 100,000 gallons a month or with use to area ratios of 13 gallons per square foot, further investigation is warranted. One example are stone cutting (counter tops etc.) businesses. They use significant volumes of water. Audits or at least walk-through surveys of these facilities could prove valuable. This is especially true of the top ten percent of water users.

2. DOR 42 (Heavy Industry, Heavy Equipment Manufacturing, Large Machine Shops and Foundries) is the single largest water using sector. Self-supplied ground and surface water make up the majority of the water used. The pulp and paper industry is the dominant industry in this sector. Analysis shows that Georgia Pacific and Rock-Tenn (Formerly Smurfit) mills have water use characteristics that are close to median values for the industry. Georgia Pacific is a craft mill and has water use equal to between 14,330 and 16,354 gallons per ton of paper. The two Rock-Tenn mills are recycle paper mills and use between 5,400 gallons and 9,000 gallons per ton of paper. All of these values are within the expected range for these types of facilities. The Rayonier facility has much higher use per ton of paper, but it produces stock for the rayon fabric industry. This pulp must be of the most pure quality and requires significantly more rinsing with fresh water.

   The other industries are large water users, but benchmarking data is not readily available. The very diversity of this sector makes any general analysis such as that done for DOR 41 impractical. This sector could yield significant savings, but it would require a special effort to work with the industries. This sector would be an ideal candidate for additional studies.

3. DOR 43 (Lumber Yards, Saw Mills, and Planing Mills) are composed of a number of lumber yards where domestic use dominates for employees and customers and a few other types of facilities such as mulch sales, truss mills, etc. Most of these entities would benefit from a general conservation effort such as plumbing retrofits. Individual audits should be targeted at only the top three or four entities in this sector.

4. DOR 44-46 (Food and Beverage Processing) is a well-recognized industry in Florida. This combination of sectors includes:
    - *DOR 44 – Packing, Fruit and Vegetable and Meat Packing Plants*
    - *DOR 45 - Canneries, Fruit and Vegetables, Bottlers and Brewers*
    - *DOR 46 – Other Good Processing, Candy and Bakeries*

    The dominant single water user in this sector is brewing and beverage processing. Fruit packing is seasonal in nature and individual plants tend to use water mainly to wash fruit, clean equipment and provide for domestic use. Fruit packing accounts for the most potable water use since these facilities are located in or near cities. Beverage manufacturing tends to be self-supplied although several entities use potable water from city utilities. The beverage industry is working to improve water efficiency as part of its public relations efforts as well as efforts to reduce costs. It is an industry that would respond very well to awards and recognition by water utilities. The other industries hold potential for water reduction. Only on-site, case by case studies can determine their true water savings potential. The food processing sectors have historically not released production information to the public. No comparison of gallons of water per unit of production was possible except for Anheuser Busch Brewery. There have been a number of studies of the industry that offer benchmarking information. Summaries of studies completed since 2000 are included in that section.

5. DOR 47 (Mineral Processing, Phosphate Processing, and Cement Plants) is actually four industries within one sector. There are the very large minerals extraction facilities such as the E.I. Du Pont's titanium dioxide mines and the Edgar Kaolin clay mines, then there are the sand and gravel and borrow pit mines that extract building materials, small specialty mines such as peat mining, and ready mix concrete plants. The description lists cement plants but included ready mix plants in the sector. Cement plants actually convert lime and clays into cement, the material that when mixed with water, sand and gravel, makes concrete.

    The majority of water use in this sector directly associated with mining is surface water or water that infiltrates and fills the pits that are being mined. The District correctly assumes that 95 percent of this water is returned to the pit of origination. The water does provide an important function in washing and separating materials.

    It was not clear how groundwater and potable use was within most of these facilities; however, domestic use and uses that require high quality water were obvious. Located within employee areas/populated areas, concrete batch plants are using potable water.

    Water conservation opportunities in the areas where groundwater is being used should be investigated. Since many of the concrete ready mix (batch) plants use potable water, they may be open to site surveys to identify opportunities of using stormwater for more of their operations.

6. DOR 48 (Warehousing, Distribution Terminals, Vans and Storage Warehousing**),** like DOR 41, tends to be a "catch-all" category. The sector is dominated by a large number of low water using facilities. Half of the facilities used less than 45,000 gallons of water. The focus of a conservation program may be most effectively targeted at the top 20 percent of water users.

2.3: BEST MANAGEMENT PRACTICES

There are a number of practices that various industries and commercial activities can undertake to reduce water use. Some of these are specific to a given industry and others apply across all commercial, institutional and industrial sectors. Where best management practices (BMP's) were specific to a sector, they were included. The general guide contains the following sections:

1. Introduction and Purpose
2. Applicability
3. Description of BMP's (the main body of document)

Specific BMP's addressing specific industries are included in each of the Sector (DOR) sections.

In order to reduce water waste in industry, it is important to understand the many ways that water is used within facilities. Understanding water end uses is critical to identifying water savings opportunities. While end uses of water vary by industry and by facility, there are categories of water use that are present at most industrial facilities. Water use in most industries can be classified into the following broad end uses:

- Production processing, in-product use, Auxiliary processes (e.g., pollution control, labs, and cleaning)
- Cooling and heating (e.g., cooling towers and boilers)
- Indoor domestic use (e.g., restrooms, kitchens, and laundry)
- Landscape irrigation
- Metering and Submetering

These broad categories encompass many of the ways industrial facilities use water. Among U.S. industrial customers, cooling operations (including cooling towers and open cooling systems) comprise the single largest category of industrial water end use.

2.4: WATER CONSERVATION POTENTIAL

The DOR sectors 41-48, which can be classified in general as industrial and heavy commercial water users, are a very diverse set of water users. Some of the largest individual facility water uses in the whole District occur in these sectors. However, these sectors and especially DOR sectors 41, 47, and 48 contain a very large number of very small users. Analysis of the small users' water use data shows that use is primarily for domestic purposes. Over 75 percent of all of the entities in these sectors fall into the small water user category.

The combined DOR sectors 41-48 use over 80 million gallons of water daily. Clearly there are opportunities to reduce water use. For the smaller entities, plumbing fixture replacement would be a definite target of any program. Current efforts in the other commercial and institutional sectors could be applied here. Although irrigation of landscapes does not appear to be a major use for many of the entities, existing landscape water conservation programs for commercial users would also apply.

For certain segments such as concrete ready mix plants, there are specific BMP's that can apply. For many of the larger entities, only a technical evaluation of water use within that specific facility can identify water saving opportunities. This set of very large users accounts for under 20 percent of entities, but have the largest potential.

There are a number of ways that these larger water using facility's efficiency can be addressed with a water conservation program. These efforts generally can be divided into three categories:

1. Non-financial incentives can be effective: Many of the larger water users strive to be known as "good corporate citizens." They tend to respond to any public recognition of an effort that can be seen as environmentally friendly. These larger users also generally have engineers and technical staff who are capable of identifying many water saving potentials within their facilities. Exchange of information and ideas can help distribute the good ideas of one facility to another. To this end, the following types of District and utility programs may foster efficiency:

   - Develop an awards program that provides a public forum for entities that accomplish real, measurable water efficiencies to be recognized by the general public and by local officials
   - Provide workshops and training that addresses their technical needs;
   - Provide a newsletter directed at this sector that provides information on conservation programs and lets all know about accomplishments by those in this sector.
   - Develop a District or utility speakers program to be available to meet with industry organizations and speak at their functions.

Another activity that has proven to be effective in many utilities or water districts across the nation is to develop a focus group or advisory committee formed from the various types of industries in the eight DOR sectors. This provides a two-way opportunity for communication and a sounding board for program changes.

2. Financial incentives can take many forms. Tax relief for the purchase of water efficient equipment, rebates for measured and verified water savings, and even low interest loan programs have been used. Very large industrial water users will welcome financial incentives, but the type of improvements that they make can cost millions. This means that incentives may not be as important a factor as the recognition. On the other hand, the medium size facilities can benefit greatly from a rebate or incentive. In many cases it can be the factor that makes the payback attractive.

   For smaller users, financial incentives directed at plumbing fixture and irrigation programs will help incentivize them. It is important to remember that toilets and urinals in most of these facilities receive many more uses a day than toilets in a residence. This makes existing plumbing replacement programs even more effective in these settings.

3. Technical assistance is the third component of any effective industrial and large commercial program. In examining efforts to provide technical assistance, several factors must be considered. They include:

   - For many of these facilities, workshops and simple site visits by conservation personnel are effective since the majority of the facility use is either related to plumbing fixtures or irrigation. For the larger facilities, a more extensive set of expertise is generally needed. For large industrial facilities, an engineering background may be necessary.

   - The level of assistance is also a key consideration. This can range from simply providing workshops and technical talks to complete facility audits. Site visits, however, offer significant benefits to both the entity being visited and to the District or utility conservation personnel. Actually seeing how water is being used by a second set of eyes can help, and it enforces that the District is actually interested in water conservation.

     For on-site visits, the three levels normally found are: (1) Simply explaining the need for conservation, available programs, and a quick review of facility activities, (2) a walkthrough of the facility to determine how water is being used and to identify potential opportunities, and (3) an actual technical study (audit) of the facility to quantify potential savings and costs.

   - Enlisting technical organizations that serve the various industries can also be an avenue to reach members of each of the eight DOR sectors that may not respond to other forms of assistance.

4. Use of an outside expert's help can be of benefit. This can be in the form of technical workshops and training or in the form of facility technical studies (audits) of carefully selected sectors or facilities. To truly understand the potential of the larger water users, such expert assistance and audits may prove to be invaluable.

With a water use of 80 plus million gallons a day, it is felt that an overall reduction of ten percent of higher in use of potable water and ground water is very feasible.

3.0: ANALYSIS OF POTABLE WATER USE INFORMATION FROM UTILITIES

Individual entity information was not available on all of the water use billing data sets provided by the water utility for the eleven users. Non-the-less, a significant amount of information was obtainable by the analysis of this data. This section presents the general findings for DOR 41-48 sectors.

The first analysis was to simply quantify water use in each sector. The figure titled "Distribution of Potable Water Use for DOR Codes 41 to 48" shows that DOR sectors 41 and 48 account for 84 percent of use in the 41-48 range of users. . The majority of use is almost equally distributed among DOR 42, 43, 44, and 47 category users. Table "Summary of Annual Average Potable Water Use for 2008 – 2009" shows potable water use by category. All figures are in millions of gallons per year. On a daily basis total potable water use in all eight sectors only equaled 0.95 million gallons of water a day (MGD).

Summary of Annual Average Potable Water Use for 2008 - 2009 *Millions of gallons per Year*									
Utility	**DOR Code**								
	41	**42**	**43**	**44**	**45**	**46**	**47**	**48***	**Total**
Atlantic Beach	**0.7**	**x**	**x**	**x**	**x**	**x**	**x**	**1.4**	**2.1**
Daytona Beach	**5.6**	**2.4**	**0.7**	**x**	**x**	**0.7**	**13.7**	**18.7**	**41.9**
GRU	**41.9**	**0.0**	**4.3**	**x**	**x**	**0.0**	**0.0**	**48.4**	**94.6**
Indian River	**4.3**	**0.3**	**0.0**	**4.7**	**x**	**x**	**0.4**	**11.4**	**21.2**
Lake Mary	**3.8**	**x**	**x**	**x**	**x**	**x**	**x**	**0.8**	**4.6**
Leesburg	**14.4**	**5.9**	**0.6**	**3.9**	**0.0**	**0.3**	**1.6**	**18.6**	**45.3**
Palm Bay	**52.0**	**x**	**0.1**	**x**	**x**	**x**	**5.1**	**7.6**	**64.7**
Palm Coast	**9.4**	**3.3**	**x**	**x**	**x**	**x**	**x**	**0.5**	**13.1**
Sanford	**21.3**	**0.2**	**0.3**	**x**	**x**	**0.6**	**0.4**	**23.2**	**46.0**
St. Johns County	**2.6**	**3.5**	**1.7**	**0.0**	**0.2**	**0.0**	**0.9**	**5.5**	**14.4**
Total	**155.9**	**15.6**	**7.6**	**8.6**	**0.2**	**1.7**	**22.1**	**136.1**	**347.8**

FIGURE 2: SUMMARY OF ANNUAL AVERAGE POTABLE WATER USE FOR 2008 - 2009

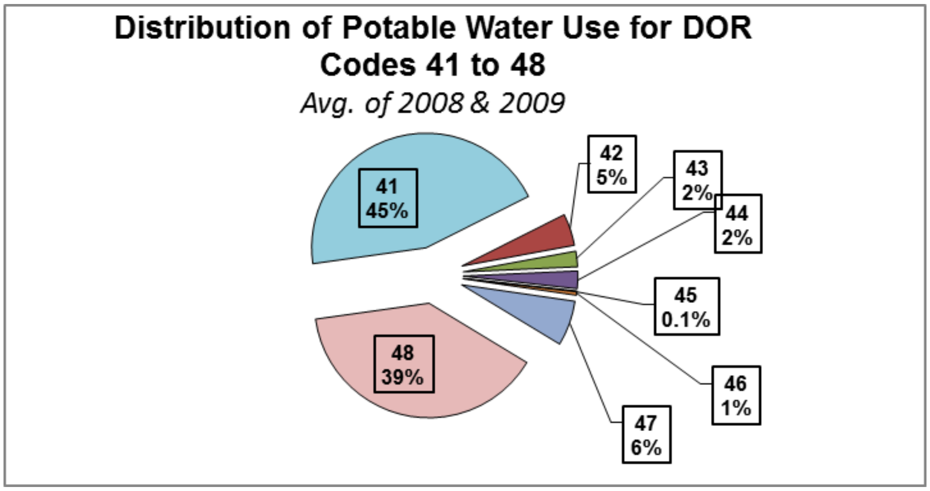


FIGURE 3: DISTRIBUTION OF POTABLE WATER USE FOR DOR CODES 41 TO 48

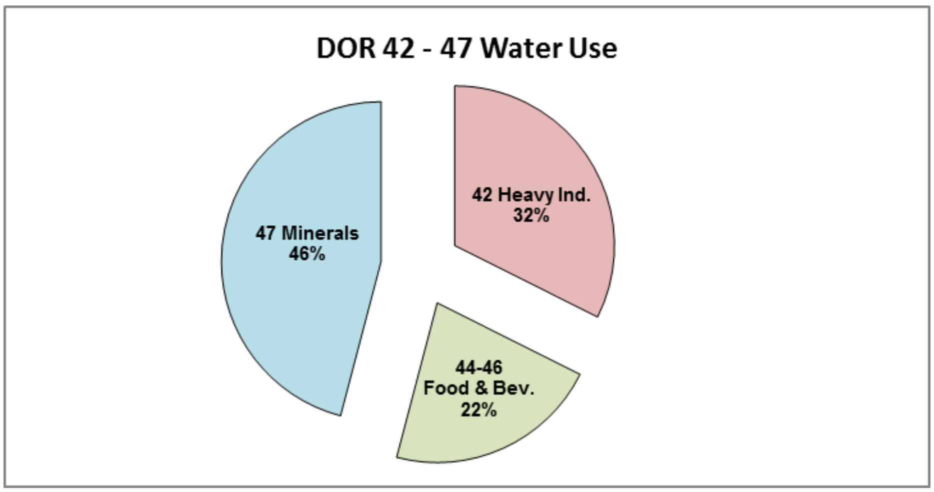


FIGURE 4: DOR 42 - 47 WATER USE

Another factor to analyze is the seasonal nature of water use in these sectors. The Chart titled "Climatic Averages for Gainsville, FL" shows historical average weather data for Gainesville,

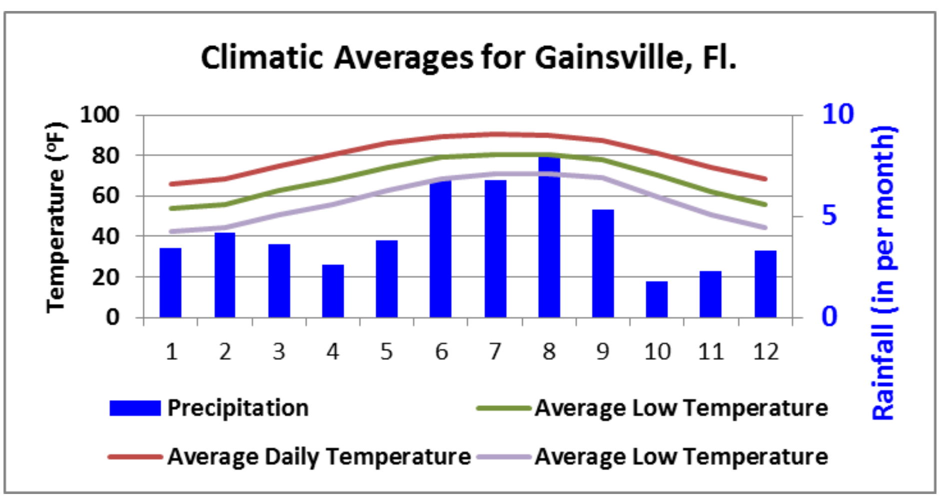


FIGURE 5: CLIMATIC AVERAGES FOR GAINSVILLE, FL.

Florida. If irrigation is the dominant climatically impacted water use, spring and fall spikes in use would be expected since summer is typically a period of high rainfall in this area of Florida. By contrast, if cooling towers were a major seasonal water use, summer spikes would be expected.

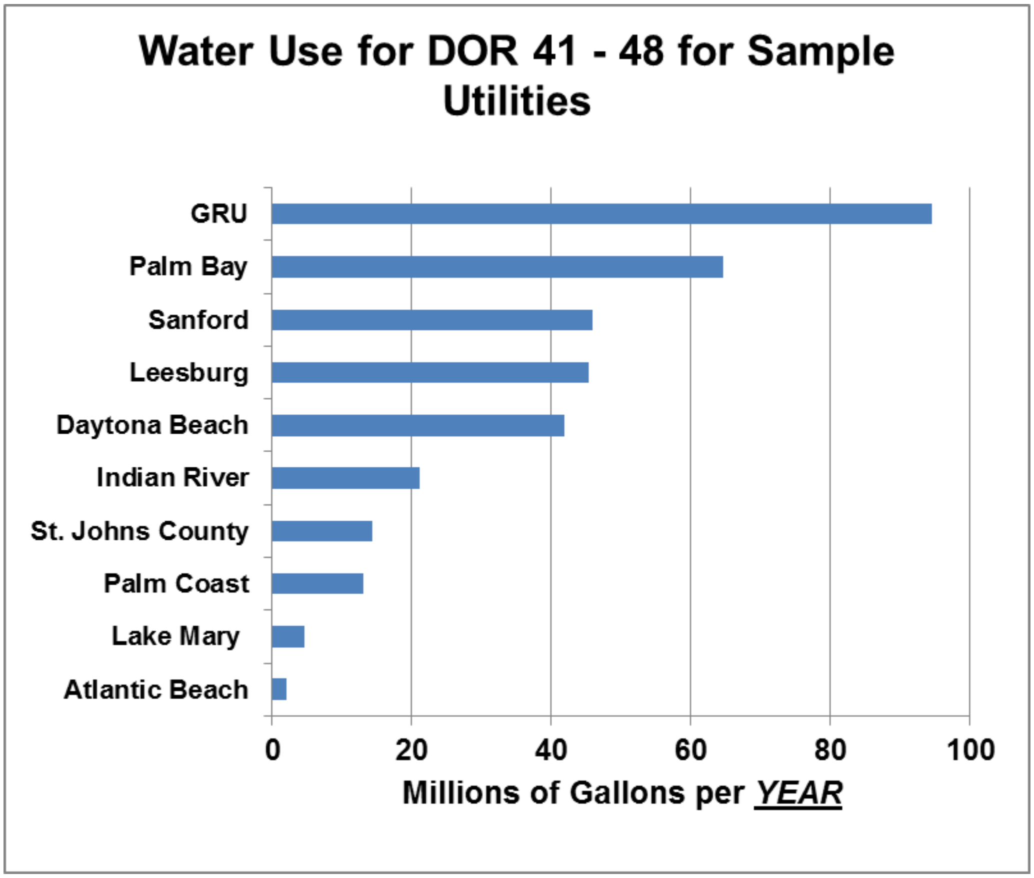


FIGURE 6: WATER USE FOR DOR 41 - 48 FOR SAMPLE UTILITIES

The economy is also a factor. The table titled "Comparison of Potable Water Use for 2008 and 2009" shows the impact the downturn in 2008 has had on use. Unfortunately, water use data for 2010 was available for only a few entities so the comparison is for 2008 and 2009.

Comparison of Potable Water Use for 2008 and 2009 (millions of gallons per year)			
DOR Code	**2008**	**2009**	**Percent Change**
41	**166.62**	**145.2**	**-12.90%**
42	**18.57**	**12.69**	**-31.70%**
43	**9.64**	**5.62**	**-41.70%**
44	**9.51**	**7.68**	**-19.20%**
45	**0.21**	**0.21**	**-1.60%**
46	**2.26**	**1.06**	**-53.10%**
47	**16.02**	**28.26**	**+76.40%**
48	**144.78**	**127.34**	**-12.05%**
Total	**367.61**	**328.06**	**-5.00%**

FIGURE 7: COMPARISON OF POTABLE WATER USE FOR 2008 AND 2009

The following four graphs (Sanford and Daytona Beach Water Use Graphs) illustrate typical monthly water use patterns for DOR 41 and 48 water use. As the graphs show, monthly water use patterns can be discerned but patterns are not consistent. DOR 41 for Sanford has no patterns. Also, only two years are used for Daytona Beach since November and December 2010 data is missing.

Sanford DOR 41 water use does not show a monthly pattern, but Dayton Beach DOR 41water use shows less use during times of low rainfall. Sanford DOR 48 water use appears to peak in times when rainfall is less, but just the opposite appears to be true for Daytona Beach DOR 48 water use.

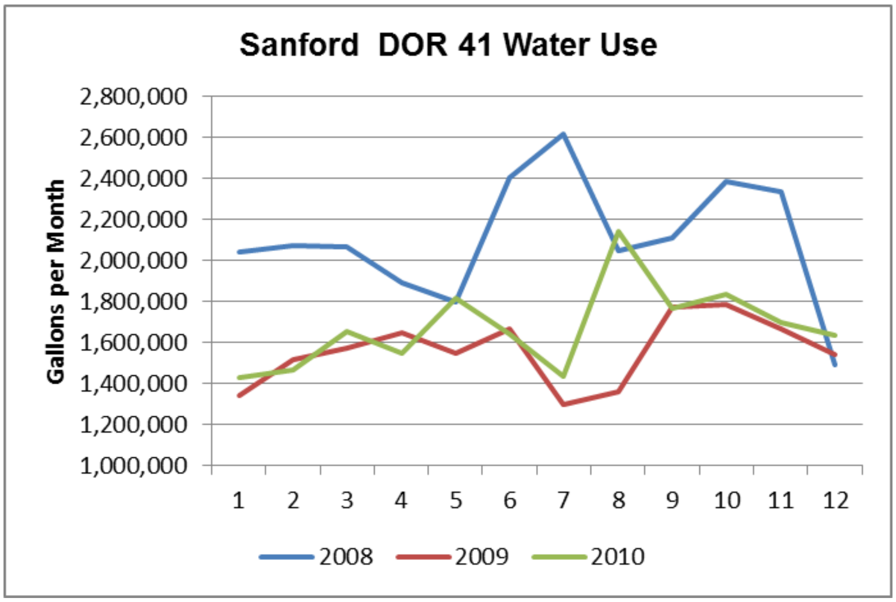


FIGURE 8: SANFORD DOR 41 WATER USE

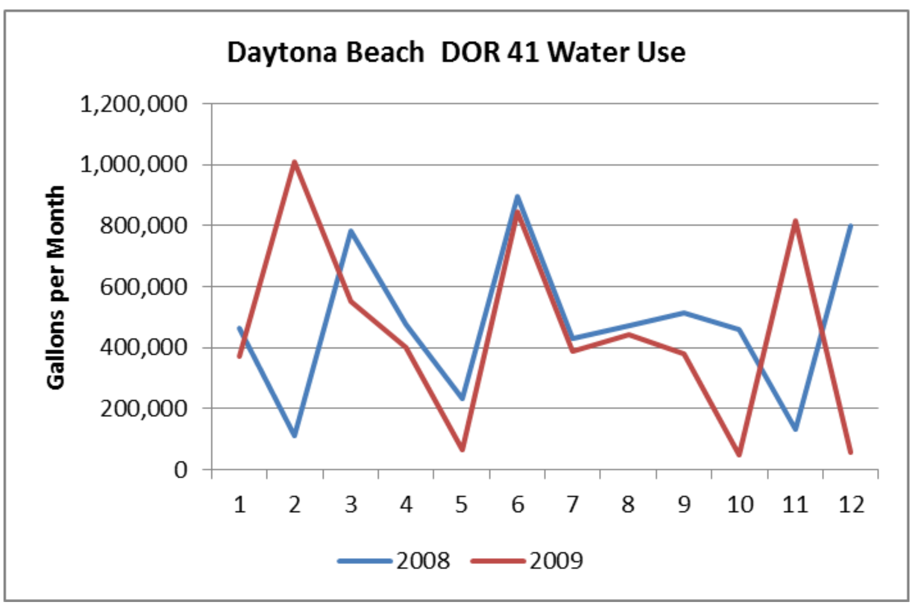


FIGURE 9: DAYTONA BEACH DOR 41 WATER USE

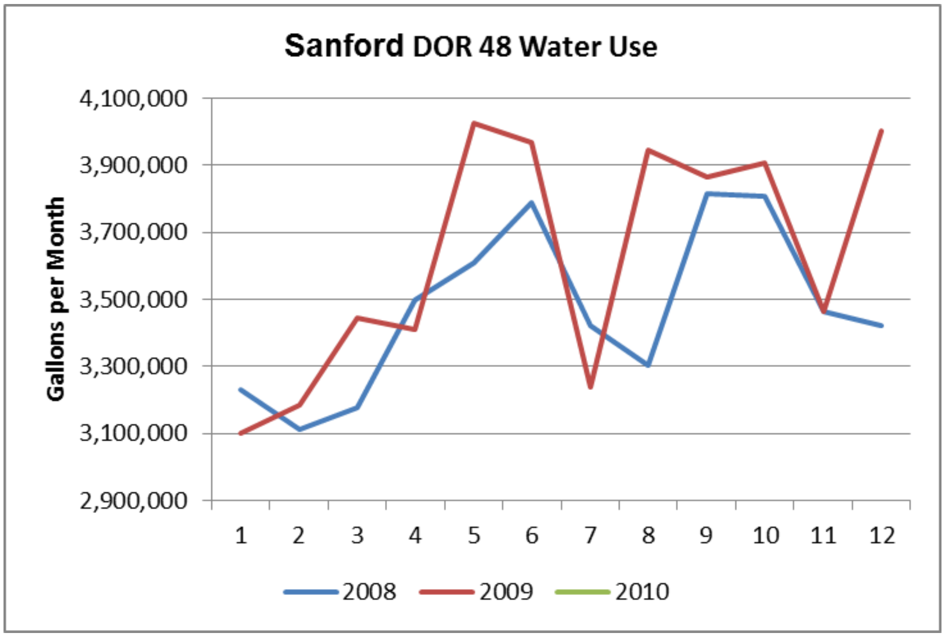


FIGURE 10: SANFORD DOR 48 WATER USE

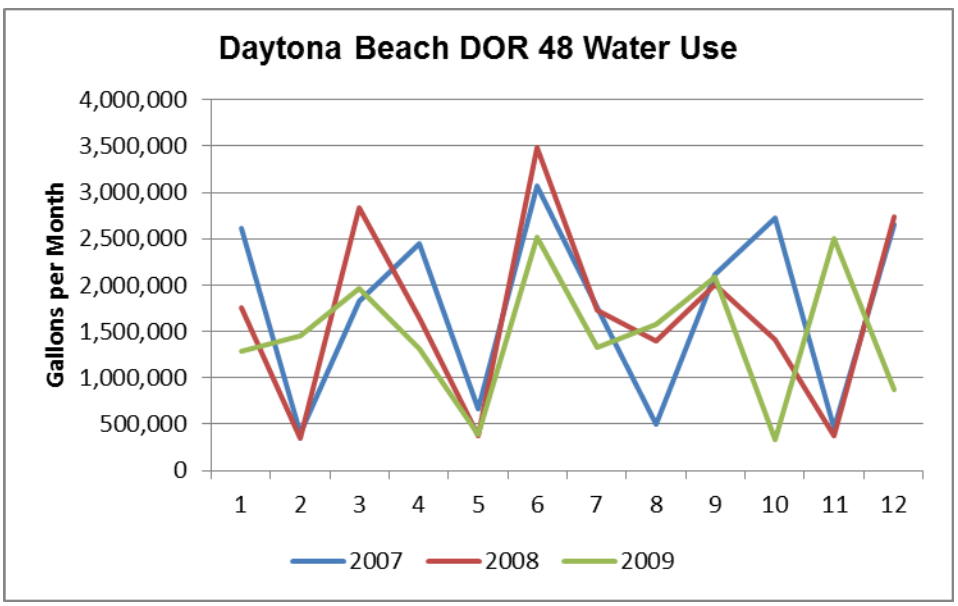


FIGURE 11: DAYTONA BEACH DOR 48 WATER USE

From this analysis, it is assumed that landscape irrigation is typically not a major water use for either DOR 41 or 48 water use. A similar comparison of all DOR 41, 48 and a combined DOR 42-47 does show a slight dip in use during periods of low rainfall for DOR 41 and 48 and no pattern for DOR 42-47 (See Chart titled "Monthly Water Use Patterns").

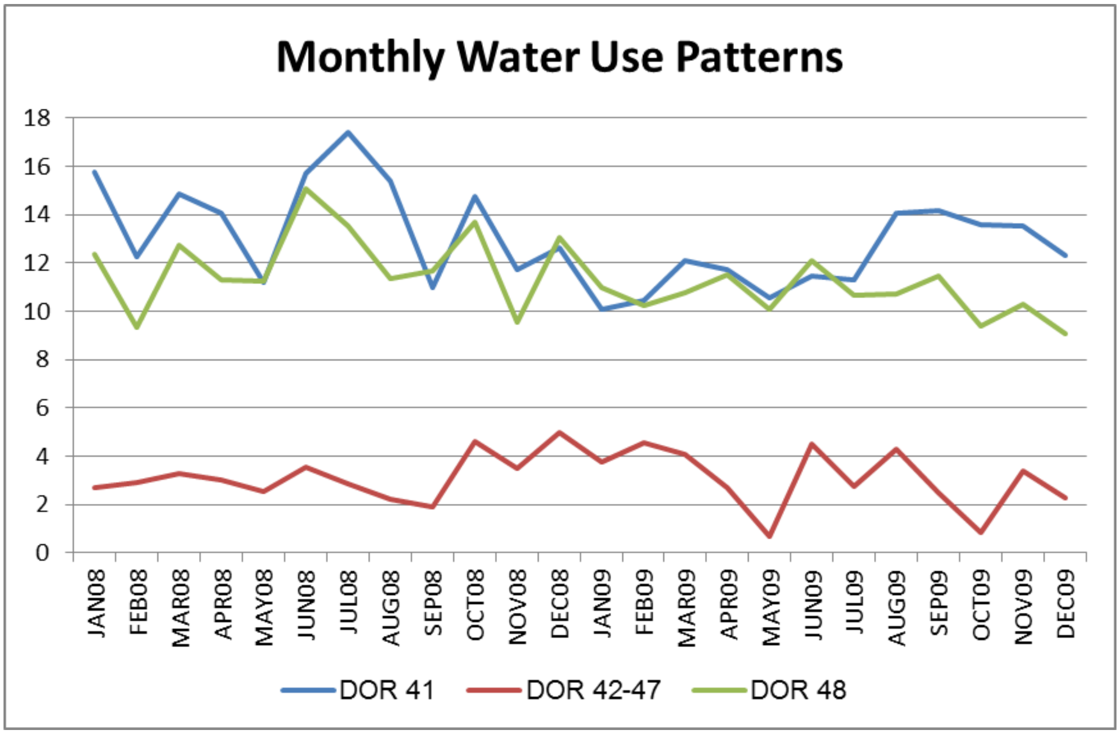


FIGURE 12: MONTHLY WATER USE PATTERNS

The main conclusion of the seasonal water use analysis is that for these sectors, some seasonality was observed, but for most entities, water is used consistently throughout the year, or in patterns that are not dominated by rainfall. One certain example is fruit packing plants that follow harvesting times and not rainfall. For most warehouses and many light industries, plumbing fixture use is the dominant use.

3.1: RECLAIMED AND IRRIGATION WATER USE

Lake Mary, Mount Dora and Sanford provided data for irrigation and reclaimed water use. Lake Mary showed irrigation and reuse information for a number of entities, but only one user fell into the DOR 41-48 category and the records show that there was no use. The figure titled "Sanford Reclaimed & Irrigation Use" summarizes reclaimed water and irrigation use for Sanford. The figure titled "Irrigation & Reuse for Sanford" shows that DOR 41 and 48 sectors used 6% of reclaimed use and 15% of irrigation use. From examination of several aerial views, all of Sanford's use was for irrigation. Only four entities used irrigation water in Mount Dora. Almost all irrigation and reuse occurred in areas west of the Orlando Sanford International Airport and along Highway 417.

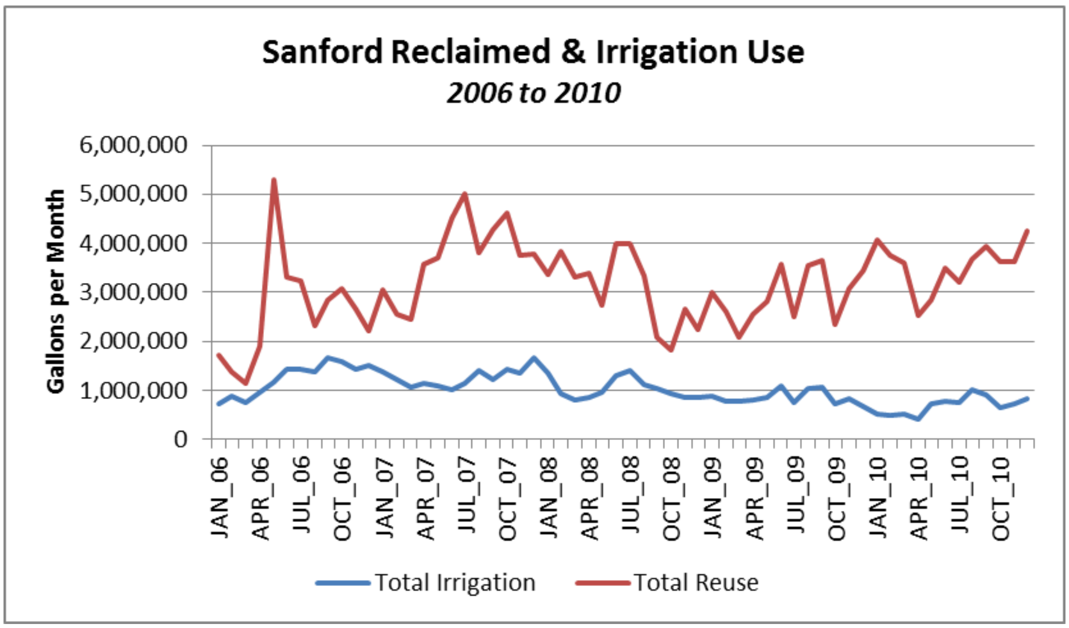


FIGURE 13: SANFORD RECLAIMED & IRRIGATION USE

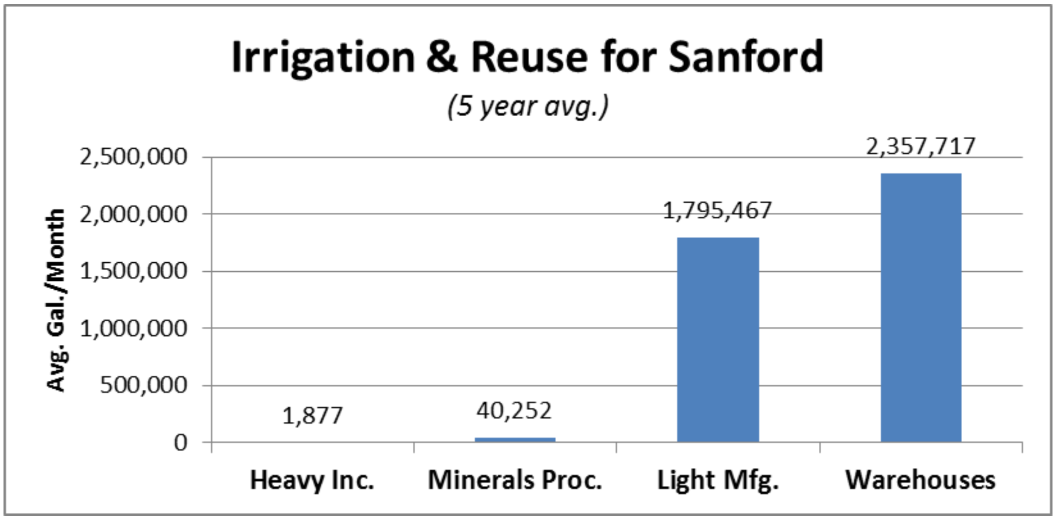


FIGURE 14: IRRIGATION & REUSE FOR SANFORD

Only four entities used irrigation water in Mount Dora. The figure titled "Mount Dora Irrigation Use" summarizes their use.

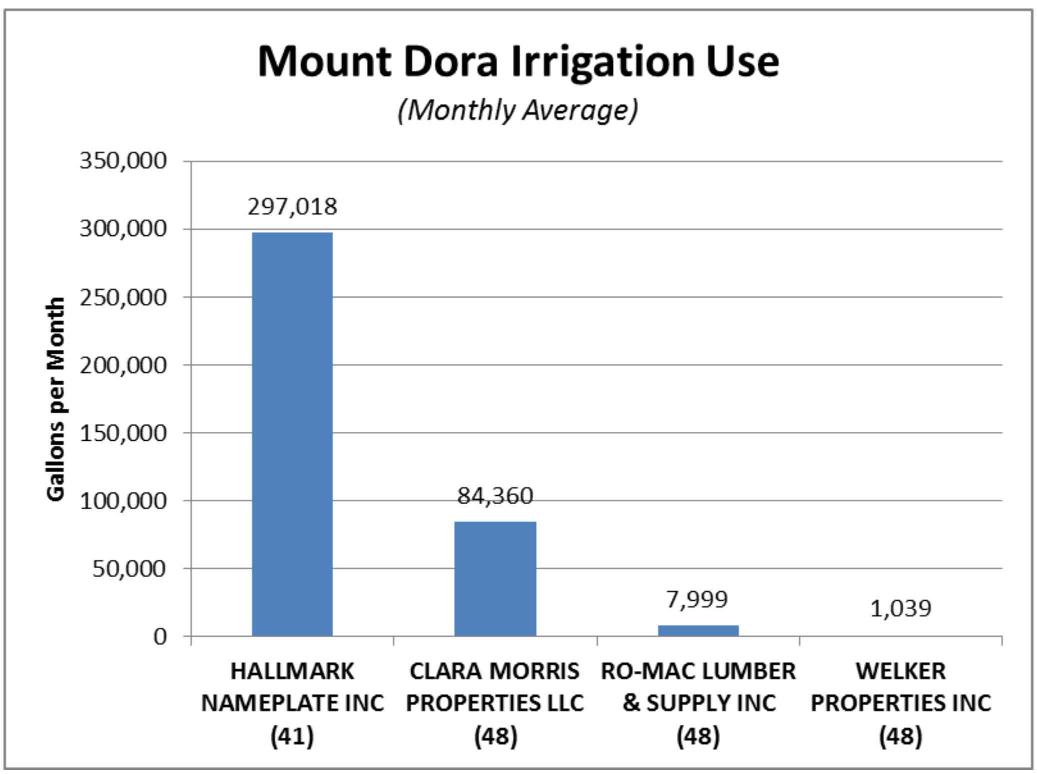


FIGURE 15: MOUNT DORA IRRIGATION USE

3.2: SELF-SUPPLIED WATER USE DATA

The District collects self-supplied data through its EN - 50 annual survey forms. The table below titled "St. Johns River Water Management District in Million Gallons per Day" is taken from the District's annual summary of self-supplied water users. It shows water use for 2009 and 2010.

Self-Supplied Water Use St. Johns River Water Management District in Million Gallons per Day (mgd)			
County	**2009 All Water (mgd)**	**2010 All Water (mgd)**	**2009-20010 Per Cent Change**
Alachua	0.280	0.420	50%
Baker	0.400	0.422	5%
Bradford	0.270	0.226	-16%
Brevard	4.960	5.996	21%
Clay	0.450	0.349	-22%
Duval	15.730	16.576	5%
Flagler	1.930	1.812	-6%
Indian River	0.000	0.000	0%
Lake	5.720	6.128	7%
Marion	5.800	6.553	13%
Nassau	32.990	32.747	-1%
Okeechobee	0.000	0.000	0%
Orange	2.130	1.387	-35%
Osceola	0.000	0.000	0%
Putnam	23.140	24.922	8%
St. Johns	0.570	1.036	82%
Seminole	0.130	0.000	100%
Volusia	1.000	1.542	54%
Total	**95.500**	**100.116**	**5%**

FIGURE 16: SELF-SUPPLIED WATER USE

The District data also shows that three uses, pulp and paper and mining dominate total use. In 2010, 97.3 MGD of the total of 100.1 MGD of use was fresh water and 2.8 MGD was saline water. The table titled "Summary of 2010 Self Supplied Fresh Water Use" summarizes self-supplied use for 2010.

Summary of 2010 Self-Supplied Fresh Water Use*	
DOR Category	**Million Gallons per Day (MGD)**
Pulp and Paper (DOR 42 - partial)	64.4
Mining (DOR 47)	7.3
Food Processing (DOR 44 - 46)	6.6
All Other DOR's *(commercial & industrial)*	19.3
Total	**97.3**
** DOR codes are were assigned to the EN - 50 information* *The data contains commercial and institutional use too.*	

FIGURE 17: SUMMARY OF 2010 SELF SUPPLIED FRESH WATER USE

For mining, the groundwater use was 6.2 MGD. Actual withdrawals of surface water were significantly higher, but the District assumes that 95 percent of that water is returned to the lake or reservoir that it was withdrawn from.

3.3: WASTEWATER PERMIT DATA

The Florida Department of Environmental Protection, through each District, permits wastewater discharges. The data is helpful in understanding the ultimate disposal of wastewater from mining and ready mix concrete facilities. Storm water runoff and water diverted and then returned to its point or origin were the predominant types of discharge permits for the mining and concrete ready mix facilities.

The other important observation was that most of these discharges were small. The chart titled “Concrete Batch Plant Waste Discharge Permit Volumes” shows the permits for concrete ready mix plants.

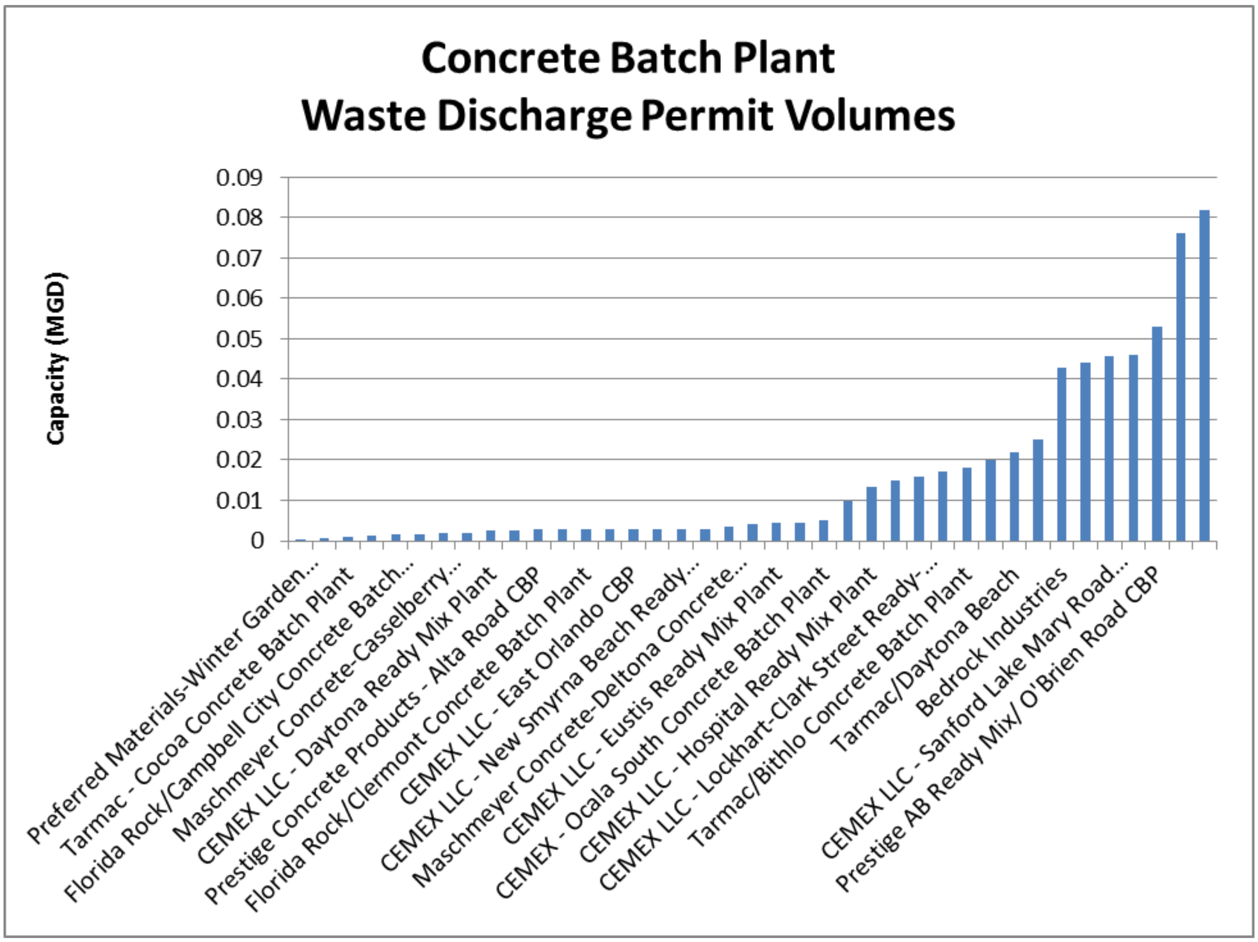


FIGURE 18: CONCRETE BATCH PLANT WASTE DISCHARGE PERMIT VOLUMES

As the graph shows, most permit capacity volumes were very small. The table titled “Summary of Facilities with Larger Capacity Wastewater Discharge Permits” summarizes the permits for some of the larger mining and manufacturing operations showing that most of the water is consumed rather than returned to the lake or reservoir that it was withdrawn from.

Summary of Facilities with Larger Capacity Wastewater Discharge Permits		
Name of Facility	**Nature of Business**	**CAPACITY (MGD)**
Florida Rock Ind - Lake Sand Plant	Sand Mine	2.7
Florida Rock Industries/Marion Mine	Sand Mine	2.7
DuPont Maxville Mine	Heavy Minerals Mining Facility	4.0
DuPont North Maxville Expansion	heavy mineral mining	5.0
Hurley Peat Mine	Peat mining	5.2
Florida Rock Ind - Astatula Mine	Mining Company	6.2
Tarmac - Center Sand Mine	Sand Mine	7.6
Iluka Resources	Primary Producers Of Mineral Sands	8.0
Edgar Minerals, Inc.	Operation Of Edgar Mine-Kaolin Bearing Sand	8.2
E R Jahna/Sr 474 Sand Mine	Sand Mining Using Electrical Hydraulic Dredge	11.5
CEMEX Construction Materials Florida-474 Sand Mine	Sand Mine	15.6
RockTenn - Seminole Mill Jax	Paper Mill - recycle old corrugated cardboard	20.0
Rayonier, Inc	Chemical Cellulose Pulp Mill (Sulfite Process)	26.3
RockTenn - Fernandina Beach Mill	Integrated Pulp And Paper Mill Produces Unbleached Kraft Linerboard	37.5
E I DuPont De Nemours - Highland Mine	Heavy Minerals Dredge Mining To Separate Ilmenite, Zircon, And Staurolite	40.0

FIGURE 19: SUMMARY OF FACILITIES WITH LARGER CAPACITY

4.0: INFORMATION ON WATER USE DATA

The District provided potable water use information from eleven utilities for the purpose of this report. The District also provided metered irrigation and reclaimed water use for Lake Mary, Sanford and Mount Dora. Self-supplied industrial water user was provided from the District's annual survey (Form EN - 50) for the years 2007 through 2010. Information on wastewater discharge permitting was obtained from the Florida Department of Environmental Protection and information on major industrial water users. In addition to the databases, information from company web sites, contacts with manufacturing trade organizations, the use of web based map and image systems (Google Earth and Google maps), and an extensive literature review were used as a basis for the analysis of the industries in the DOR sectors 41-48.

Analysis of the data showed that there were some idiosyncrasies and limitations. For example, many of the utility potable water data sets did not include the name or address of the water users. In a similar manner the addresses for the entities in the EN - 50 forms was not available, but a Google search was successful in identifying most of them used in the analysis.

Summary of Water Utility Data Limitations

Name of Utility	Heated Square Foot	Name	Address	Use units (gal - kgal)	Usefulness of Data
Atlantic Beach	x	x	x	gal	Yes
Lake Mary	x	x	x	gal	Yes
GRU	x	no	no	gal	Limited
Daytona Beach	x	x	x	gal	Yes
Indian River	x	no	x	kgal	partial
Leesburg	x	no	no	gal	Limited
Mt Dora	x	x	x	gal	Yes
Palm Bay	no	no	no	gal	Limited
Palm Coast	x	no	no	gal	Limited
Penny Farms	No DOR 41 - 48				Not Used
Sanford	X	no	X	gal	partial
St. James	X	no	no	gal	partial

FIGURE 20: SUMMARY OF WATER UTILITY DATA LIMITATIONS

Data problems: Many anomalies appeared in the potable water use data. Some data sets would report negative use for a month and in the case of Daytona Beach *South Daytona Storage and Offices located at 2090 S Nova Road accounted for 94 percent of all water use for DOR 48 in Daytona Beach.* Total water use for that one storage facility accounted for 137 million of the 156 million gallons of water use in Sector 48 in Daytona Beach. Therefore, the Daytona Storage water use was removed from the water use analysis.

Another factor that impacts the data analysis is the closing of businesses. This is especially true where that business represents the major use in that DOR category in a specific utility. For example, Advanced Lens Technologies, LLC had been the largest water user in DOR 41 in Atlantic Beach until the summer or 2010 when its use went to essentially zero.

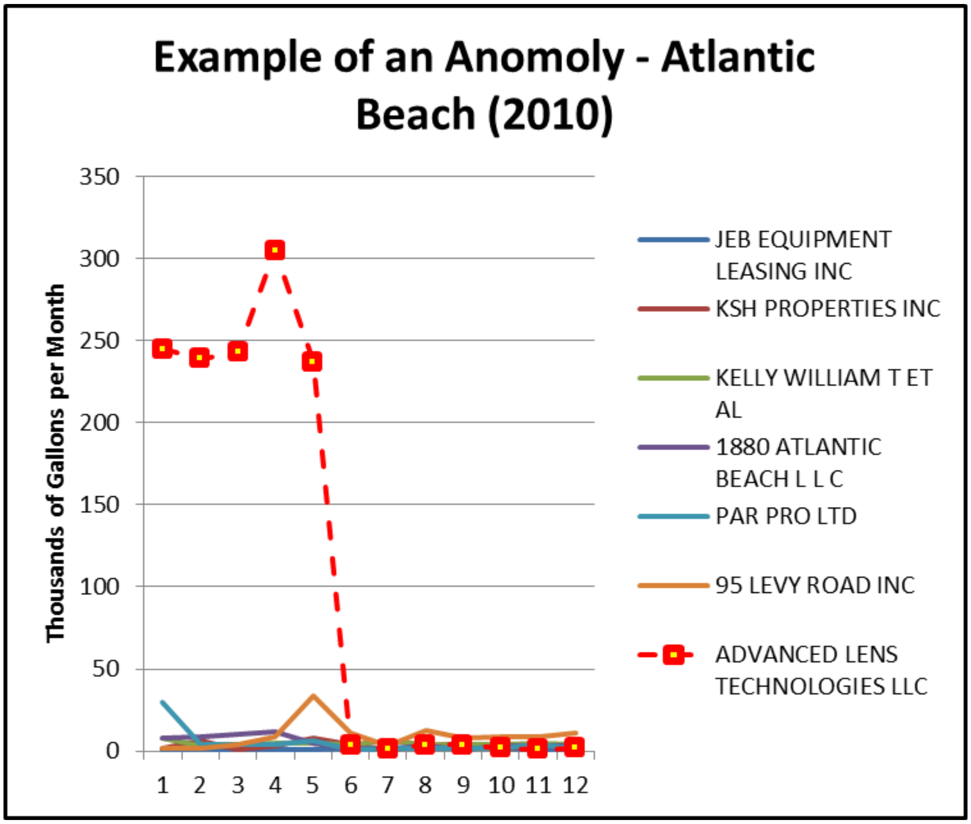


FIGURE 21: EXAMPLE OF AN ANOMOLY - ATLANTIC BEACH

In the case of the self-supplied water use data (EN-50), the district states that:

> "For this report, surface water use by mining operations in the commercial/industrial/institutional self-supply category represents 5% of surface water use, to account for the loss of water in mining products. The remaining surface water is assumed to be recirculated in the mining process and, therefore, is considered non-consumptive. Non-consumptive is defined by SJRWMD as any use of water that does not reduce the supply from which it is withdrawn or diverted."

As the analysis of water use will show, this assumption is well founded. Wastewater permit data was of limited value, but it did help confirm water use and was useful in analysis of concrete bath plants.

5.0 DOR 41 LIGHT INDUSTRIAL, SMALL EQUIPMENT MANUFACTURING, SMALL MACHINE SHOPS AND PRINTING PLANTS

DESCRIPTION OF THE INDUSTRY

The DOR sector 41 is a very diverse accumulation of light manufacturing, machine shops, craft shops and entities that make or craft a variety of items. Analysis of the data shows that this may be a "catch-all" category. Some of the entities were actually commercial in nature such as used auto sales.

ANALYSIS OF OVERALL WATER USE AND BENCHMARK PARAMETERS

The majority of water using entities in the DOR 41 sector use under 100,000 gallons of water a year. This is similar in volume to residential water use and most of this use is most likely associated with domestic (restroom) use and some washing of parts or irrigation. Figure Histogram of Annual Water Use by Individual Facilities for DOR 41 shows a histogram of water use.

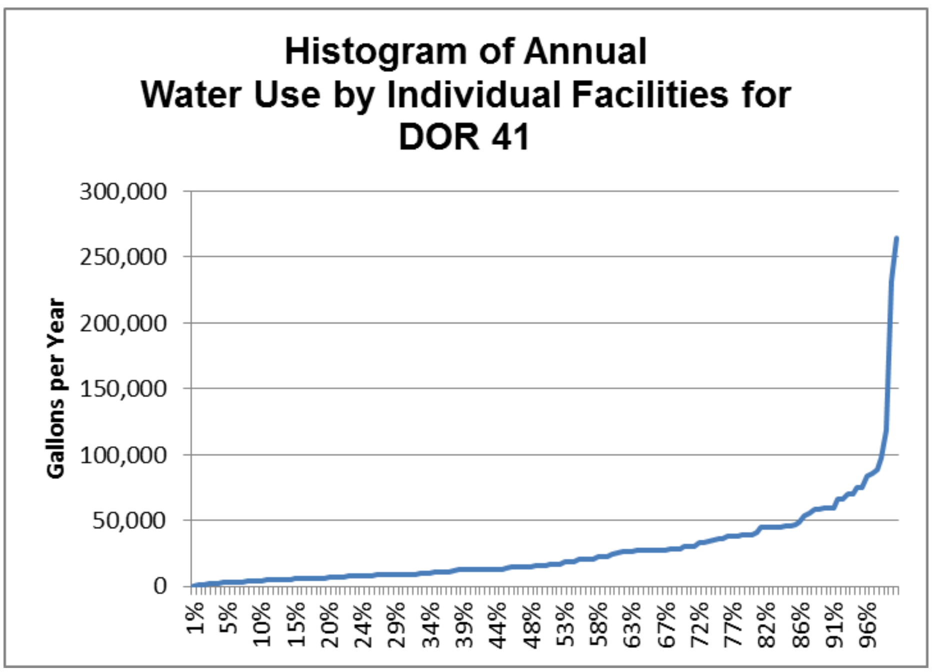


FIGURE 22: HISTOGRAM OF ANNUAL WATER USE DOR 41

The entities in the higher use category, over 250,000 gallons a year, the type of facilities tend to be higher technology entities such as

- ***FARO Technologies*** which designs, develops, and markets portable, computerized measurement devices like measuring arms, laser scanner, etc;

- **Advanced Lens Technologies** which develops software for mechanical processes; or

- **Stones of Italy** a producer of marble and granite counter tops and stone items.

An analysis of the amount of water used annually per square foot of "heated area" also shows a similar pattern as seen in figure Histogram of DOR 41 - Light Industrial.

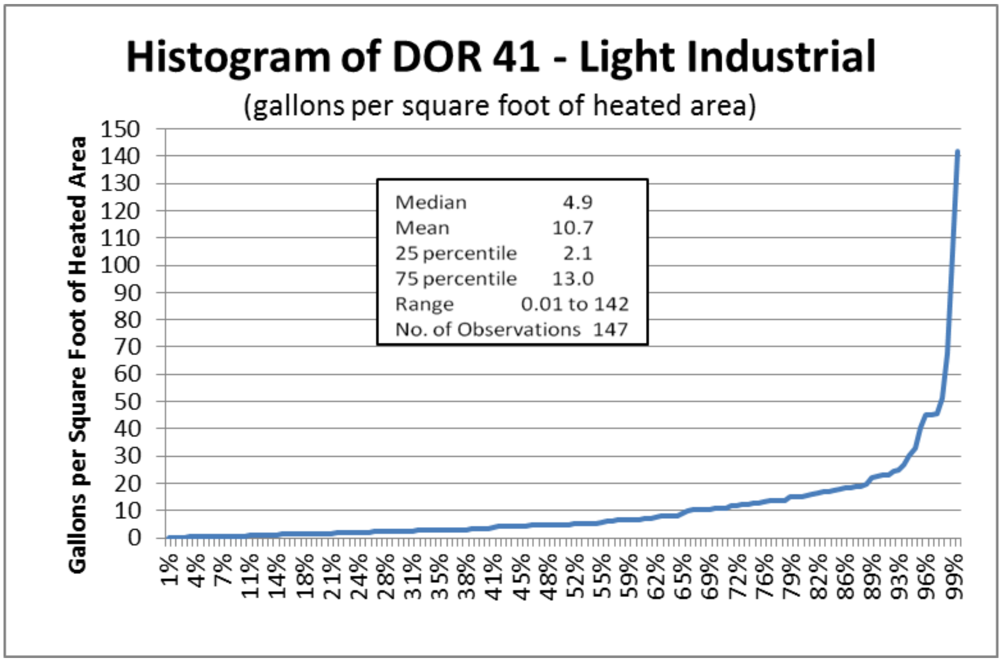


FIGURE 23: HISTOGRAM OF DOR 41 - LIGHT INDUSTRIAL

These are lower water intensity industries. For half of the entities, they use under five gallons per square foot. This lower water use intensity again indicates that the major uses are both small and more characteristic of domestic used by employees and customers as shown in Figure Annual Use vs. Heated Area for DOR 41 - Light Industrial.

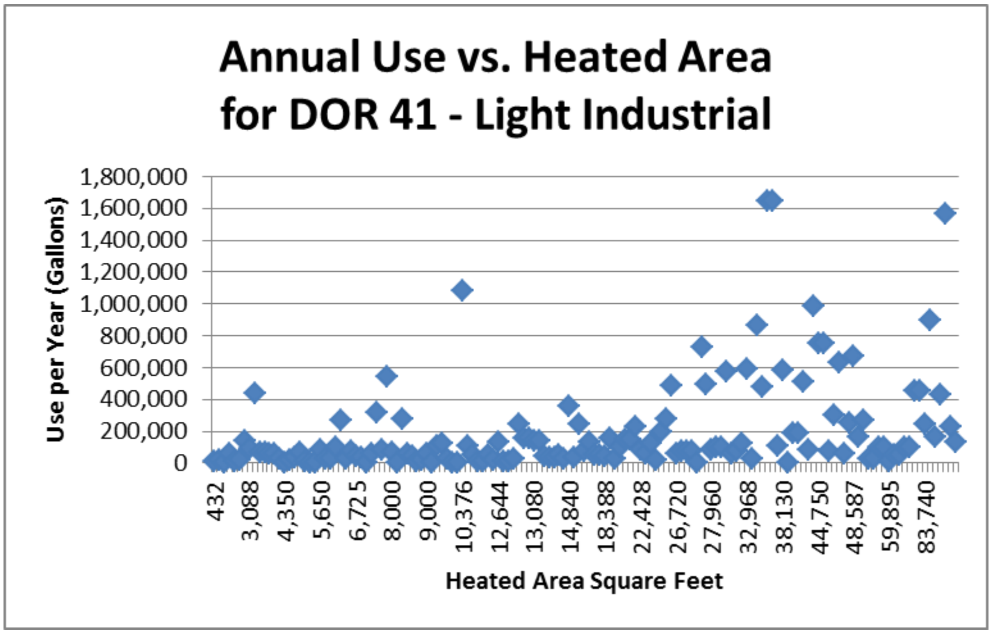


FIGURE 24: ANNUAL USE VS. HEATED AREA FOR DOR 41 – LIGHT INDUSTRIAL

Because of the diverse measure of the type of entities found in DOR sector 41, making a list of possible water uses is not possible for all entities. The following examples are divided into three categories:

1. Mainly domestic type use
2. Varied light manufacturing and varied activities
3. Stone cutting

By providing these examples taken directly from the data base, some of the flaws of the system are also shown. Office buildings, vehicle sales and similar activities are sometimes included. These would better be classified in their correct DOR class.

BEST MANAGEMENT PRACTICES

Since normal domestic use is a major component of use in this sector, the general *Water Conservation Best Management Practice Guide.*

One industry in this sector, stone cutting, is unique. Water uses in this industry include:

- gang saws,
- wet polishing and air/water polishing,
- water blasting, and
- water jet cutting.

Water is used to cool cutting tools, carry abrasive materials, and for water jet cutting.

The recovery of both water and abrasive materials from water jet cutting, the minimization of water use and recirculation of water for cooling cutting tools and the use of dry cutting and polishing technologies can all help reduce water use.

The lower water use intensity indicates that the major uses are both small and more characteristic of domestic used by employees and customers as shown in the Figure below. Further examination of the data showed that the first 55 percent of the data followed a very linear trend for gallons per square foot of heated area. This linear option can be used to determine outliers on the lower end of data.

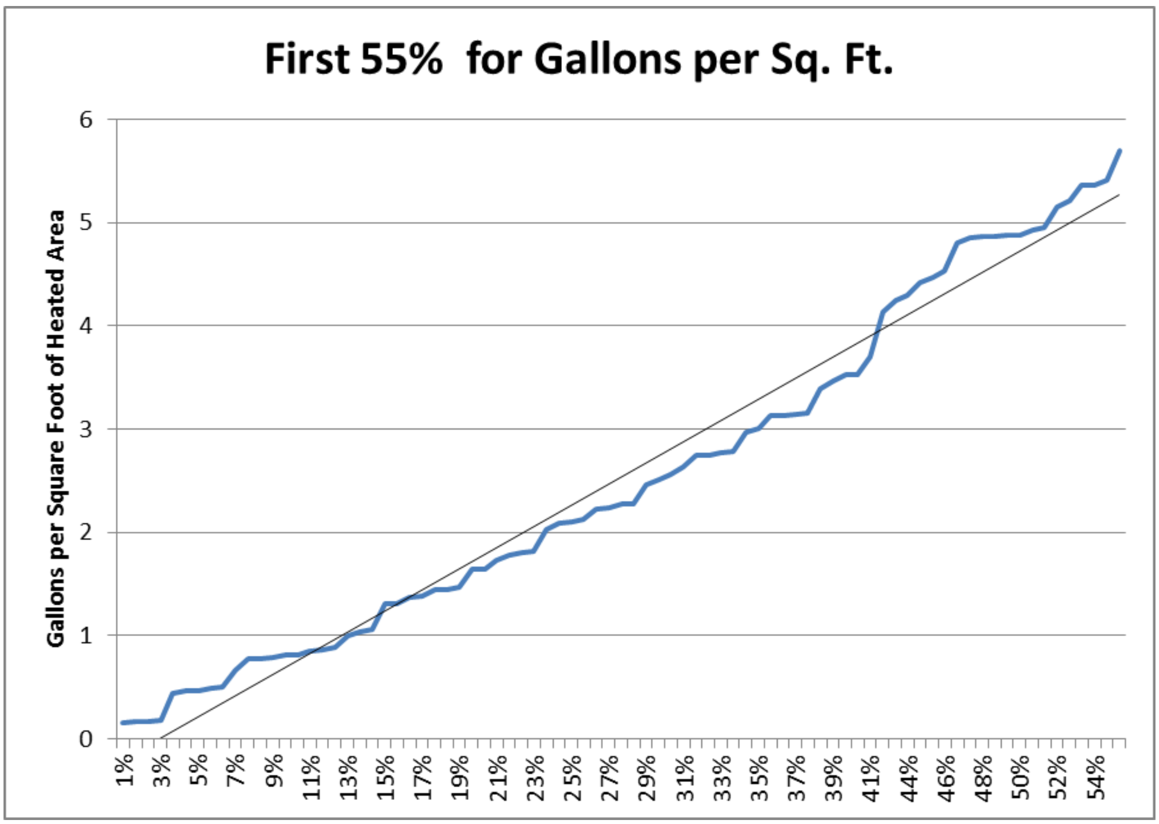


FIGURE 25: FIRST 55% FOR GALLONS PER SQ. FT.

5.1: DOR 42 LIGHT AND HEAVY INDUSTRIAL, SMALL AND HEAVY EQUIPMENT MANUFACTURING, SMALL AND LARGE MACHINE SHOPS, PRINTING PLANT, FOUNDRIES

DESCRIPTION OF INDUSTRIES

The DOR sector 42 contains the industrial water users of all types. Food processing and mining is covered elsewhere. The single largest industrial facility in this sector is the pulp and paper industry. Other examples range from gypsum wall board plants to arms manufacturing and several different types of metal finishers and formers.

ANALYSIS OF OVERALL WATER USE AND BENCHMARK PARAMETERS

The largest industry in this sector is the pulp and paper industry. Gypsum wall board production is another example of an industrial water using sector and is the second highest user in this category. Other examples vary considerably. From potable water use records, there are six utilities that report DOR 42 use

Utilities Reporting Potable Water Use in DOR 42		
Utility	**2008 Use (Million gal./yr)**	**2009 Use (Million gal./yr)**
Indian River	0.40	0.17
Sanford	0.26	0.18
Daytona Beach	3.93	0.97
Palm Coast	3.83	2.73
St. Johns River	3.56	3.42
Leesburg	6.60	5.23

FIGURE 26: UTILITIES REPORTING POTABLE WATER USE IN DOR 42

Of these six utilities only Indian River and Daytona Beach have enough information to be able to identify individual users. None of the pulp and paper or gypsum wall board plants were included in any of the potable water use records. Several smaller facilities involved metal treating and plating of some form. The examples section at the end of this section show examples of some of the identified potable water users in this category.

The pulp and paper mills and wall board plants were all self-supplied. The following is a detailed description of these facilities.

The Pulp and Paper Industry in the St. Johns River Water Management District

There are four operating pulp and paper mills in the St. Johns Water Management District. Two owned by Rock-Tenn Corporation (formerly Smurfit) are major recycled paper operations. The Rock-Tenn Jacksonville plant produces linerboard and corrugating medium. The Rayonier Fernandina Beach plant produces sulfite pulp cellulose for conversion to rayon fibers. The Georgia Pacific mill produces conventional pulp and paper from pulp wood for packaging and tissue products. The Georgia Pacific Hawthorn operation is now mostly closed. Both the Rayonier and Georgia Pacific mills use the Kraft pulping process.

Combined water use by all four facilities averages 65 to 66 million gallons a day. This makes this industrial sector one of the largest water using industrial sectors in the District. The Water Use Characteristics of Pulp and Paper Mills in the St. Johns Water Management District Area table summarizes water use, production capacity and gallons of water used per ton of capacity for each of the four mills.

Water Use Characteristics of Pulp and Paper Mills in the St. Johns Water Management District Area

Facility	Location	Tons per year (b)	2009 Average Daily Use MGD	2010 Average Daily Use MGD	2009 Water use per ton of Capacity Gal./Ton	2010 Water use per ton of Capacity Gal./Ton
Rayonier	Fernandina Beach	170,500[(a)]	14.3	14.5	30,613	31,041
Georgia Pacific	Palatka	527,000	20.7	23.7	14,337	16,415
Georgia Pacific	Hawthorn Operations	Not Available	0.14	0.12	N/A	N/A
Rock Tenn.	Jacksonville	520,000	7.7	9.04	5,405	6,345
Rock Tenn.	Fernandina Beach	930,000	23	18.1	9,027	7,104

(a) mill reports producing 155,000 metric tons
(b) Capacity is taken from company reports available on the internet.

FIGURE 27: WATER USE CHARACTERISTICS OF PULP AND PAPER MILLS

Source of Water for Paper Mills		
Facility	**% Aquifer**	**% Surface**
Smurfit - Fernandina Beach Mill	100%	0%
Smurfit-Stone Container - Jacksonville Mill	100%	0%
Rayonier Performance Fibers LLC	93%	7%
Georgia-Pacific Corp Hawthorne	100%	0%
Georgia Pacific Palatka Operations	8%	92%

FIGURE 28: SOURCE OF WATER FOR PAPER MILLS

Based on data from several sources, the 14,337 to 16,415 gallons of water used per ton of pulp for the Georgia Pacific Kraft mills and 5,405 gallons to 9,027 gallons per ton for the two Rock Tenn. recycle facilities are typical amounts of water for these types of operations.

The Georgia Pacific mill, the larger of the two Kraft mills, has significantly reduced water use over the last ten years according to a 2007 report by Mr. Mike McGee, retired Region IV U.S. Environmental Protection Administrator, "Georgia-Pacific's St. Johns River Enhancement Project." Total water use has been reduced 40 percent and groundwater use by 90 percent. The mill now recycles 96 percent of its water according to the report.

Rock Tenn., according to the 2012 Sustainability report, states that all of their mills are recycling water and looking for ways to reduce water. They have a corporate goal of a 12 percent reduction by 2020.

The American Forest and Paper Association's 2006 Annual Survey shows that paper mills have continued to reduce water use. The following table from that report shows typical water rates for various types of paper mills.

Effluent Flows at Pulp and Paper Mills

Mill	No. of Mills	Effluent Flow, gal/ton* (Range for Mills in mid-50 Percentile)	Average
Bleached Kraft	56	13,168 – 19,592	16,380
Deinking	8	11,962 – 15,103	13,533
Groundwood	10	5,551 – 8,603	7,077
Non-Integrated	17	3,475 – 20,184	11,830
Recycled Non-Deinking	51	586 – 1,367	977
Semi-Chemical	10	3,118 – 4,401	3,760
Unbleached Kraft	32	6,131 – 9,236	7,683

FIGURE 29: EFFLUENT FLOWS AT PULP AND PAPER MILLS

The following shows ranges for European pulp and paper mills.

European Pulp and Paper Mill Water Use
Gallons per Ton of Paper

Pulping Process	Range: Minimum	Range: Maximum
Sulfite	5,300	26,400
Kraft	10,600	26,400
Recovered Paper	1,300	5,300

Sources: European Commission. 2001. Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Pulp and Paper Industry. December 2001; and U.S. EPA Effluent Guidelines for the Pulp, Paper, and Paperboard Point Source Category, 40 CFR Part 430.

FIGURE 30: EUROPEAN PULP AND PAPER MILL WATER USE

As these tables show, all but the Rayonier mill fall within the water uses ranges presented in these two tables. However, since rayon is produced from the Rayonier mill, the mill must produce fibers of exceptional pure quality. These types of mills must use fresh water for extensive rinsing of the fibers before they are converted into rayon.

Pulp and paper mills use water for a variety of uses, but the main uses are:

- Debarking logs
- Cooking wood chips
- Washing chemicals from cooked chip pulp
- Bleaching pulp
- Washing bleached pulp
- Transfer of pulp to paper machines
- Seal water for vacuum pumps for pulp washing and paper making
- Cooling water
- Boiler water
- Domestic water use

- Dust control and plant wash-down

The following is a diagram of water use in a typical chemical pulp process.

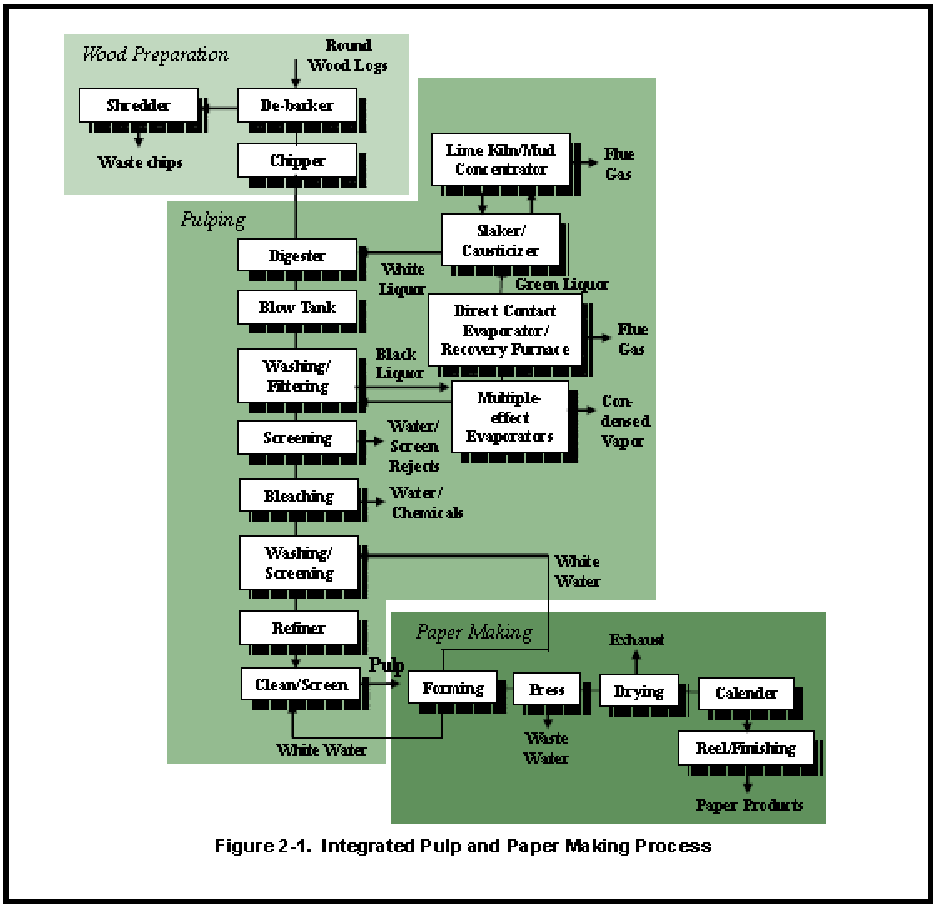


FIGURE 31: INTEGRATED PULP AND PAPER MAKING PROCESS

Source: U.S. Department of Energy, ENERGY AND ENVIRONMENTAL PROFILE OF THE U.S. PULP AND PAPER INDUSTRY, December 2005

Gypsum Board Manufacturing

Three gypsum board manufacturing facilities are located within the District. Although they are large facilities, their water use is relatively small. Based on the EN - 50 annual survey of self-supplied water, the three facilities used approximately 300,000 gallons of water a day combined. The La Farge North America, Inc. Drywall plant near Palatka is the largest of the three facilities. It has the capability of running 600 linear feet of gypsum wall board per minute according to the facility. Actual production figures for the facilities are not available. Information for benchmarking wallboard production water use is limited, but one Certain Teed Gypsum plant in Nevada reported using 0.2 gallons of water per square foot of wallboard. The Gypsum Board Manufacturing Facilities table below summarizes the self-reporting water use for the three plants in 2010.

Gypsum Board Manufacturing Facilities		
Plant	**County**	**MGD**
United States Gypsum Co	Duval	0.081
Lafarge Corporation - Gypsum Division	Putnam	0.218
CertainTeed Gypsum & Ceiling Manufacturing Inc.	Duval	0.001
Total (Millions of Gallons per Day - MGD)		**0.300**

FIGURE 32: GYPSUM BOARD MANUFACTURING FACILITIES

Drywall Production

Drywall is a construction material consisting of thin panels of gypsum board. The board is composed of a layer of gypsum rock sandwiched between two layers of special paper. The primary component of drywall is the mineral gypsum. Gypsum that has been crushed and heated to remove 75% of its water content is known as plaster of Paris. When water is added to this fine white powder, the resulting material is easily molded into any desired shape.

Making drywall includes the following steps:

- **Blending of additives** - Additives are added to the gypsum to change its properties and make it stronger. The gypsum, water and additives are blended.
- **Making the sandwich** - The gypsum slurry is poured onto a layer of paper that is unrolling onto a long board machine. Another layer of paper unrolls on top of the slurry. The sandwich then passes through a system of rollers that compact the gypsum core to the proper thickness.
- **Finishing the edges** - As the drywall continues along the conveyor belt, the edges are formed. Various shapes of edges are possible, depending on the final use of the panel. Options include the traditional square edge, a tongue and groove type, tapered and/or beveled edges, and even rounded edges. The face paper is wrapped snugly around each edge and sealed to the back paper. Panels are then cut to size.
- **The drying process** - The panels are transferred to a conveyor line that feeds them through a long, drying oven. Humidity and temperature are carefully controlled in the dryer. The finished product is then sent to the warehouse for shipment.

BEST MANAGEMENT PRACTICES

The manufacturing sector (DOR 42) contains a broad variety of industries. Best management practice guides for three specific industries are included in this section. These industries are:

1. Pulp and Paper
2. Gypsum Board
3. Metal Finishing

Water Use, by End Use, in the Paper and Pulp Industry

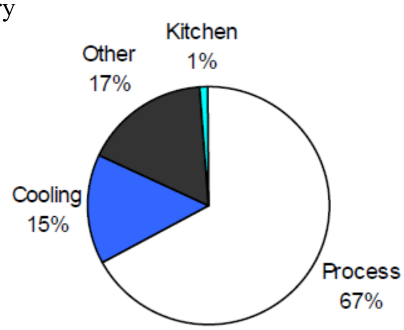
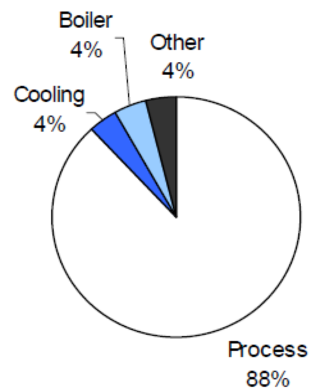


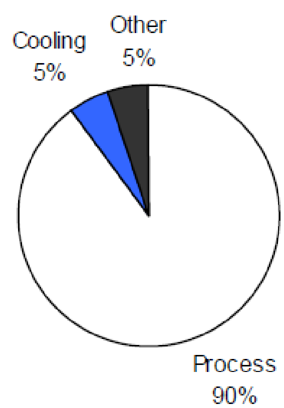
FIGURE 34: WATER USE, BY END USE, IN THE PAPER AND PULP INDUSTRY



Water Use, by End Use, in the Metals Industry

FIGURE 33: WATER USE, BY END USE, IN THE METALS INDUSTRY

In order to reduce water waste in industry, it is important to understand the many ways that water is used within facilities. Understanding water end uses is critical to identifying water savings opportunities. While end uses of water vary by industry and by facility, there are categories of water



Water Use, by End Use, in the Textile Industry

FIGURE 35: WATER USE, BY END USE, IN THE TEXTILE INDUSTRY

use that are present at most industrial facilities. Water use in most industries can be classified into the following broad end uses:

- Production processing, in-product use, Auxiliary processes (e.g., pollution control, labs, and cleaning)
- Cooling and heating (e.g., cooling towers and boilers)
- Indoor domestic use (e.g., restrooms, kitchens, and laundry)
- Landscape irrigation
- Metering and Submetering

These broad categories encompass many of the ways industrial facilities use water. Among U.S. industrial customers, cooling operations (including cooling towers and open cooling systems) comprise the single largest category of industrial water end use.

<u>Best Management Practices Unique to Pulp and Paper Production</u>

The reduction of water use in pulp and paper production is often the result of water recycling within the plant. There are limits to how much water can be recycled since each time it is used; it picks up salts and organic matter. Control of dissolved solids and bacterial growth are often limiting factors. The most common water reduction practices include:

- Reuse of vacuum seal water for use in the chemical pulping process,
- Use of continuous pulpers with advanced computer controls;
- Countercurrent washing of raw pulp (brown stock) and bleached stock on the washing drums;
- Use of water from the paper machine for washing bleach stock;
- Use of low volume showers to remove initial high salt content pulp;
- Use of mill wastewater in the debarking process;
- Recovery and reuse of cooling liquors;
- Use of condensate from multiple effect evaporators for chemical recovery;
- Reuse of “white water” from paper machines for many purposes in the pulping process.

In all of the above, recycled paper has the potential to reduce both water and energy use and conserve the use of trees. Mechanical pulp processes use less water but the paper produced is not a high strength paper. It has historically been used for new print. New combination processes such as terminal - chemical – mechanical processes hold promise of reducing water use.

<u>Best Management Practices for Wall board Manufacturing</u>

For wallboard production, the formulation of the slurry to minimize water use is essential. Air pollution control equipment such as bag filters help reduce water use. Dust control is another major concern at these facilities. Using dust control chemicals, paving all outdoor work areas and drives and capturing and using stormwater for dust control are all specific measures that wall board facilities can implement to reduce water use.

Best Management Practices for Metal Finishing Operations

Cleaning metal, metal plating and surface finishing, coating plastic parts with metal, and the processing of circuit and wire boards all use similar techniques to clean and plate surfaces. Metal finishing includes all industrial operations that change the properties of metals to improve:

- Corrosion resistance
- Wear resistance
- Electrical conductivity
- Electrical resistance
- Reflectivity and appearance (e.g., brightness or color)
- Torque tolerance
- Solder-ability
- Tarnish resistance
- Chemical resistance
- Ability to bond to rubber (e.g., vulcanizing)
- Hardness

In these operations, the parts to be processed are either drawn through the tanks, as is the case with roles of metal to be cleaned and painted, or they are suspended on racks or placed in plastic barrels that are dipped in the tanks. All processes begin with the preparation of the parts by cleaning followed by the process. Water uses include:

-Process water
-Chemical solutions makeup
-Air scrubbers
-Water treatment
-Parts and plant cleaning
-Cooling towers
-Boiler
-Domestic use
-Irrigation

Processes include but are not limited to:

-Metal cleaning for painting
-Wire and circuit board processing
-Anodizing
-Electrolytic plating
-Electro less plating
-Galvanizing

PRODUCTION PROCESSING AND IN-PRODUCT USE

DRAGOUT CONTROL FOR RINSING

Dragout control is a term for minimizing water that is carried from one tank to another. Carryover occurs when liquid adheres to some part while it is transferred. Use of spray nozzles can increase drain and rinsing action. Methods used to obtain dragout control include:

- Designing racks, barrels and processes, so that liquids captured in bends and curves of the pieces being processed are minimized, allowing time for parts to drain (dwell) over tank
- Withdraw parts from tanks slowly
- Using sprays, reactive rinsing, in place of dipping parts
- Using air knives, fogs, misting, centrifugation to remove solution
- Vibrating or "bumping" parts to knock off liquid
- Ensuring parts are pointed down so that they drain most effectively
- Using non-ionic wetting agents to remove surface tension in process baths
- Hanging parts above tanks to allow parts to drain
- Hang parts so the longest dimension is horizontal, tilt the lowest edge
- Installing drip guards between tanks
- Restore barrel holes
- Raise and lower in and out of tank rather than submerged agitation
- Using drain boards

http://www.epa.gov/region9/waste/p2/projects/metal-spray.pdf

CHEMICAL CONCENTRATION CONTROL

The use of conductivity meters, chemical analysis equipment, optical sensors and similar methods to control the timing of draining, rinse baths, or adding chemicals to ensure it is necessary.

-pH meter, conductivity probe, or pH cell can measure dissolved solids or hydrogen ions and signal a valve that controls flow

RAPID INVERSE DYEING

-First reactive dye is applied, then piece is washed in acidic disperse dye-bath
-Move from lighter shades to darker shades
-Operate machinery at lower liquor levels

MULTIPLE TANK AND COUNTERCURRENT RINSING

Countercurrent rinsing and the use of multiple tanks for rinsing allow parts to be placed in the most contaminated water first, proceeding with progressively cleaner water. With countercurrent flow, the water from the cleanest tank is used to replace the more contaminated water in the next tank. Reactive rinsing, where the rinse water from the final tank is used for the pickle-rinse tank, can also be used in some applications. Dual purpose rinsing is an option where the same rinse tanks or spray rinses can be used for multiple purposes when water quality is not critical.

- Counter current applies to de-size washers, scour washers, mercerizing washers, bleach washers, dye ranges, and print house soaper ranges
- Use automatic or restricted flow controls
- Spray rinsing shorts the during of water application
- Washing raw pulp (brown stock) and bleached stock on the washing drums

MECHANICAL MIXING, AGITATION AND AIR BLOWING

Agitation of plating liquids and rinsing solution maximizes contact of the liquid with the parts being processed, thus reducing time in each bath, extending the usefulness of plating liquids, allowing lower concentrations of the chemicals in a bath, and helping to improve uniformity of the product.

- Induce turbulence with rotating impellers, propellers, turbines, and paddles
- Pump air to create turbulence with bubbles
- Ultrasonic (65kHz) and megasonic (860 kHz) agitation for hard to reach surfaces

CLEANING METHOD SELECTION

Techniques for cleaning metals before painting have changed over the years. The classic zinc and iron phosphate cleaning processes require several rinses. New zirconium compounds and methods, such as the patented Piclex process, exemplify new strategies that eliminating one or more rinses.

- Vacuum extraction of residuals
- Use water-based adhesives for easier removal
- Water brooms shaped to equipment needs
- Remove all excess water before the next portion of wash water is added
- Mass transfer of species from rich stream to lean stream or mass separating agent (MSA)
- Graphical "water pinch", cascade analysis, and mathematical optimization by means modeling
- Maintain nozzle pressure and coverage
- Install self-strutting, trigger-controlled nozzles on hoses
- Use mechanical means such as brushes, scrappers, rubber wipes, or pucks

PRETREATMENT OF MAKEUP WATER

The treatment of the water used to make up the solutions in the tanks can be important measures to achieve the maximum use of chemicals. Many plants soften their water and most major platers use reverse osmosis (RO) to produce high quality water for their makeup to plating solutions. By using RO water, unwanted constituents that would concentrate with evaporation are no longer present.

EVAOPORATION CONTROL

Many processes are operated at elevated temperatures or they actually produce heat during the plating process. Foams or floating balls specially designed to retard evaporation can cut evaporative losses by as much as 50 percent.

AIR SCRUBBERS

Air pollution is a concern in many plating operations. Air scrubbers draw the contaminated air through a scrubbing system. The section on medical and laboratory facilities describes the scrubbing process in more detail. Installing recirculation systems with conductivity controllers, temperature probes, and fill and dump controls similar to conductivity blowdown controls on cooling towers helps reduce makeup water to the scrubbers. In plating operations, the reuse of spent rinse water and other sources of water is often an excellent alternate source of makeup water.

- Reuse process water, reverse osmosis concentrate, boiler blowdown, and cooling tower blowdown for scrubber make-up

WATER RECOVERY AND RECYCLE

Rinse water can often be used as makeup water to the process tank containing the chemicals being rinsed or some fabrication process. Isolating the cleanest wastewater recovers chemicals and reduces fresh water use. Some platers have used filtration and reverse osmosis to recover chemicals and produce a very clean stream of water for reuse. Zero liquid discharge (ZLD) is becoming a goal of many platers as levels of allowable chrome and other metals in effluent become more stringent. A desired treatment may remove cysts, bacteria, viruses, organics, metals, and inorganics.

-Evaporators and crystallizers or mechanical vapor compression can eliminate all liquids
-Flocculation, sedimentation, clarifier, and flotation
-Reuse bleach wash in caustic washer
-Reuse scouring water for desizing, floor and equipment washing
-Reuse mercerizing or bleach rinse water can be used for scouring
-Reuse final rinse water for dye-bath makeup
-Reuse paper machine water for washing bleach stock
-Reuse vacuum pump seal water for use in chemical pulping and painting process
-Reuse treated water for electric arc steel furnaces verses basic-oxygen blast furnace
-Treat seal water and recycle back to vacuum pumps

-Reuse mill wastewater in the debarking process
-Reuse condensate from multiple effect evaporators for chemical recovery
-Reuse "white water" from paper machines for many purposes in the pulping process
-Reuse calcium chloride solutions, filter backwash, for dust control
-Reuse rinse water for glass toughening furnace
-Reuse grinding fluids in glass grinding machines
-Use continuous pulpers with advance controls
-Remove all excess water before the next portion of wash water is added
-A series of small washes are easy to recover than a single large wash
-Reuse non-contact cooling water from separated contact-cooling water
-Filtration treatment by means of sand, charcoal, peat, textile
-Ion exchange treatment removes cations and/or anions (commonly used chromic acid baths)
-Microfiltration and reverse osmosis systems (non-chromic acid baths)
-Ceramic (MF/UF) and polymeric membranes (MF/UF/NF/RO)
-Forward osmosis by means of cellular acetate
-Electrochemical activation, electrochemical ozone, electro flotation module
-Electro dialysis (anion exchange membranes and cation exchange membranes), electrodialysis reversal
-Capacitive deionization, eletrodeionization, weak acid cation exchange
-Membrane distillation (polytetrafluorethylene (PTFE), polypropylene (PP), and polyvinylidenedifluoride (PVDF)
-Humidification and dehumidification
-Advanced oxidation process by means of ultraviolet disinfection and oxidation
-Hydrogen peroxide, sodium hydroxide, chlorine, ferric chloride, bromine
-Aerobic digestion with activated sludge or suspended growth
-Dispersed or fixed media, fixed-film, attached growth, trickling filter
-Membrane bioreactor for nitrification, submerged membrane bioreactor
-Subsurface wetland, mound, leach field

PLATING TANK COOLING

Input of electric energy into plating operations generates heat in the plating solutions. In the past, if the tank was air agitated or mixed, this heat was dissipated into the plating building. With the need to reduce air pollution and reduce evaporation, other cooling methods have been successfully employed. Recovery of this heat for use in other operation within the facility is the optimum method. This practice recovers waste energy, does not require cooling equipment, and does not consume water. Where cooling is needed, air cooling offers a real option where bath temperatures can operate at 140^{o}F or above. The use of a cooling tower or chilled water system represent other options, but they involve water and energy use. If cooling coils are used in the tank, some form of agitation will help ensure good heat exchange. Some platers circulate tank fluids through heat exchangers with pumps, thus providing for good heat transfer and helping to agitate the tank fluids.

RECTIFIER SELECTION AND COOLING

Rectifiers that convert alternating current (AC) to direct current (DC) for use in plating are found in all electroplating operations. Rectifiers may be either air cooled or water cooled. Air cooled rectifiers have to be placed where corrosive fumes from plating operations are not present, which usually means they are outside the plating line building. They also have to be sized so they do not overheat.

Many older facilities use once-through cooling to cool the rectifiers. The use of a cooling tower or chilled water loop will significantly reduce water use. The waste heat produced by the rectifiers should also be recovered where possible. In addition, many plating operations operate boilers, and the waste heat from rectifiers and tank cooling operations can be used to pre-heat boiler makeup water. Heating water for the reverse osmosis system also helps improve the productivity and efficiency of RO systems.

METERING, FLOW CONTROL, AND DATA ACQUISITION

Metering of makeup water to the RO system, tank filling, cooling towers, and other major water using areas will help manage the system and reduce costs. Seperating non-contact cooling water, contact cooling water, and stormwater from process water in combination with a computer control system can improve. Good metering will also alert managers to potential problems.

- Experiment to elinimize batch wash time without affecting quality
- Use automation shut-off valves set to time, level, temperature
- Use timers for uniform batch rinsing
- Use flow-reducing or pressure-reducing valves
- Use low volume showers to remove initial high salt content pulp
- Monitor recipes in batch process
- Measure water level when there is no tank extraction occcuring

5.3: DOR 43 LUMBER YARDS, SAW MILLS, AND PLANING MILLS

DESCRIPTION OF THE INDUSTRY

The DOR sector 43 is made up of lumber yards, saw mills, planing mills and related industries. From an analysis of the information available, most entities in this category in the District are commercial lumber yards. Truss manufacturing and other types of operations including a facility selling mulch and compost were identified.

ANALYSIS OF OVERALL WATER USE AND BENCHMARK PARAMETERS

There were actually few examples of this sector. Several of the lumber yards in the potable water use listed by the sample utilities are now closed. Interesting, even a mulch operation was listed under this category. The gallons per square foot of heated space followed patterns similar to many of the other sectors. There were 18 entities listed in the potable water data from the utilities. One entity did not report heated area, so the analysis is based on 17 entities. The median value for gallons per square foot was 3.85. Total use varied from 20,000 gallons a year to over four million gallons a year. Unfortunately, most of the entities in this category were in utilities (GRU, Leesburg, and St. Johns) that did not provide names of addresses. For the majority of the entities, data indicates that they are commercial lumber yards. A plot of the amount of water used per square foot of heated area vs. annual use also shows that only four entities actually have use outside of the pattern. This analysis should help identify DOR 43 operations that use above the normal either by volume of gallons used per square foot of heated space or selection of entities to examine for exceptional use.

BEST MANAGEMENT PRACTICES

In order to reduce water waste in industry, it is important to understand the many ways that water is used within facilities. Understanding water end uses is critical to identifying water savings opportunities. While end uses of water vary by industry and by facility, there are categories of water use that are present at most industrial facilities. Water use in most industries can be classified into the following broad end uses:

- Production processing, in-product use, Auxiliary processes (e.g., pollution control, labs, and cleaning)
- Cooling and heating (e.g., cooling towers and boilers)
- Indoor domestic use (e.g., restrooms, kitchens, and laundry)
- Landscape irrigation
- Metering and Submetering

These broad categories encompass many of the ways industrial facilities use water. Among U.S. industrial customers, cooling operations (including cooling towers and open cooling systems) comprise the single largest category of industrial water end use.

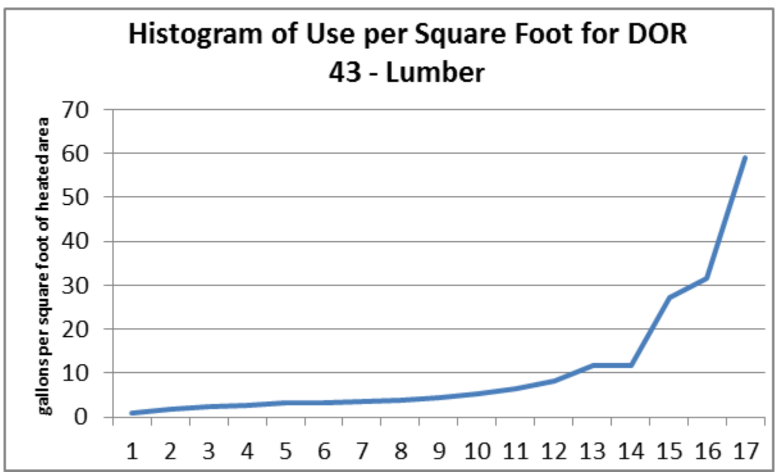


FIGURE 36: HISTOGRAM OF USE PER SQUARE FOOT FOR DOR 43 - LUMBER

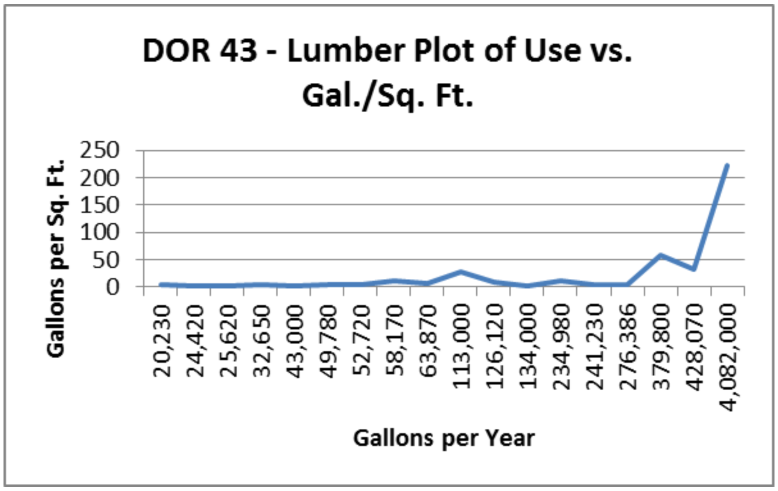


FIGURE 37: DOR 43 - LUMBER PLOT OF USE VS. GAL./SQ. FT.

PRODUCTION PROCESSING, IN-PRODUCT USE

MULTIPLE TANK AND COUNTERCURRENT RINSING

Countercurrent rinsing and the use of multiple tanks for rinsing allow parts to be placed in the most contaminated water first, proceeding with progressively cleaner water. With countercurrent flow, the water from the cleanest tank is used to replace the more contaminated water in the next tank. Reactive rinsing, where the rinse water from the final tank is used for the pickle-rinse tank, can also be used in some applications. Dual purpose rinsing is an option where the same rinse tanks or spray rinses can be used for multiple purposes when water quality is not critical.

- Counter current applies to de-size washers, scour washers, mercerizing washers, bleach washers, dye ranges, and print house soap ranges
- Use automatic or restricted flow controls
- Spray rinsing shorts the during of water application
- Washing raw pulp (brown stock) and bleached stock on the washing drums

CLEANING METHOD SELECTION

Techniques for cleaning metals before painting have changed over the years. The classic zinc and iron phosphate cleaning processes require several rinses. New zirconium compounds and methods, such as the patented Piclex process, exemplify new strategies that eliminate one or more rinses.

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- Graphical "water pinch", cascade analysis, and mathematical optimization by means modeling
- Maintain nozzle pressure and coverage

- Install self-shutting, trigger-controlled nozzles on hoses
- Use mechanical means such as brushes, scrapers, rubber wipes, or pucks

PRETREATMENT OF MAKEUP WATER

The treatment of the water used to make up the solutions in the tanks can be important measures to achieve the maximum use of chemicals. Many plants soften their water and most major platers use reverse osmosis (RO) to produce high quality water for their makeup to plating solutions. By using RO water, unwanted constituents that would concentrate with evaporation are no longer present.

WATER RECOVERY AND RECYCLE

Rinse water can often be used as makeup water to the process tank containing the chemicals being rinsed or some fabrication process. Isolating the cleanest wastewater recovers chemicals and reduces fresh water use. Some platers have used filtration and reverse osmosis to recover chemicals and produce a very clean stream of water for reuse. Zero liquid discharge (ZLD) is becoming a goal of many platers as levels of allowable chrome and other metals in effluent become more stringent. A desired treatment may remove cysts, bacteria, viruses, organics, metals, and inorganics.

-Evaporators and crystallizers or mechanical vapor compression can eliminate all liquids
-Flocculation, sedimentation, clarifier, and flotation
-Reuse desize effluent in reuse mix
-Reuse bleach wash in caustic washer
-Reuse scouring water for desizing, floor and equipment washing
-Reuse mercerizing or bleach rinse water can be used for scouring
-Reuse final rinse water for dye bath makeup
-Reuse paper machine water for washing bleach stock
-Reuse vacuum pump seal water for use in chemical pulping and painting process
-Reuse treated water for electric arc steel furnaces verses basic-oxygen blast furnace
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-Reuse calcium chloride solutions, filter backwash, for dust control
-Reuse rinse water for glass toughening furnace
-Reuse grinding fluids in glass grinding machines
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-Remove all excess water before the next portion of wash water is added
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-Reuse non-contact cooling water from separated contact-cooling water
-Filtration treatment by means of sand, charcoal, peat, textile
-Ion exchange treatment removes cations and/or anions (commonly used chromic acid baths)

-Microfiltration and reverse osmosis systems (non-chromic acid baths)
-Ceramic (MF/UF) and polymeric membranes (MF/UF/NF/RO)
-Forward osmosis by means of cellular acetate
-Electrochemical activation, electrochemical ozone, electroflotation module
-Electrodialysis (anion exchange membranes and cation exchange membranes), electrodialysis reversal
Capacitive deionization, electrodeionization, weak acid cation exchange
-Membrane distillation (polytetrafluorethylene (PTFE), polypropylene (PP), and polyvinylidenedifluoride (PVDF))
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-Aerobic digestion with activated sludge or suspended growth
-Dispersed or fixed media, fixed-film, attached growth, trickling filter
-Membrane bioreactor for nitrification, submerged membrane bioreactor
-Subsurface wetland, mound, leach field

5.4: DOR 44 – 46 FOOD AND BEVERAGE PROCESSING OF ALL TYPES

DESCRIPTION OF THE INDUSTRY

The food and beverage industry covers a multitude of entities. Most listed in the data sets provided by the district are associated with beer and other beverages or with fruit and vegetable processing. Meat processing and similar activities are also present. It includes the following:

- DOR 44 – Packing, Fruit and Vegetable and Meat Packing Plants
- DOR 45 - Canneries, Fruit and Vegetables, Bottlers and Brewers
- DOR 46 – Other Good Processing, Candy and Bakeries

The fruit packing and processing industry in Florida is a major component to the state's economy. Providing adequate, clean water supplies to this industry is vital to the economy.

ANALYSIS OF OVERALL WATER USE AND BENCHMARK PARAMETERS

Water use in this sector includes many different types of use. The table "Water Use in Food & Beverage Processing" summarizes where water is used in different food and beverage sectors.

Water Use in Food & Beverage Processing										
Water Using Processes	**Food Processing Industry**									
	Animal Processing	**Animal Food**	**Bakeries & Tortillas**	**Beverages**	**Dairy Products**	**Fruits & Vegetables**	**Grains & Oil Seeds**	***Miscellaneous**	**Seafood**	**Sugars & Confectionaries**
1. Domestic Uses	x	x	x	x	x	x	x	x	x	x
• Sanitation	x	x	x	x	x	x	x	x	x	x
• Irrigation	x	x	x	x	x	x	x	x	x	x
2. Thermodynamic Processes	x	x	x	x	x	x	x	x	x	x
• Cooling towers	x	x	x	x	x	x	x	x	x	x
• Boilers	x	x	x	x	x	x	x	x	x	x
• Refrigeration	x	x	x	x	x	x	x	x	x	x
• Cogeneration & thermal recovery	x	x	x	x	x	x	x	x	x	x
• Air Conditioning	x	x	x	x	x	x	x	x	x	x
• Humidification	x	x	x	x	x	x	x	x	x	x
3. Laboratory Operations	x	x	x	x	x	x	x	x	x	x
4. Water Treatment	x	x	x	x	x	x	x	x	x	x
5. Potential Water Reuse	x	x	x	x	x	x	x	x	x	x
6. Environmental Control	x	x	x	x	x	x	x	x	x	x

Water Using Processes	Food Processing Industry									
	Animal Processing	**Animal Food**	**Bakeries & Tortillas**	**Beverages**	**Dairy Products**	**Fruits & Vegetables**	**Grains & Oil Seeds**	***Miscellaneous**	**Seafood**	**Sugars & Confectionaries**
• Air Pollution	x	x	x	x	x	x	x	x	x	x
• Area Cleaning/Dust Cont.	x	x	x	x	x	x	x	x	x	x
• Wastewater Treatment/Reuse	x	x	x	x	x	x	x	x	x	x
7. Process Water Use	x	x	x	x	x	x	x	x	x	x
• Inclusion in product	x	x	x	x	x	x	x	x	x	x
• Fluming/transport	x	x				x		x	x	
• Product washing	x	x	x	x	x	x	x	x	x	x
• Cooking/Autoclaving	x	x	x	x	x	x	x	x	x	x
• Blanching/Pre-cook	x					x		x	x	
• Pealing & Prep.						x			x	
• Processing animal parts	x	x	x	x	x	x	x	x	x	
• Canning & bottling	x	x		x	x	x	x	x	x	
• Can/bottle cooling/warming	x	x		x	x	x	x	x	x	
• Conveyor lubrication	x	x	x	x	x	x	x	x	x	
• Pump seal water & other uses	x	x	x	x	x	x	x	x	x	x
8. Cleaning	x	x	x	x	x	x	x	x	x	x
• Clean in/out-or place systems	x	x	x	x	x	x	x	x	x	x
• Can/bottle/package cleaning	x	x	x	x	x	x	x	x	x	x
• Transport vehicle cleaning	x	x	x	x	x	x	x	x	x	x
• Crate & pallet washing	x	x	x	x	x	x	x	x	x	x
• Other cleaning	x	x	x	x	x	x	x	x	x	x
* Miscellaneous - Snacks, Seasonings, Coffee, Dressings, etc.										

FIGURE 38: WATER USE IN FOOD & BEVERAGE PROCESSING

The potable water data shows that six of the eleven utilities in the sample reported potable water use in these sectors. The table “Summary of Potable Water Use for the Food and Beverage Processing Sectors” summarizes the cities and their use. As the table shows, fruit packing was the largest water use area in this sector. Because of the seasonality of fruit packing, monthly use was very uneven for OR 44 as shown in Figure “Potable Water Use.” The other sectors were more consistent.

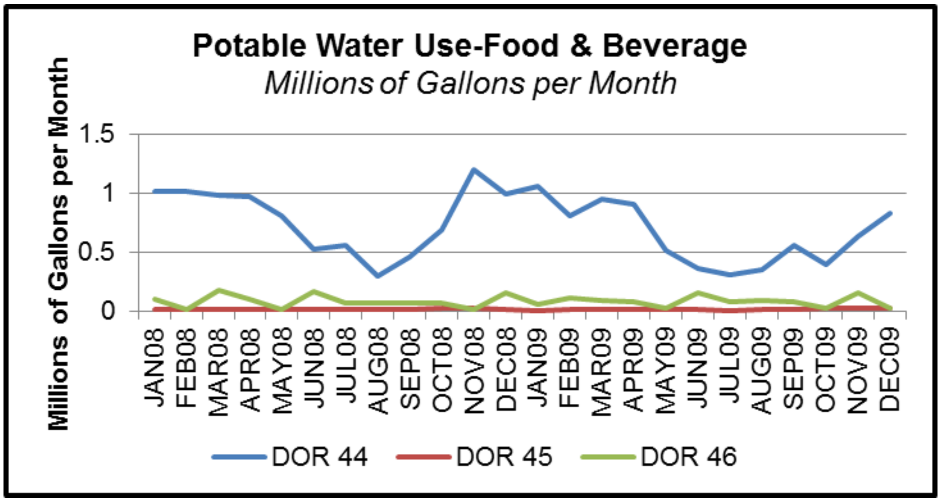


FIGURE 39: POTABLE WATER USE-FOOD & BEVERAGE

Summary of Potable Water Use for the Food and Beverage Processing Sectors *(Millions of Gallons per Year)*				
Utility	**DOR Code**			
	44	**45**	**46**	**Total**
Daytona Beach	x	x	0.73	**0.73**
GRU	x	x	0.01	**0.01**
Indian River	4.70	x	x	**4.70**
Leesburg	3.89	0.04	0.30	**4.23**
Sanford	x	x	0.63	**0.63**
St. Johns County	0.00	0.17	0.00	**0.17**
Total	**8.59**	**0.21**	**1.67**	**10.47**

FIGURE 39: SUMMARY OF POTABLE WATER USE – FOOD & BEVERAGE PROCESSING

Unfortunately, most food and beverage producers do not release production information. Analysis of the gallons used per square foot of heated area varied widely, but as with other sectors, a few were very high while over 75 percent were under 20 gallons per square foot of heated area and half were under 4.0 gallons per square foot of heated area. All three food and beverage sectors showed similar patterns. Because of the huge variability in the types of processes and products involved, it is felt that this type of analysis is of very limited use.

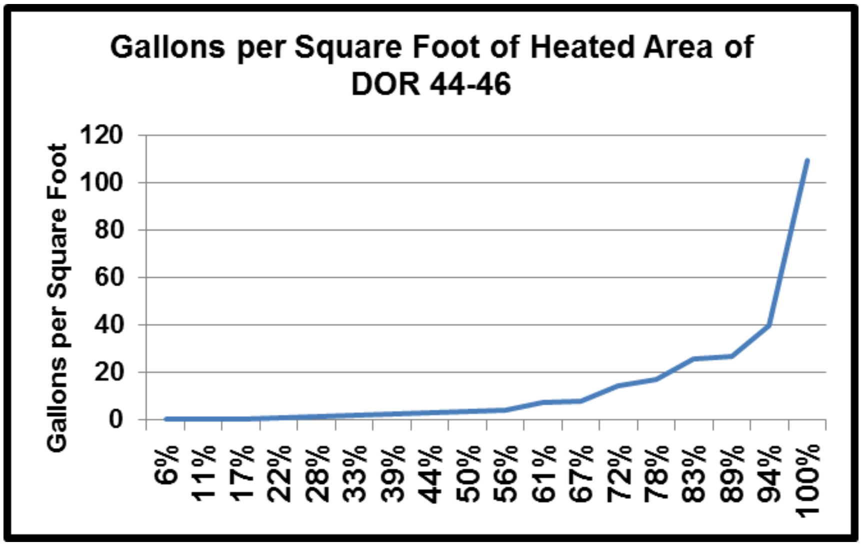


FIGURE 40: GALLONS PER SQUARE FOOT OF HEATED AREA OF DOR 44-46

Self-supplied water users in the DOR 44 - 46 categories show different patterns. Monthly use is relatively flat and DOR 45 contains the largest users. Groundwater accounts for almost all use.

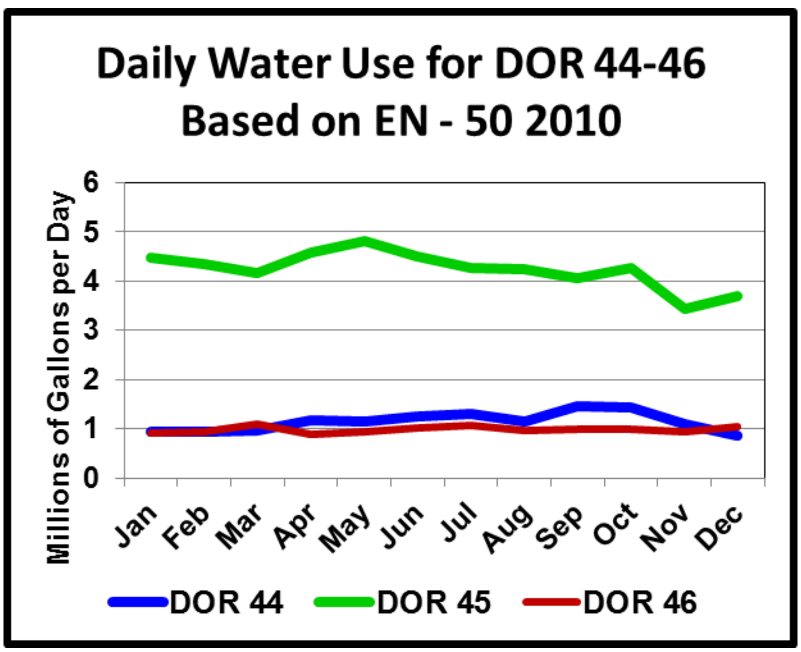


FIGURE 41: DAILY WATER USE FOR DOR 44-46

Water use by entity in the 2010 EN - 50 self-reporting data is summarized in the table "Self-Supplied Water Use Reported."

Self-Supplied Water Use Reported in EN -50 2010 Report for DOR 44-46*				
Company	**DOR Code**	**Notes**	**Water source**	**Annual Average MGD**
IMG Citrus	44	Fruit packing	Groundwater	0.002
Greene River Packing	44	Fruit and Produce Packers	Groundwater	0.008
Golden Flake Plant	44	chips (potato, etc.)	Groundwater	0.057
Citrus World	44	Orange juice	Groundwater	0.146
Ocala Manufacturing	44	Citrus Fruit Products	Groundwater	0.256
Silver Springs Citrus	44	Citrus Fruit Products	Groundwater	0.675
Total of DOR 44				1.144
Leesburg Plant	45	Fruit juice food products	Groundwater	0.005
CCNA Apopka	45	Beverage	Groundwater	0.055
Louis Dreyfus Citrus	45	Frozen Juice	Groundwater	0.088
Bacardi Bottling Corporation	45	Rum	Groundwater	0.095
Cutrale Citrus Juices USA, Inc.	45	Fruit juice food products	Groundwater	0.716
ANHEUSER-BUSCH, INC	45	Beer	Groundwater	3.264
		Total of DOR 45		4.223
Frito Lay	46	Food	Groundwater	0.001
Maxwell House Coffee Company	46	Coffee	Groundwater	0.067
IFF Chemical Holdings	46	Flavors and fragrances	Groundwater	0.914
Total of DOR 46				0.982
Total of all Sectors DOR 44-46				***6.349***
** Entities showing no water use in 2010 are not included.*				

FIGURE 42: SELF-SUPPLIED WATER USE REPORTED IN EN -50 2010 REPORT FOR DOR 44-46

BEST MANAGEMENT PRACTICES

Food and beverage processing (Department of Revenue Codes 44-46) is one of the largest industrial sectors in Florida. How water is used also varies by the food product being processed.

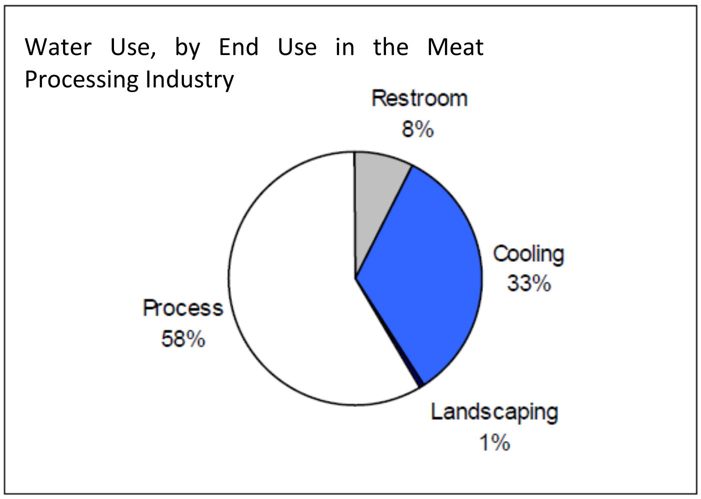


FIGURE 44: WATER USE, BY END USE IN THE MEAT PROCESSING INDUSTRY

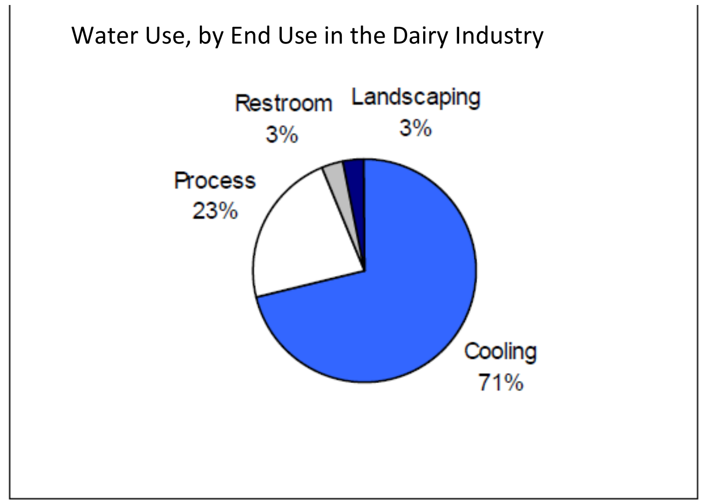


FIGURE 44: WATER USE, BY END USE IN THE DAIRY INDUSTRY

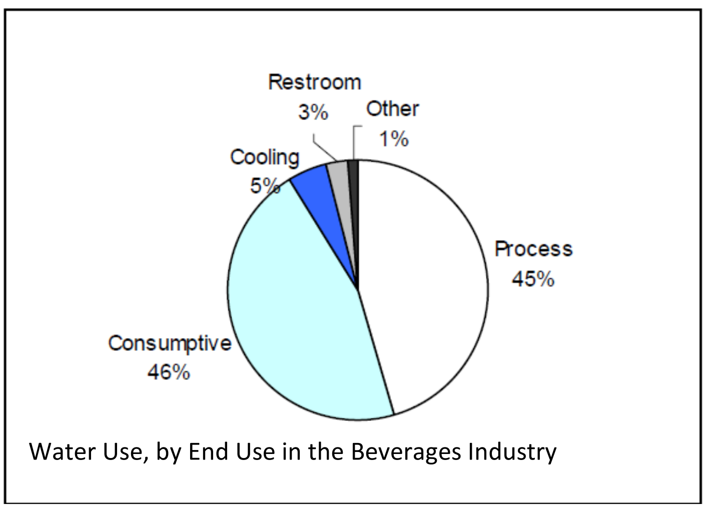


FIGURE 43: WATER USE, BY END USE IN THE BEVERAGES INDUSTRY

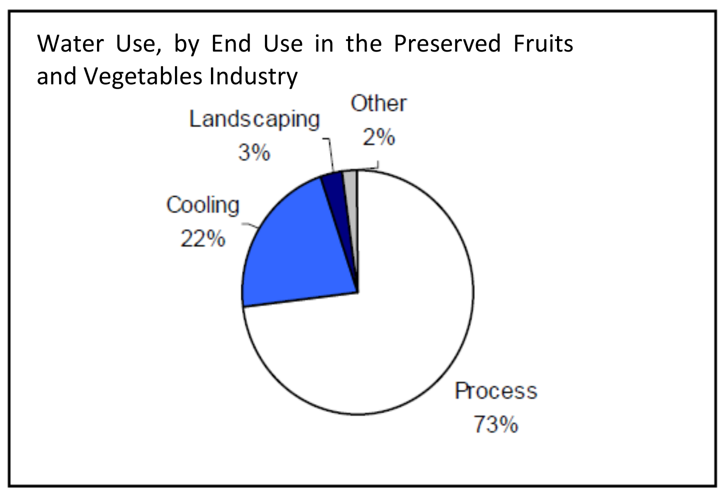


FIGURE 45: WATER USE, BY END USE IN THE PRESERVED FRUITS AND VEGETABLES INDUSTRY

In order to reduce water waste in industry, it is important to understand the many ways that water is used within facilities. Understanding water end uses is critical to identifying water savings opportunities. While end uses of water vary by industry and by facility, there are categories of water use that are present at most industrial facilities. Water use in most industries can be classified into the following broad end uses:

- Production processing and in-product use
- Auxiliary processes (e.g., pollution control, labs, and cleaning)
- Cooling and heating (e.g., cooling towers and boilers)
- Indoor domestic use (e.g., restrooms, kitchens, and laundry)
- Landscape irrigation
- Metering and Submetering

These broad categories encompass many of the ways industrial facilities use water. Among U.S. industrial customers, cooling operations (including cooling towers and open cooling systems) comprise the single largest category of industrial water end use.

PRODUCTION PROCESSING AND IN-PRODUCT USE

ALTERNATE SOURCES OF WATER FOR THE FOOD PROCESSING INDUSTRIES

This BMP is intended for industrial water users that have the opportunity to reuse process water or other sources of nonpotable water such as treated effluent, rainwater collected on site, condensate, graywater, storm water, sump pump discharge or saline sources as a substitute for potable or raw water. Once an industrial water user decides to adopt this BMP, the water user should follow the BMP process closely in order to achieve the maximum water efficiency benefit from this BMP. Several options for reuse include:

- Recycle within plant
- Use of alternate sources for non-food processing areas
- Reuse of plant effluent for irrigation

One of the most important considerations is that most food processing wastewaters can be used for irrigation. Nutrients in the wastewater can help fertilize the crops, and this irrigation also removes pollution from receiving streams or wastewater treatment plants. In examining food processing water use, this reuse is often left out of the analysis.

Where water is to be used for crop irrigation, water quality is a major concern. Organic loading, irrigation rates, nutrient levels and other factors are important to consider. Many companies are using potassium salts for recharging softeners and pH adjustment, isolating waste streams with very high concentration of salts, and providing "end-of-the-pipe" treatment technologies to make their effluent usable for irrigation.

PRODUCT WASHING AND SORTING

Product washing and sorting including the transport of the raw product offers several opportunities. The first is the reuse of water to transport the fruits or vegetables into the facility. Fluming as it is called has been a staple of the transport process. It is often the first washing process also. Health and safety regulations will determine the degree to which this water can be treated and reused. Many have reported success, but these are "designed" systems that meet all regulatory requirements. Washing of fruits and vegetables must follow similar regulations. These waters can be treated to remove solids, color, biochemical oxygen demand (BOD) and other wastes.

Ways to reduce water use in the washing operations include:

- Using vibration and air to help clear fruit and vegetables of debris and dirt before fluming or washing.
- Using brushes to clean produce
- Spray washing instead of submerging fruits and vegetables to wash them
- Countercurrent washing
- Reduce overflow
- Use of can cooling water for first flush water
- If the produce is to be sold in a raw state, it is bagged and sent for shipment at this point.

Ways to reduce water for fluming for transport of raw, pealed, or blanched products include:

- Where the fruit or vegetable will not be damaged by mechanical handling , use of conveyor belts, pneumatic systems and totes to move product
- Use of flumes with a minimum cross section to reduce water volume
- Recirculation of flume water where allowed by code
- Use flumes with parabolic cross-sections rather than flat- bottom troughs.

Elimination of fluming water and dry removal of dirt also reduce wastewater loading, conserve energy and reduce chemical use.

PREPARATION FOR PROCESSING

Preparation for processing is the next step in vegetable or fruit processing and involve blanching, pealing, coring and pitting, and washing of prepared items for processing and preservation. The process varies depending on the item being processed. Ways to reduce water use and wastewater loading in these stages include:

- Dry pealing and blanching
- Mechanical pealing
- Chemical pealing
- Steam blanching

In coring and pitting and dicing operations, juices and waste are produced that are typically removed with water. These products can have value as animal feed or for other uses. By not using water to transport peals, cores, pits, etc. water can be reduced. Since pealing, blanching and dicing and cutting release juices and sugars, the water used to wash produce after this operation will contain high BOD loads. Use conveyor belts and other dry transport where possible.

FOOD PROCESSING AND COOKING

Food processing and cooking prepares the food so that its shelf life is extended and desirable food products produced. Produce can be preserved for market in a number of ways including:

1. Refrigeration and freezing
2. Canning
3. Irradiation
4. Dehydration
5. Freeze-drying
6. Salting
7. Pickling
8. Pasteurizing
9. Fermentation
10. Chemical preservation

With the exception of irradiation, salting and chemical preservation, thermal energy either heat or cold is used. Even with salting, dehydration of the salted product is common. All of these involve thermodynamic processes. One of the most heat intensive of these is the retort or autoclave to heat and sterilize food products. Similar processes are used to sterilize pharmaceuticals and cosmetics. In the case of some foods like tomato paste and sauces as well as dehydrated foods, energy is used to remove water. Heat, vacuum systems, and freeze drying are all examples of this. The reader is referred to the section on thermodynamic processes for cooling towers, boilers and similar equipment.

Many of the cooking, autoclaving, drying and similar operations are done with steam. Capture and return of steam condensate is both an energy and water saving measure. Capture and reuse of heat or cold are also major ways to reduce energy use.

In cases where food or juices are concentrated, a number of newer food processing technologies are now available to separate solids from liquids. Thermal methods have dominated the industry. They consume large amounts of energy and thus water since steam is the primary heat source. In recent years, filtration and membrane processes have started to make inroads in these areas. They use less energy, do not cause thermal degradation of the food and recover both a useful liquid and concentrate. The following summarizes some of these membrane applications.

1. Typical food industrial applications of micro-filtration are:
    - cold sterilization of beverages
    - clarification of fruit juices, beers and wines
    - continuous fermentation
    - separation of oil-water emulsions
    - wastewater treatment

2. Applications of ultra-filtration are:
    - concentration of milk
    - recovery of whey proteins
    - recovery of potato starch and proteins
    - concentration of egg
    - clarification of fruit juices and alcoholic beverages.
3. Main application of nano-filtration:
    - removal of micro-pollutants
    - water softening
    - wastewater treatment

- Typically reverse osmosis is used in:
    - desalination
    - concentration of food juice and sugars
    - concentration of milk.

Pump seals in food processing offer some opportunities. In all pipe systems, pumps are needed to move the product to its destination. Food service pumps must be made of food grade materials do not have lubricants or materials that could contaminate the food being processed. The seals on the pump must also keep out unwanted materials. Because of this, water seals are commonly used. Since the water is under pressure, if the seal leaks, clean potable water is the only thing that will enter the food. However, water seals on pumps continuously discharge water. With multiple pumps in a typical food processing plants, pump seal water can add up. This water is generally clean and very usable for crate and pallet washing, can cooling and similar non-food contact uses.

CANNING AND PACKING

Canning and packing offers several opportunities for water conservation. First, cans must be cooled once they exit the retort or autoclave. Conversely, cold products such as bottled fruit juices, beer, and sodas must be warmed so that the can or bottle does not collect condensation ("sweat"). This water used in these processes should be recycled within the process where ever possible. Many have recirculating filtration and disinfection systems the recirculate the water. When this water is discharged, it should be re-used for crate and pallet washing and other areas where it does not directly contact food. The North Carolina Department of Environment and Natural Resources guide, Water Efficiency Manual for Commercial, Institutional, and Industrial Facilities lists several possible areas of reuse including, conveyor belt lubrication, plant cleaning, raw product fluming, and first wash of incoming produce.

WASHING OF BOTTLES, JUGS AND CONTAINERS

Washing of bottles, jugs and containers after filling historically was done by immersion of large volume sprays that were kept on as long as the process line operated. Electronic sensors on the line after filling can be used to actuate a spray system that only washes cans and bottles when they are passing by.

DRY LUBRICATION OF CONVEYOR BELTS

Dry lubrication of conveyor belts offers another opportunity. Historically, one of the most common uses of water in the food and beverage industry is as a lubricant for conveyor belts that move cans and bottles, so they can "slip" easily on the high-speed conveyor belts and not tip over. This water is softened and mixed with biocides and soaps before it is sprayed onto the conveyors. Early attempts at dry lubrication systems were not always successful, but dry lubrication is now becoming commonplace. In Australia, eight Cadbury Schweppes plants are testing dry lubricant conveyor systems (Smart Water Fund of Australia). For now, ensuring that the spray nozzles are properly sized, well aligned, and equipped with automatic shutoffs is the best that can be done.

General considerations for good water efficiency in the fruit and vegetable processing areas always include good employee education and motivation. They are the eyes and ears that can alert a facility manager to water waste and possible solutions.

REFRIGERATION

This BMP is intended for any water user which utilizes water as a primary refrigerant fluid to remove heat. Water conservation practices for cooling towers that use evaporation of water to remove the heat at the "condenser" where the refrigerant is changed from high temperature to a lower temperature are described in the Cooling Towers BMP.

Examples of refrigeration processes that this BMP is intended for are primarily chilled water facilities. These facilities circulate refrigerated water for use in precision cooling of process units or large scale air conditioning systems of buildings or campuses.

Using the latent heat properties of the refrigerant, mechanical refrigeration removes heat from a colder medium and rejects it to a warmer medium. A chilled water system is for all intents a refrigeration system that cools water. Most chillers are used as closed loop systems with the heat removed by air-cooling or through a cooling tower, and water consumption can be reduced. All chilled water systems require a reservoir for the returned fluid to act as a heat sink, but very little water is lost due to evaporation.

The major water use in these systems, other than at the cooling towers, occurs when water is replaced due to leaks or equipment problems. The primary maintenance recommendations for the closed chilled water loop include treatment of the water periodically with rust inhibitor and biocides, use of strainer screens and filters, and regular inspection and maintenance of pipes, valves, and pumps. For larger systems condensate water from the condenser coils can potentially be collected as an alternative to potable water for cooling tower make up or for some other use.

Water is not the only fluid that can be used as a liquid refrigerant. For example, direct cooling of deionized water, hydraulic oil, glycol solutions, and water soluble oils is possible in refrigerated systems.

Refer to the sources below for additional information and specifics recommendations for your systems:

- Process Cooling & Equipment, magazine published by BNP Media.
  http//www.process-cooling.com
- American Society of Heating, Refrigerating and Air-Conditioning Engineers
  (ASHRAE) is an international membership organization founded to advance the arts and sciences of heating, ventilation, air conditioning, refrigeration and related human factors. www.ashrae.org

CIP SYSTEM OPTIMIZATION

Clean-in-Place (CIP) systems operate with five steps from pre-rinse to sanitizer. Considerable advances have been made recently in CIP-related technology, which can provide the potential for significant reductions in water, energy, cleaning chemicals, and also wastewater load as a result of implementing one or more of the following strategies.

- Minimize water lost under current conditions
  - To minimize loss of water through the open hatches of tanks and silos during cleaning operations, purchase boots (a venting door device) specifically designed for each and educate operators to use them
  - Adjust plumbing as needed to enable leak-free connections for return lines from tanks and silos
- Change plumbing to enable, where appropriate, circulating sanitizer sent directly through pipework to the drain
- Add real-time sensing for circuits where none is currently employed to curtail rinses to avoid excess use of fresh water. Optical sensors are commonly used for this purpose.
- If sufficient space is available, install an additional tank for CIP systems to provide additional flexibility for caustic and water recovery
- Recover and clean hot wash water for reuse as wash water
  - Via advanced oxidation system (UV light and air) proven in US dairy plants, that cleans water on site while avoiding the complications of membrane technology, and also avoiding BOD and TSS charges from wastewater authority by converting product in wash water to CO_2 gas that may be vented

    - Via membrane system, if space is available, to remove both suspended and dissolved solids
- Evaluate more resource-efficient cleaning chemistry
    - EcoLab caustic cleaner designed to be effective at lower temperature (reduces boiler energy)
    - Diversey product (part of their "Rapid CIP" platform) said to be available soon can possibly reduce the CIP process from five to three steps and reduce energy by providing cleaning and sanitizing in a single step at ambient temperature.

CIP wash water typically has the highest embedded cost of all types of water use by the dairy industry given its combined costs of water, wastewater, heat, and chemicals. This makes it an attractive candidate for reuse. While membrane systems have been employed to clean and reuse this water, the most elegant means available was first (and continues to be) used in a dairy plant in Tyler, TX. Using only ultraviolet light as its active ingredient, caustic wash water can be processed within the CIP circuit to allow its water, heat, and caustic chemical to be reused throughout each day. As an advanced oxidation technology, organic material with the water (dairy product residue) is converted to CO_2 gas and vented from the system. This system alone, if used for all CIP systems, could create savings on the scale of hundreds of thousands of dollars annually depending on the capacity of a particular facility.

Photon Induced Oxidation (PIOx) technology utilizes short wave ultraviolet light (185nm) to convert oxygen to ozone. Ozone reacts with organic material to convert it to carbon dioxide and water; if the organic material is a bacterium or virus, it is not only killed but also oxidized.

Other components of organic material such as nitrogen are released as gaseous nitrogen. The exposure of the organic contaminated water occurs within a pipe, which consists of a micro-porous tube contained within an air plenum. The contaminated water is injected tangentially to the edge of the tube so that the water forms a thin film on the inside surface of the gas porous tube. The film follows a ribbon type pattern around and down the surface of the tube. As the water swirls, air is injected through the gas porous tube and becomes entrained in the water forming a froth containing billions of micro-bubbles.

The UV lamp is located in the core of the tube and emits the short wave photons into the froth. As the short wave photons radiate the oxygen within the bubbles, the oxygen converts to ozone or nascent oxygen which then reacts with organic matter converting it to carbon dioxide and water. As there is a significant centrifugal force field created by the swirling water, the carbon dioxide and nitrogen move to the core of the tube and then vertically to the exit port located at the top of the chamber. The treated water exits the tube through the lower end of the tube (opposite of the water entry and electrical connections for the lamp). This water is collected in a container for subsequent reuse or discharge.

CLEANING AND SANITATION

This BMP is intended for industrial water users that use rinsing or cleaning in processing, production or finishing operations. Rinsing and cleaning are important operations for a number of industries. Water conservation opportunities arise in improvements in flow rates, pressure, or timing. Many operations can also increase efficiency by recirculating water or by filtering contaminants and reclaiming water for reuse internally.

Specific processes in which this BMP can be implemented will have been identified in the Industrial Water Audit BMP. Each process requires careful evaluation to determine the most economical and efficient measures to implement. Initial cost-effectiveness analysis should begin with the simplest measures including adjusting operating parameters on existing equipment.

Often reductions in water pressure, changes in timing or adjustments to nozzles can achieve measurable results in water savings. In container rinsing for reuse or disposal, immediate rinsing before products solidify or gel can reduce the amount of time and water required for cleaning. In multiple rinse processes, reducing the amount of "dragout" or contaminated rinse water carryover from one container to the next can reduce the total amount of water needed for the process.

The FDA water quality requirements for water used in food processing and packaging makes it economically infeasible to reuse and recycle the wastewater from the sanitizing or wash down of the process equipment and the facility. The FDA regulations also limit the reuse of wastewater from the cooling tower and other miscellaneous areas for this same reason. Although reusing the water from sanitizing is not feasible there are certain device upgrades that can be made that can significantly reduce water usage.

There are several types of low-flow high-pressure nozzles available on the market that can easily be purchased through most food service equipment distributors. The costs of low-flow high-pressure industrial nozzles range between $50 and $200 per nozzle. These nozzles are not like those used in kitchen sinks, but are industrial grade nozzles made for sanitary wash down operations. A lot of water is used for lubricating the conveyors. In plants where surfactants are used – not just water – there is a separate higher pressure loop for the conveyor nozzles. The driver is the cost of the lubricant and the organic load charge for sewer disposal. Reductions are often larger than 25%.

There are several manufacturers of industrial low flow high pressure nozzles specialized for food production and packing operations. Specialized attachments are available including foam, chemical rinse and bleach attachments. The low-flow nozzles can be easily installed within a short time by facility maintenance staff or a plumber. The total cost for replacing nozzles will depend on the selected type and number required for the facility to effectively operate. When implementing the recommended components (low flow nozzles), it can be assumed that 25 percent of the currently used water for sanitizing can be saved.

Product wastes and residues are constantly being moved, pushed and removed manually from the flooring surfaces. It is recommended that a new model water broom be investigated due to the potential high amount of savings from these water brooms. Several manufacturers offer industrial water brooms in various sizes and designs, including brooms that roll on castors to easily *move waste and debris. Water brooms can* also reduce labor steps for leaning and lifting while cleaning.
www.waterbrooms.com/waterbroomInfo.html

COUNTER-CURRENT WASHING SYSTEMS

Plants that have once-through product washing methods can modify their cycles to use the counter-current approach. The diagram below provides a schematic of the counter-current washing approach. In contrast to once-through product washing methods, counter-current washing makes use of progressively dirtier rinse water to provide pre-rinsing for incoming product streams, thereby saving water. As illustrated rinse water flows in the opposite direction of the product flow, thereby ensuring that the dirtiest water is used for the first rinse and that clean water is used for the final rinse.

Counter-current washing systems can save up to 40% of the water used in efficient traditional, once-through washing systems.

An alternative to counter-current technique and a much easier approach to reducing water use for a spray rinsing system would be to reduce the water pressure. Reducing water pressure from 70 psi to 30 psi would reduce water use by 35% and will reduce the amount of product being damaged and wasted.

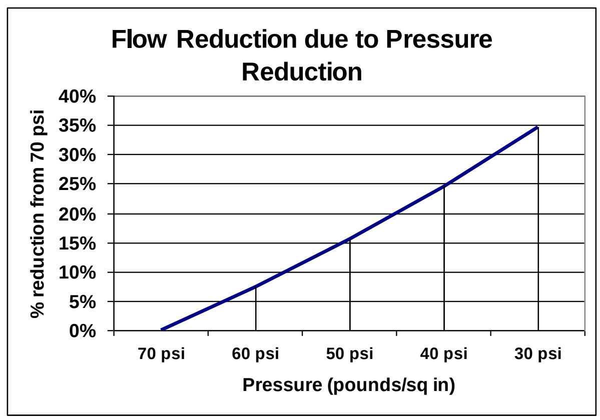


FIGURE 46: FLOW REDUCTION DUE TO PRESSURE REDUCTION

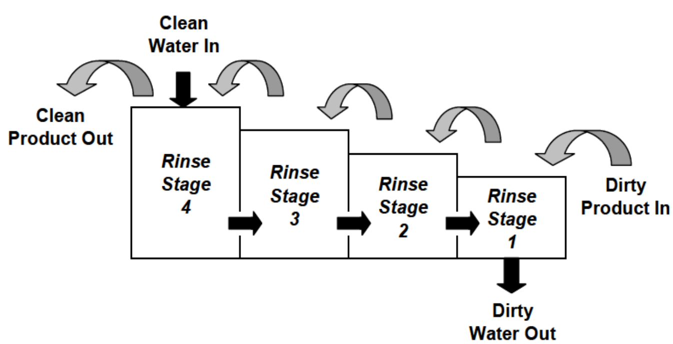


FIGURE 49: COUNTER-CURRENT TECHNIQUE

SITE EXAMPLES

EXAMPLES OF ENTITIES LISTED IN DOR 46

The following analysis of the Anheuser Busch Brewery in Jacksonville, Florida is an example of water use in the food and beverage sector.

Anheuser Busch

111 Busch Drive, Jacksonville, FL

The Anheuser Bush Brewery was opened approximately 45 years ago. It has undergone many improvements and expansions over its history. Based on company news accounts in the Seminole Sentinel and other local papers, the plant has significantly reduced water use. The Anheuser-Busch plant had held a permit to pump as much as 6.2 million gallons of water a day from the underground Floridan Aquifer. The new, 20-year permit allows a maximum of 4 million gallons daily. According to a 2011 story in the Jacksonville News, the plant currently produces 125 million cases of beer a year and discharges 650 million gallons of wastewater to its farms near the facility including a 400 acre site close to the brewery and its 1,500 acre Lem Turner Road site located nearby. The Orlando Sentinel places production at 135 million cases a year. At 2.38 gallons of beer per case, this is equal to 0.82 to 0.88 million gallons of beer produced a day.

Based on information provided by the St. Johns Water Management District (EN 50-CII 2010), the plant used 3.264 million gallons of water a day in 2010. According to facility reports, the brewery sends 1.8 million gallons or treated wastewater to irrigation a day (650 million gallons a year).

Based on the reported production rates the amount of water used to produce a gallon of beer would range between 3.7 and 4.0 gallons of water per gallon of beer.

Based on the Beverage Industry Environmental Roundtable, and international beverage industry annual report, the range of water use per unit of beer for 142 reporting breweries shows that the amount of water used ranges from 3.44 to 9.13 gallons of water per gallon of beer and averaged 4.67 gallons of water per gallon of beer. This indicates that the Jacksonville brewery is relatively efficient. The amount of water used depends to some extent on the complexity of the brewery. According to General Manager Steve Foppe , a decade ago, it took more than seven gallons of water for each gallon of beer. Since then, the ratio has dropped rapidly. Plant workers aren't predicting the ultimate ratio, though 2-to-1 doesn't seem impossible (Orlando Sentinel June 2011).

Estimated Daily Water Use Patterns At Anheuser Bush, Jacksonville, FL. *Millions of Gallons per Day*	
2010 Water Use	**3.264**
Beer *(based on 125 - 135 million cases a year)*	**0.82 to 0.88**
Calculated Plant Water Use	**2.38 to 2.44**

FIGURE 47: ESTIMATED DAILY WATER USE PATTERNS AT ANHEUSER BUSH, JACKSONVILLE, FL.

For a typical Brewery, malted barley is purchased so water use to begin the steeping and germination process is typically not part of the brewery water use. The malted barley is ground in a grist mill, and then cooked with water to make a mash. The mash is then filtered to form a wort which sent to brew kettles to ferment. Hops and yeast are added to the brew kettles. After brewing, the beer is separated from the yeast and solids and sent to bottling and shipment.

Anheuser-Busch disposes of its wastewater through irrigation. Two sites are located nearby. The table below summarizes the permit capacity of the two sites and the following two figures show aerial views of the irrigation sites.

Anheuser Busch Land Application Sites for Wastewater Reuse for Irrigation		
Type of Waste	**Site**	**Permitted Capacity MGD***
Spray Application Of Brewery Liquor	**Lem Turner & Lannie Road**	**4.1**
Adding Nanofiltration Reject To South Borrow Bit		**1.0**
Spray Irrigation Land Application From Aluminum Can Exterior Rinse	**111 Busch Dr**	**0.4**
Total Permitted Capacity		**5.5 MGD**
** Million Gallons per Day*		

FIGURE 48: ANHEUSER BUSCH LAND APPLICATION SITES

5.5: DOR 47 MINERAL PROCESSING, PHOSPHATE PROCESSING, AND CEMENT PLANTS

DESCRIPTION OF THE INDUSTRY

The DOR sector 47 is a very diverse accumulation of mining, mineral extraction, building material extraction and cement plants. Technically, these are not one, but a collection of industries that either extract minerals or building materials from the earth or use those to produce a product such as a ready mix plant.

ANALYSIS OF OVERALL WATER USE AND BENCHMARK PARAMETERS

In total numbers, concrete ready mix plants, sand and gravel mines and borrow pits dominate this sector. Pete mines, clay and perlite mines and in a few cases, simple excavations also fall into this sector. Two large operations, the E.I. DuPont titanium dioxide mine operations Edgar Kaolin clay mines are some of the more unique and largest operations. The DOR code indicates cement pants, but classifies concrete batch plants as cement plants. In engineering terminology, cement plants convert raw materials into the cement that is mixed with sand and gravel at concrete batch plants to make concrete.

Since water tables are generally very high, most pits fill with water. In all operations, water removed from the pit from which the material is removed is returned to the pit or surface water source. The District correctly assumes that 95 percent of surface water is returned to the pit it was drawn from . Groundwater is also used at some facilities. In 2010, according to the EN-50 report, all mining used 6.17 million gallons a day (MGD) of groundwater and a total of approximately 22.5 MGD of surface water was withdrawn, but 95% of that water was returned.

Concrete batch plants (cement) are unique in that they typically use potable or ground water to make the concrete mix. Table “Examples of Groundwater Use Records for 2010 from the EN - 50 Report for Concrete Batch Plants” shows groundwater use by six typical concrete batch plants.

Figure “Concrete Batch Plant Waste Discharge Permit Volumes” shows wastewater discharge permit volumes for a number of concrete batch plants. Runoff from these facilities is typically full of fine sediment and has a very high pH. As the graph indicates however permitted wastewater volumes are typically small.

Examples of Groundwater Use Records for 2010 from the EN - 50 Report for Concrete Batch Plants		
Owner	**Name of Facility**	**Million Gallons per Day (MGD)**
CEMEX Construction Materials Florida LLC	Bunnell North Concrete Plant	0.024
CEMEX Construction Materials Florida LLC	CEMEX - Vero North Ready-Mix	0.000
CEMEX Construction Materials Florida LLC	Deland Concrete Plant	0.003
Florida Rock Industries Inc	Clermont Ready-Mixed Concrete Plant	0.024
Tarmac America	Tarmac Downtown Orlando Ready Mix Plant	0.000
Tarmac America LLC	Tarmac North Gifford Batch Plant	0.015

FIGURE 49: EXAMPLES OF GROUNDWATER USE RECORDS FOR 2010

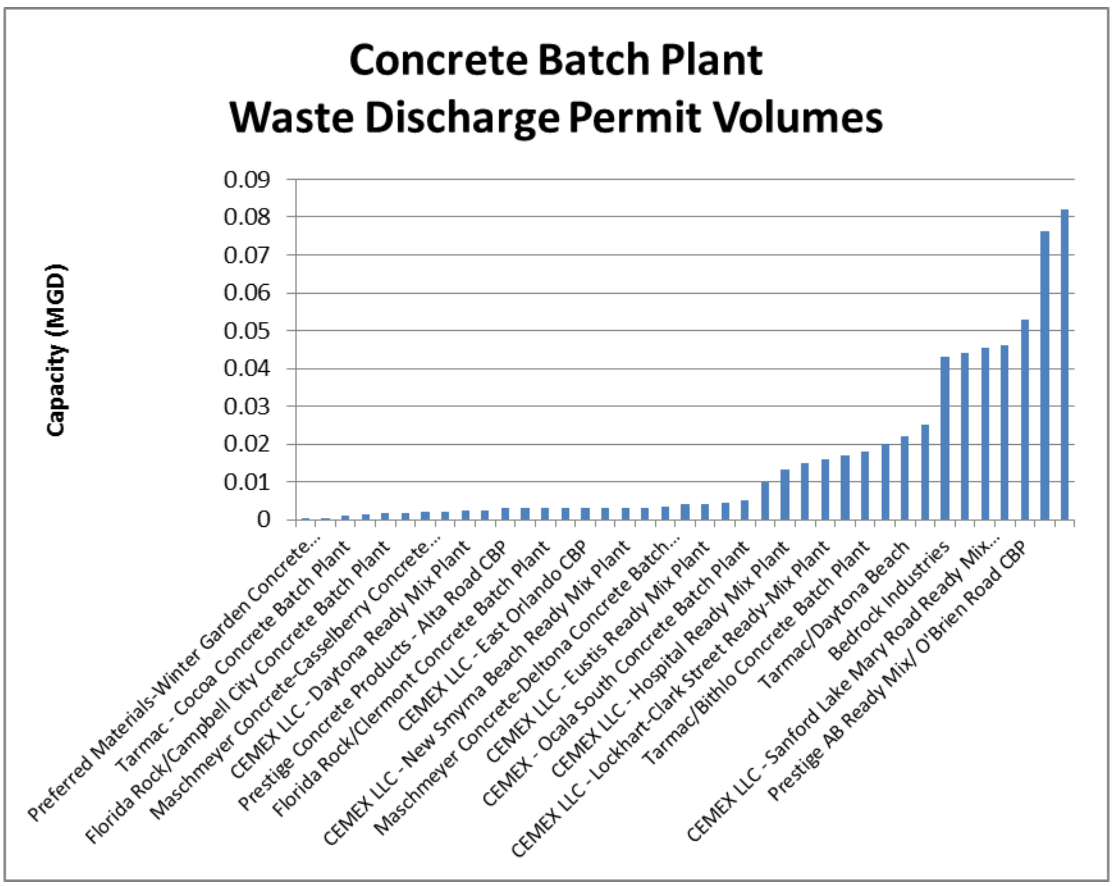


FIGURE 50: CONCRETE BATCH PLANT WASTE DISCHARGE PERMIT VOLUMES

Sand and gravel operations typically involve washing facilities to clean the sand and/or gravel of sediment and debris. Pit water is usually used for this and the water is returned to a settling pond.

Examples of Sand and Gravel Mine Water Use (EN - 50 2010 Report)		
Name of Sand Mine	**Water Source**	**Use MGD**
	Both Ground and Surface Water	
474 Sand Mine	Confined or Semi-confined Aquifer	0.100
474 Sand Mine	lake	5.664
474 Sand Mine	stormwater	2.757
Weirsdale Sand Plant	Confined or Semi-confined Aquifer	0.119
Weirsdale Sand Plant	lake	1.990
Center Sand Mine	Confined or Semi-confined Aquifer	2.011
Center Sand Mine	lake	3.834
	Groundwater Only	
Winter Garden RMC	Confined or Semi-confined Aquifer	0.011
Longwood RMC	Confined or Semi-confined Aquifer	0.014
Bithlo RMC	Confined or Semi-confined Aquifer	0.004
Tulley Dura-Rock	Confined or Semi-confined Aquifer	0.028
CSR Rinker Leesburg	Confined or Semi-confined Aquifer	0.003
Rinker/Lockhart	Confined or Semi-confined Aquifer	0.040
Keuka Sand Mine	Confined or Semi-confined Aquifer	0.583
Grandin Sand Plant	Confined or Semi-confined Aquifer	1.424

FIGURE 51: EXAMPLES OF SAND AND GRAVEL MINE WATER USE

Because of their unique size and operations, the Du Pont titanium dioxide mines and the Edgar mines are described in more detail.

E.I. Du Pont Titanium Mines

Du Pont operates two titanium dioxide processing facilities near Jacksonville, Florida. Both are located off of US Highway 301 a few miles from each other. Both mine titanium dioxide containing sand using a wet dredging process. The mines also recover Ilmenite, Staurolite, and Zircon.

These are open pit mines that have a dredge and wet milling processor on a barge that floats in the water that accumulates in the pits being mined. (see Examples of Sand and Gravel Mine Water Use (EN - 50 2010 Report).

FLOATING DREDGE AT DU PONT TITANIUM MINE

The sand is dredged and processed on board using spiral gravity separators as seen above. As the sand and water swirl down, heavier minerals accumulate on the inside of the spirals and lighter sand moves to the outside. All of the water and over 97 percent of the sand is directly returned to the pit. This provides most of the soils material used for reclamation.

SPIRAL SEPARATORS

The water originates from naturally occurring high groundwater tables and run off and from wells operated by Du Pont. The Maxville mine used an average 420,000 gallons of water a day and the Trail Ridge mine near Starke used 226,000 gallons a day in 2010 for a total of 646,000 gallons a day on average.

Based on company information, over the past ten years, the Florida Plant team has reduced their groundwater consumption by greater than 65%. Three years ago, the facility completed a project to redirect a portion of the site's final effluent to the Etonia Creek basin to augment flow in the creek during drought conditions.

As the sand is processed through the spiral separators 97% to 98% of the sand is returned to the pit along with the water. The remaining two to three percent is sent to Du Pont's Titanium processing facility where they are dried. The Titanium and zircon metals are separated using electrostatic attraction. Titanium dioxide is used as a white pigment in paint and a large variety of products. Figure Groundwater Use at the E.I. Du Pont Titanium Mines summarizes groundwater use at the two Du Pont facilities for 2010.

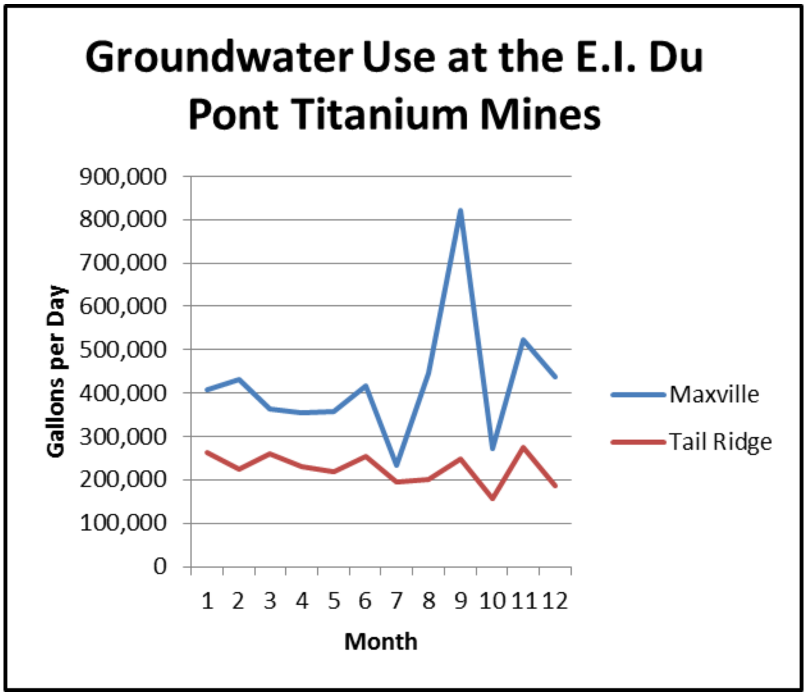


FIGURE 52: GROUNDWATER USE AT THE E.I. DU PONT TITANIUM MINES

Figure Du Pont Titanium Tail Ridge Processing shows the processing Tail Ridge processing facility and figure E.I. Du Pont Titanium Dioxide Mine

Du Pont Titanium Tail Ridge Processing

E.I. Du Pont Titanium Dioxide Mine shows the mining operations at the Tail Ridge site.

Edgar Mines

The Edgar mine in Putnam County near the City of Edgar is one oldest mining operation in Florida. Mining began in 1892. The mine produces kaolin clay and sand products. Figure Edgar Mines shows the Edgar Mines from an aerial view and Water Use by the Edgar Mine in 2010 shows water use in 2010.

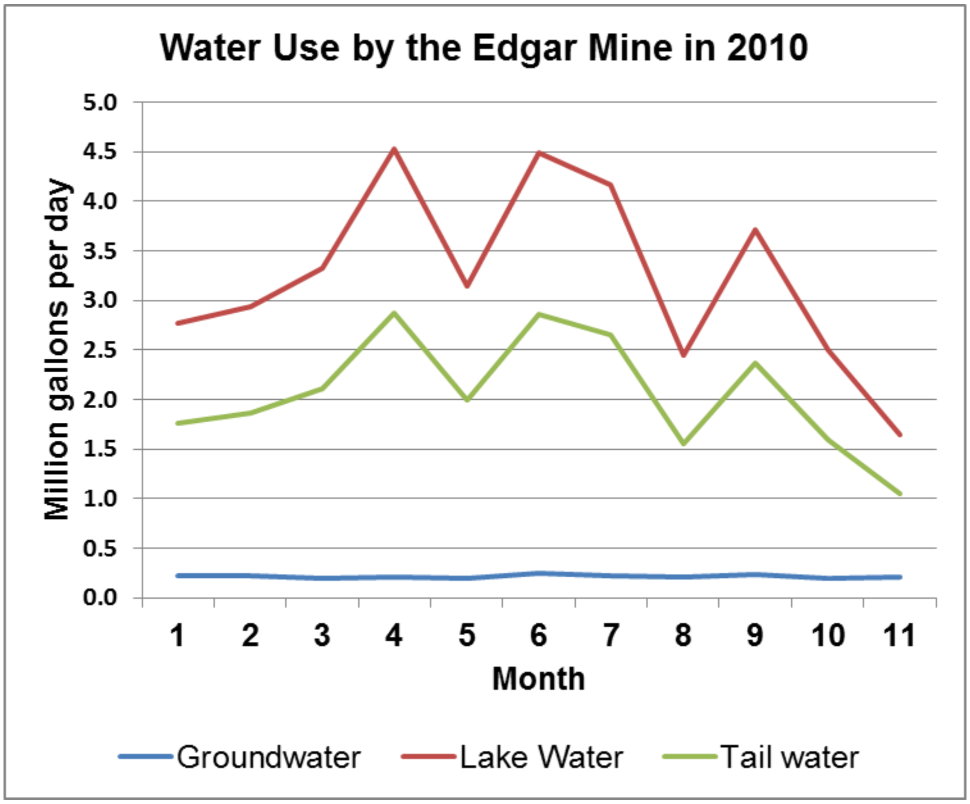


FIGURE 53: WATER USE BY THE EDGAR MINE IN 2010

BEST MANAGEMENT PRACTICES

Mining operations are unique in that they use several sources of water for their various processes. Groundwater is the normal source of water used for all domestic uses at mines. At concrete batch plants groundwater, and sometimes potable water, is used as part of the concrete mix.

PRODUCTION PROCESSES

MINE RESTORATION

If irrigation is practiced to help restore vegetation to reclaimed areas, the best management practice would be to follow proper conservation of irrigation water and to obtain the water from the mine pit. Please refer to the irrigation best management practices below. Water used for grinding and flotation can be reused in the concentrates process or in the tailings material, and total make-up water and recirculation rates can serve as an indication of total water consumption.

- Tailing impoundment bottom sealed geo-synthetically or naturally with drains
- Heap leach can use drip irrigation to reduce evaporation
- Construct drains (basal, intermediate, and pipes)
- Cover process solution ponds
- Avoid spills during truck and tank loading
- Avoid leaks in the concentrate filtering process and elsewhere
- Construct tailings at heights greater than normal (45 to 60 feet), up from the impoundments to minimize seepage
- Install wells to intercept seepage from impoundments constructed before 1985
- Reuse concentrate thickeners, tailings thickeners, tailing impoundments, pit water, and slurry water based on arsenic and antimony levels
- Float small plastic spheres on tailing ponds and thickeners to reduce evaporation
- Automatic controls to adjust water levels
- Total separation of natural water from tailings, density of 55% solids by weight
- Construct a leak-proof facility with closed-loop recirculation and leak detection
- Monitor water parameters with a measurement system and consumption indicies, automatically controlled concentration
- Install high density thickeners and pressure filters
- Watering roads according to air quality permits and using asphalt, chemical stabilizers
- Create stilling basins to minimize surface area and increase decant water recovery
- Use decant towers, barge pumps, or sump pumps to recycle water back to the mill concentrator, use multiple decant towers

- Increase the capacity of decant towers or barge pumps
- Cover or cap abandoned tailings impoundment
- Use high density polyethylene (HDPE) pipe to transport higher density tailings
- Reuse cooling tower make-up and reverse osmosis blow down water for belt filter lubrication, flocculent make-up, and gland seal water
- Replace and pull gland packing on slurry pumps
- Decouple circuits and construct holding tanks to prevent overflow
- Ensure belts are undamaged for efficient designed lubrication water flows

CHEMICAL DUST CONTROL

Control of dust should be done with minimum water usage. The use of chemical dust control methods will help reduce this use. The mine pit water should be used for these purposes. In process areas, the paving work areas helps reduce dust and allows for the collection of much cleaner runoff from precipitation.

- Reduce the length and number of haul trips
- Use road binders
- Change to conveyors from trucks

ALTERNATIVE WATER USE

Runoff from concrete batch plants offers additional opportunities. Many plants now capture the rainfall runoff from the non-truck washing areas of the facility, settle the water and use it as part of the water used to make concrete and as wash water for trucks. For larger mining operations of all types, the majority of surface water is returned to the mine pit. This is the single best conservation measure for that practice.

VEHICLE WASHING OPTIMIZATION

Mine truck operations often have on-site "wheel washers" to remove mud and dirt before the trucks enter the road. These facilities should have water recirculation pumps and settling tanks. It is also possible to use the water from the pit or other non-potable or groundwater resources where feasible.

Concrete batch plants should segregate and capture the water used to wash out concrete trucks in a separate pit. This water has a very high pH and is full of fine sediment. Most facilities recirculate this water after it has settled in the catchment pit and reuse it to wash out trucks. This is the BMP for cleaning concrete trucks.

5.6: DOR 48 WAREHOUSING, DISTRIBUTION TERMINALS, VANS AND STORAGE WAREHOUSING

DESCRIPTION OF THE INDUSTRY

The DOR sector 48 covers a wide range of facilities. This sector also contains the largest number of entities listed in the potable water data sets from the eleven utilities. Analysis of individual entities in the sector as designated by the Florida Department of Revenue also shows that some of these entities may be misclassified.

ANALYSIS OF OVERALL WATER USE AND BENCHMARK PARAMETERS

This sector is dominated by entities using under 90,000 gallons of water a year which is typical of many single family home water users. Perhaps the best way to characterize this sector is to say it in primarily low water using entities with only about 10 percent using over 200,000 gallons of water a year. Figure Annual Water Use of DOR 48 shows water use for 2009 for this sector.

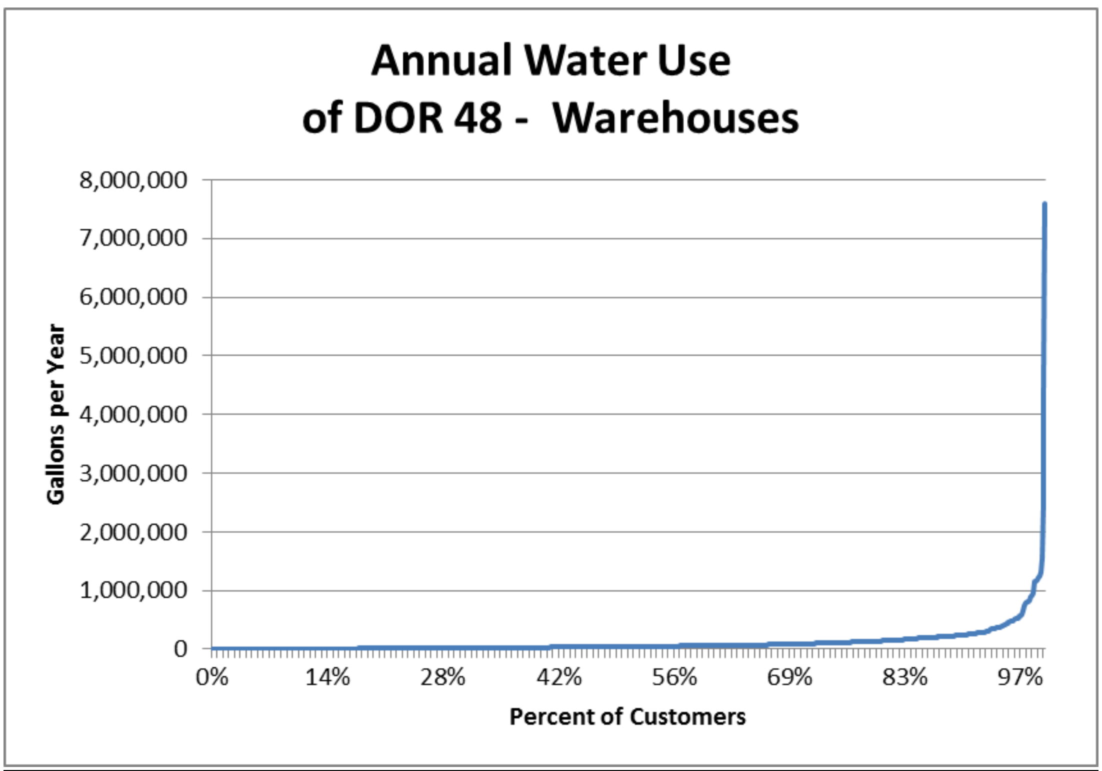


FIGURE 54: ANNUAL WATER USE OF DOR 48

An analysis of the gallons of water used per year per square foot of heated areas yields a similar graph (Figure Histogram of DOR 48).

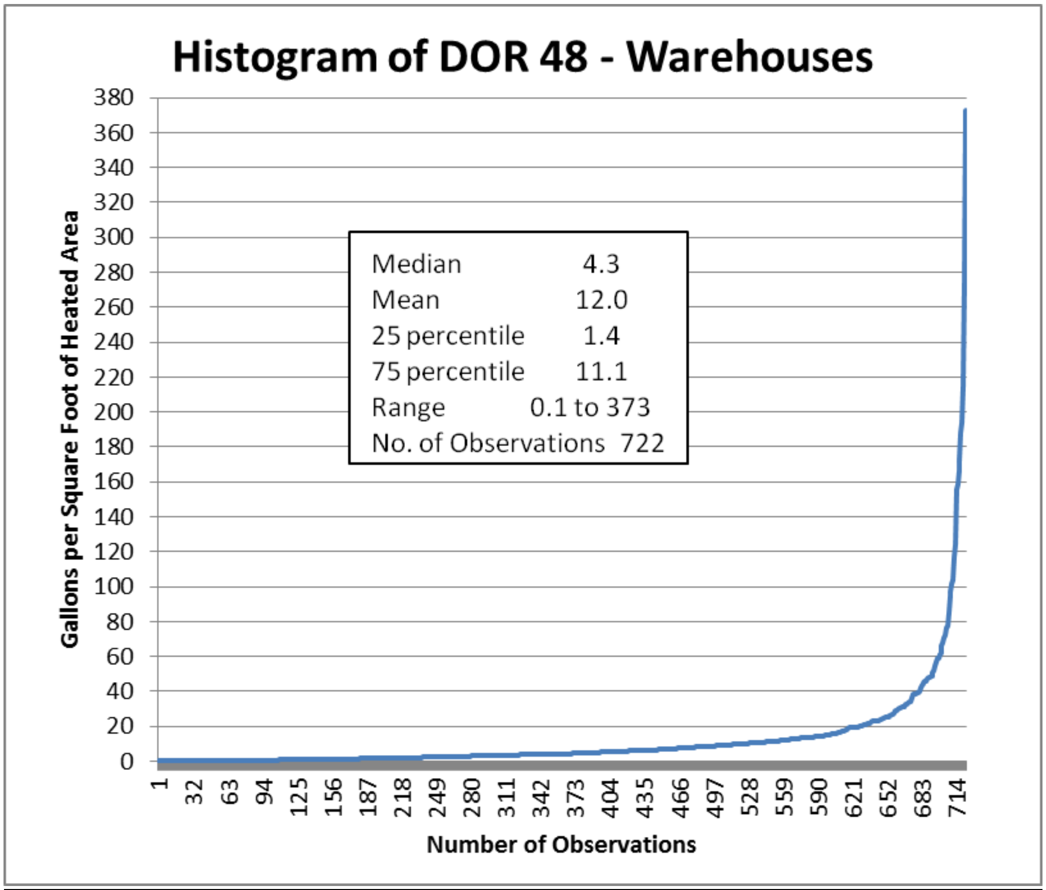


FIGURE 58: HISTOGRAM OF DOR 48 - WAREHOUSES

As with DOR Sector most entities are small water users. Over half use less than 36,000 gallons a year. These can best be addressed with outreach programs that emphasize domestic and irrigation water use efficiency. The larger users and those with uncharacteristic use per square foot could be targets for an audit program.

As with DOR Sector most entities are small water users. Over half use less than 36,000 gallons a year. These can best be addressed with outreach programs that emphasize domestic and irrigation water use efficiency. The larger users and those with uncharacteristic use per square foot could be targets for an audit program. Further examination of the data showed that the first 55 percent of the data followed a very linear trend for gallons per square foot of heated area. This linear option can be used to determine outliers on the lower end of data.

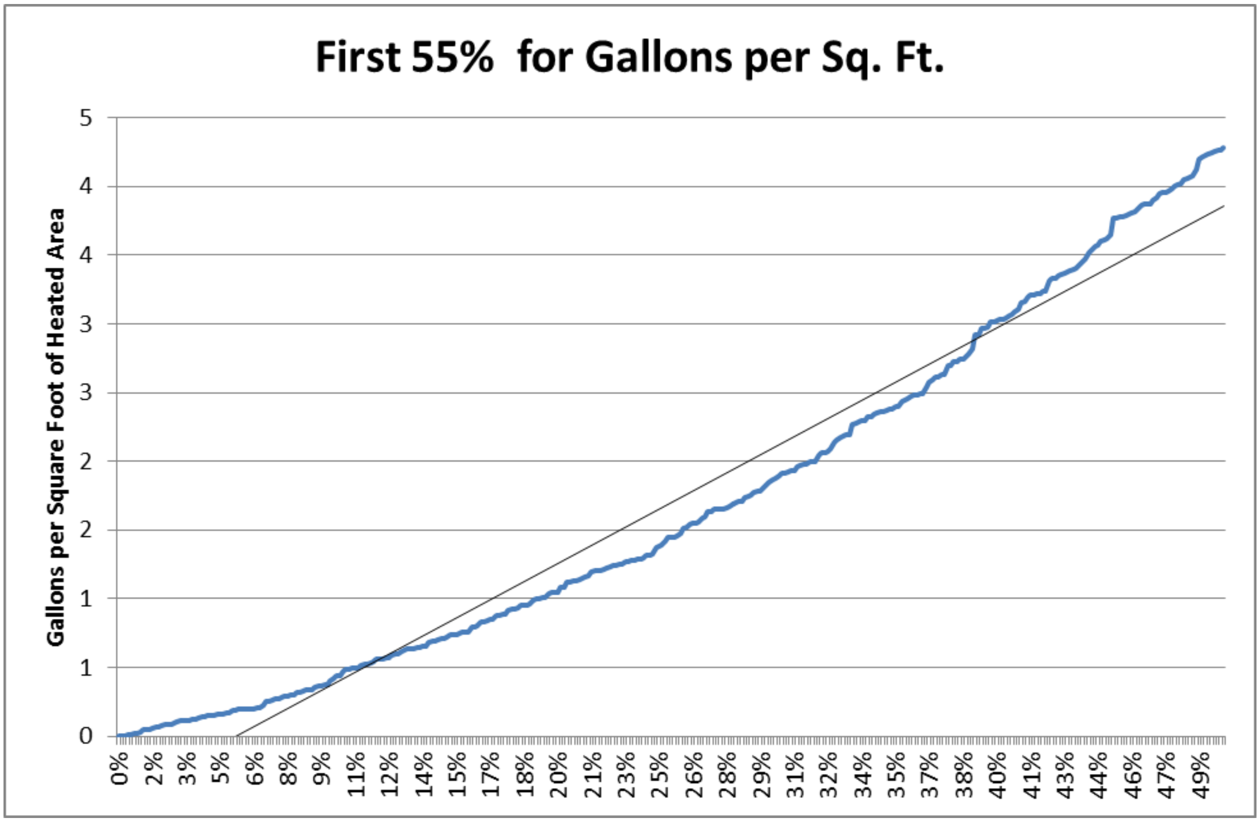


FIGURE 59: FIRST 55% FOR GALLONS PER SQ. FT.

BEST MANAGEMENT PRACTICES

In order to reduce water waste in industry, it is important to understand the many ways that water is used within facilities. Understanding water end uses is critical to identifying water savings opportunities. For facilities classified by DOR 48, the primary uses of water are generally cooling towers, bathroom fixtures, and irrigation.

6.0 BEST MANAGEMENT PRACTICES APPLICABLE TO ALL DOR CODES

Once-through cooling, also known as single-pass, or pass-through cooling, is currently banned by all green codes, standards and green rating systems. **It is our opinion that once through cooling should be banned.**

Cooling and heating of living spaces and equipment is commonplace in commercial and industrial operations. The first and most critical consideration is what type of system to use to heat or cool spaces or equipment. For heating living space, there are boilers (steam), hydronic heating, and hot water heat exchanger systems. All of these use water. There are also a number of other space heating systems such as hot air, heat pump and radiant heating.

For cooling spaces, chilled water/cooling tower type air conditioning have been the classic methods to heat larger commercial and institutional space. In smaller spaces, evaporative (swamp) coolers have been used. Both of these evaporate significant volumes of water, but ground-geothermal systems, air cooled variable refrigerant volume (VRV), and direct expansion (DX) systems as well as newer desiccant systems all provide waterless ways to cool a space.

Therefore,

(1) ***In new construction the first best management practice is to not use water intensive cooling or heating methods in the first place.*** Advances in geothermal heat pumps and VRV systems (sometimes called variable refrigerant flow systems) offer real opportunities to avoid cooling tower systems while still being cost effective.

(2) ***Conduct a life cycle cost/benefit analysis of cooling and heating systems to determine if a waterless systems makes sense***.

If boilers, evaporative cooling, or cooling towers must be used, follow these principles:

Steam Boilers: Large commercial/institutional water heating systems are sometimes called boilers, but do not actually produce steam. Large water heating systems should have cold water makeup meters. These water heating "boilers" are not the subject of these Best Management Practices for boilers that actually produce steam.

Steam boilers require water to be deaerated and for most applications softened prior to use. As they operate, fresh water must be fed to the boiler to replace steam lost through leaks or otherwise not returned to the boiler, and for boiler blowdown to maintain water quality in the boiler. The following represent best management practices for boiler operations:

- Use a hot water heater (boiler) if actual steam is not required. This eliminates losses due to steam leaks, lack of condensate return, and blowdown.
- Meter cold water makeup to the boiler,
- Maximize steam condensate return,
- Practice good energy conservation to minimize steam use
- Install conductivity controllers to determine when blowdown is needed (no timers)
- Minimize water use for blowdown cooling by installing heat recovery systems
- Minimize sampler cooler water and find ways to reuse sampler cooling water.
- Use condensing boilers or retrofit existing boilers with condensing sections to maximize energy recovery. Then use the condensate for cooling tower makeup or irrigation or other uses after pH adjustment.

Evaporative (Swamp) Coolers:

Evaporative coolers use wetted pads to cool air drawn through them by evaporating the water. Literature shows that the most significant water efficiency potential is in the control of bleed-off from the sump to control the buildup of dissolved solids and hardness that causes deposits on the pads and corrosion. The US Environmental Protection Agency's 2009 WaterSense Single-Family New Home Specification sets specific standards for evaporative coolers. WaterSense recommendations are as follows:

Evaporative cooling systems should:

- Use a maximum of 3.5 gallons (13.3 liters) of water per ton-hour of cooling when adjusted to maximum water use;
- Blowdown shall be based on time of operation, not to exceed three times in a 24-hour period of operating (every 8 hours). Some recommend the use of a dump valve that actuates each time the equipment is started or shut down;
- Blowdown shall be mediated by conductivity or basin water temperature-based controllers;
- Systems with continuous blowdown/bleedoff, and systems with timer-only mediated blowdown management shall not be used.
- Cooling systems shall automatically cease pumping water to the evaporation pads when airflow across evaporation pads ceases.

In addition to the WaterSense Best Management Practices, for large systems of more than 30,000 cubic feet of air per minute, it is recommended that the systems be equipped with the following:

- Makeup meter on water supply
- Overflow alarms for water level in the basin
- Conductivity controllers should be used to blowdown on an "as needed" basis
- Automatic water and power shutoff systems for freezing.
- Locating drain for bleed off where the flow is visible so that leaks and other problems can be easily detected.

Again, evaporative coolers consume water. They also add to humidity and can aggravate mold growth. Their use is limited in most Florida climates.

COOLING TOWERS

This BMP is intended for any water user which employs cooling towers to remove heat by the evaporation of water. Cooling towers are used extensively from relatively small facilities such as office buildings, schools, and supermarkets to large facilities such as hospitals, electric power generation plants, and manufacturing and industrial plants.

Cooling towers fulfill their purpose by rejecting heat to the atmosphere by convective and evaporative heat transfer. As water cascades through the cooling tower, it comes into contact with air that is pushed or pulled through the fill by mechanical draft fans. The heat is removed by evaporation of a small percentage of the recirculated water. The evaporation rate is determined by the following equation:

Evaporation (E) = (0.0085) * (Recirculation rate, R) * (ΔT° across tower)

The water that is evaporated from the tower is pure; that is, it doesn't contain any of the mineral solids that are dissolved in the cooling water. Evaporation has the effect of concentrating these dissolved minerals in the remainder of the tower water. If this were to occur without restriction, however, the solubility limit of the dissolved minerals would soon be reached. When the solubility limit is reached, dissolved minerals (most commonly calcium and magnesium salts) precipitate as an insoluble scale or sludge. This is the off-white, mineral scale that is frequently found in heat exchangers, in the tower fill, or deposited in the sump.

To prevent the tower from over concentrating minerals, a percentage of the cooling water is discharged to drain. The bleed or blowdown rate is adjusted to control the concentration of dissolved minerals to just below their solubility limit. This limit is commonly set and controlled by specific conductance (microsiemens) or total dissolved solids (mg/l) measurements.

The water that is lost by evaporation and bleed must be replaced by fresh makeup to maintain a constant system volume.

Makeup (MU) = Evaporation (E) + Bleed (B) + Uncontrolled losses

The makeup water is obtained from surface water sources and from ground water sources. This is significant because the quality of the incoming water to the central plant has a direct correlation to the Cycles of concentration. One indicator of cooling tower efficiency is cycles of concentration, or concentration ratio. This is the ratio of the makeup rate to the bleed rate, MU/B, assuming the uncontrolled losses are negligible.

Cycles of concentration are also estimated by the ratio of the specific conductance of the cooling water and the makeup water:

Cycles of concentration (C) = MU / B

From these relationships, the amount of bleed required to maintain a specific cycle of concentration is determined by:

B = E / (C – 1)

If E is held constant, reducing the bleed causes the cycles to increase. Conversely, increasing the bleed causes the cycles to decrease. Operating the cooling tower at maximum cycles of concentration reduces the amount of water sent to drain and thereby decreases the freshwater makeup demand. Overall, higher cycles of concentration translate into greater efficiency as measured by a decrease in freshwater consumption and wastewater discharge.

Cycles of concentration	Cooling tower water efficiency (%)
10	100.0
9	98.8
8	97.4
7	96.4
6	93.8
5	90.0
4	84.4
3	75.0
2	56.3

FIGURE 55: CYCLES OF CONCENTRATION VS COOLING TOWER EFFICIENCY

Increasing the cycles of concentration or cooling tower water dissolved mineral content will decrease the cooling tower blowdown and thereby decrease makeup water requirements.

It may be that the cooling towers are adjusted to have a constant bleed that is adjusted manually. If this is the case then it would make sense to add conductivity controllers to towers.

The diminishing returns curve (in chart BLEED RATE V. CONCENTRATION) indicates that major gains in water conservation can be achieved by increasing the cycles from two to three. As we approach higher cycles, however, the incremental gains decrease. From a practical view, drift, leaks, and other uncontrolled losses limit the cycles to a maximum of about 10.

These figures suggest that cooling towers that operate at fewer than five cycles of

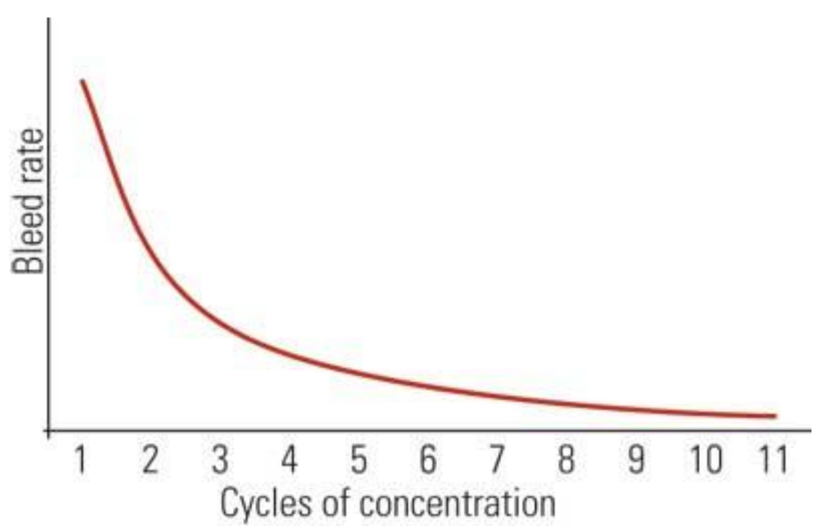


FIGURE 56: BLEED RATE VS CONCENTRATION

concentration (less than 90% efficient) are not achieving their full potential and would benefit from optimized chemical treatment and retrofits that would reduce freshwater consumption and decrease waste. Towers operating at six to eight cycles are acceptable for most applications.

Potential for Improving Performance

Cooling tower cycles can be maximized in a variety of ways. These include ensuring that there is proper pretreatment of the tower makeup, pH adjustment, and chemical scale inhibitors.

The first question to ask is does a cooling tower provide the best life cycle alternative bases on the rapid rise in water and wastewater rates compared to electricity, treatment, labor, liability and water and wastewater infrastructure and supply consideration. Hybrid cooling towers, wet-dry systems, geothermal heat sinks, and newer air cooled equipment such as variable refrigerant volume technologies may become better choices when total lifecycle considerations are evaluated.

Operational considerations are the first consideration in the efficient operation of a tower. For towers larger than 500 tons, a continuous electrical record of operations should be available for downloading. If that record is not available, the operator should maintain a written shift log. A logbook also provides a written shift log. At a minimum, the shift log should contain:

- Details of make-up and blowdown quantities, conductivity, and cycles of concentration;
- Chiller water and cooling tower water inlet and outlet temperatures;
- A checklist of basin levels, valve leaks, and appearance; A description of potential problems.
- Above all, ensure that the employee responsible for the cooling tower operations, is knowledgeable of what to look for when examining records and what to look for when visually examining the cooling tower.

Choose a Water Treatment Vendor that will work with your facility.

- Select a water treatment vendor that focuses on water efficiency. Request an estimate of the quantities and costs of treatment chemicals, volumes of make-up and blowdown water expected per year, and the expected cycles of concentration that the vendor plans to achieve. Specify operational parameters such as cycles of concentration (CC) in the contract. Increasing cycles from three to six reduces cooling tower make-up water by 20 percent and cooling tower blowdown by 50 percent.

- Work with the water treatment vendor to ensure that clear and understandable reports are transmitted to management in a timely manner. Critical water chemistry parameters that require review and control include pH, alkalinity, conductivity, hardness, microbial growth, biocide, and corrosion inhibitor levels.

Design and Retrofit Best Management Practices include proper instrumentation and tower design and operation.

- Install a conductivity controller that can continuously measure the conductivity of the cooling tower water and will initiate blowdown only when the conductivity set point is exceeded. Working with the water treatment vendor, determine the maximum cycles of concentration that the cooling tower can sustain, then identify and program the conductivity controller to the associated conductivity set point, typically measured in microSiemens per centimeter (US/cm) necessary to achieve that number of cycles. Conductivity controller systems cost from $3,500 to $100,000 depending on the nature of the facility in which it is installed. Possible savings possible depend on the increase in cycles of concentration.

- Install flow meters on make-up and blowdown lines. On most cooling towers, meters can be installed at a cost of between $1,000 and $50,000. Manually read meters can be used for smaller towers, but if the tower is 500 tons or more, meter readings should be automated and be connected to an electronic data management system.

- Install automated chemical feed systems or treatment equipment. These systems minimize water and chemical use while protecting against scale, corrosion, and biological growth.

- Install overflow alarms on cooling tower overflow lines, and connect the overflow alarm to the central location so that an operator can determine if overflows are occurring. This alarm can be as simple as a flashing light in the control area. More sophisticated systems may include a computer alert.

- Install drift eliminator that are capable of achieving drift reduction to 0.002 percent of the circulated water volume for counterflow towers and 0.005 percent for cross-flow towers.

- A biocide shall be used to treat the cooling system recirculation water where the recycled water may come in contact with employees or members of the public.

- The US Green Building Council's draft 2012 LEED for new buildings recommends the following maximum concentrations parameters for cooling tower water quality.

Parameter	**Maximum level**
Ca (as CaCO3)	1,000 ppm
Total alkalinity	1,000 ppm
SiO2	100 ppm
Cl	250 ppm
Conductivity	3,500 US/ml

FIGURE 57: COOLING TOWER WATER QUALITY

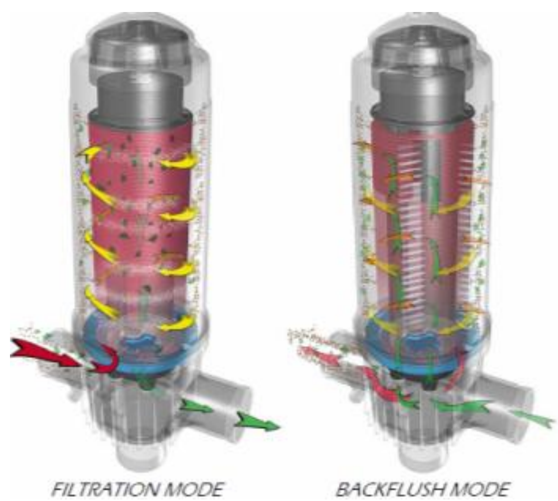
Additional equipment and systems that reduce water and improve tower and systems efficiency use include:

- Side stream treatment to soften tower water or remove dissolved solids;
- The use of alternate sources of water is strongly encouraged,
- Side stream filtration to remove particulate matter. This may allow for an increase in cycles of concentration, and it will help increase overall energy efficiency by maintaining clean tower and heat exchanger surfaces.

PRETREATMENT OF COOLING TOWER MAKEUP & UTILIZATION OF DISC FILTRATION

The primary limiting factor for cycles of concentration is calcium hardness. As a general rule of thumb, the calcium hardness in the cooling tower should be maintained within the range of 350 to 400 ppm (parts per million) on a non-acid treatment program. If the makeup water contains, say, 100 ppm calcium hardness, the cycles of concentration at Plants would be restricted to 3.5 to 4.0. This is equivalent to 75% to 85% water efficiency. Reducing the calcium hardness to 50 ppm allows the tower to run at seven to eight cycles, which is equivalent to over 96% water efficiency.

TURBO DISC FILTRATION



Hardness reduction or removal can be accomplished by lime softening, sodium ion exchange (water softener), or reverse osmosis. Low-hardness makeup is often available from recycled and reused plant wastewater such as spent rinse water and steam condensate. Water of any desired hardness can be obtained by the controlled blending of softened water with untreated raw or recycled water.

Another method for treating the cooling tower make-up includes the utilization of a turbo disc filtration system. The system uses stacks of compressed, grooved discs, disc filters to capture debris not only on the surface of the disc stack, but throughout the depth of the grooved rings. Water is filtered from the outside of the disc stack to the inside.

The design of the Turbo-Disc enables the removal of debris from the water source while minimizing backflush frequency and backflush flow. Using the Turbo-Disc Element, located at the base of the disc stack, the Turbo-Disc spins incoming water and debris as it enters the filter chamber (see Filtration Mode illustration). Heavy debris spins along the housing wall and make little contact with the disc stack. This spinning action enables the filter to run much longer between required backflushes. When the filter element requires cleaning, a pressure differential sensor, within the filter controller, will engage the backflush cycle.

During backflush, the disc stack is decompressed and the flow of water is reversed through the filter housing. During the backflush cycle, filtered water from the other filter pod(s) is used sequentially to backflush one disc cartridge at a time. The filtered water comes back through the outlet of the filter, flowing up through four posts on the interior of the discs. These posts spray pressurized, clean, backflush water tangentially through the disc stack. The spray of water induces a high velocity spinning action, which rapidly cleans the entire disc stack. After the backflush cycle is completed, normal filtration resumes.

PH ADJUSTMENT

Traditionally, cooling towers operating on high-hardness, high-alkalinity makeup water have utilized pH adjustment with sulfuric acid to maximize cycles of concentration. One part of 66° Baume acid is required to neutralize one part of alkalinity. Sufficient acid is injected into the makeup to maintain the total alkalinity of the cooling water in the range of 50 to 100 ppm or at a level that will maintain the pH within the range of 6.8 to 7.5. The Langelier, Ryznar, or Practical scaling index is used as an additional control measure to correlate the calcium hardness, total alkalinity, pH, total dissolved solids, and temperature to maintain water chemistry at the neutral point of the index (neither scaling nor corrosive).

The problem with using acid to increase cycles is one of control. Accidental overfeed conditions (low pH) make the cooling water very corrosive to system metals. And reducing the M alkalinity removes the natural passivating effect that carbonate and bicarbonate alkalinity have on steel. Operating the cooling tower at pH levels above 8.5 creates an environment that passivates steel and minimizes corrosion of galvanized steel and copper.

Unlike scale deposition, which can be removed by chemical or mechanical cleaning, damage caused by acid corrosion cannot be reversed and is very expensive to repair. In addition, the handling, transporting, and feeding of concentrated sulfuric acid creates additional environmental, health, and safety issues.

CHEMICAL SCALE INHIBITORS

Various chemical additives and formulations are marketed that enhance the solubility of calcium and magnesium salts while at the same time controlling corrosion to within acceptable rates. These chemicals are generally phosphonates (organically bound phosphate compounds), polymers (mono-, co-, and ter-), and organic corrosion inhibitors. These products are used alone or in combination with supplemental acid feed to maximize tower cycles.

Proven effective in lab tests and in the field, cooling water additives are usually limited to keeping calcium and magnesium salts soluble up to a Langelier Index value of about +2.5. Other chemical programs push through the calcium solubility limit by claiming to maintain clean heat transfer surfaces at even higher cycles, despite the precipitation of hardness salts, which are chemically conditioned into a fluid, nonadherent sludge that is removed by routine bleed.

Notwithstanding the benefits of a sound chemical treatment program, if the cooling tower cycles are limited to fewer than five, significant water savings can be realized by improving the quality of the tower makeup.

Clean systems result in significant energy savings. TRANE data states that even 0.01" (less than the thickness of an egg shell) of calcium carbonate scale increases energy consumption and cost by 10%. Because microbiological fouling is an even better insulator, a paper-thin layer of slime, 50-100 microns, increases energy consumption and cost by 20%. A facility could save $15,000 for every $100,000 dollars spent on energy by avoiding even a 15% reduction in efficiency. The following chart shows the projected savings as a result of maintaining the cooling towers dedicated refrigeration.

Savings Resulting From Water Treatment Service**

A/C Tonnage	Heavy .003 Fouling Factor (1/32") In Dollars	Light .001 Fouling factor (1/64") In Dollars	Savings Resulting From Treatment In Dollars
500	**10,400**	**3,400**	**3,400 - 10,400**
1,000	**20,800**	**6,800**	**6,800 - 20,800**
2,500	**52,000**	**17,000**	**17,000 - 52,000**
5,000	**104,000**	**34,000**	**34,000 - 104,000**

FIGURE 58: SAVINGS RESULTING FROM WATER TREATMENT SERVICE

***The amounts above reflect the increased costs that would be incurred as a result of any fouling/scaling, and are based on an electrical cost of $0.125/KW Hour.*

ALTERNATIVE COOLING TOWER WATER TREATMENT

Conventional cooling tower water treatment relies on chemistry to inhibit corrosion, scale, and bacteria in cooling water systems. As water evaporates the remaining water becomes concentrated. If the water becomes too concentrated the dissolved solids will begin to precipitate on heat transfer surfaces. To prevent over concentration, the system is blown down; meaning a portion of the concentrated water is sent to drain, and the remaining water is diluted with new make-up water that has lower concentrations of dissolved solids. A conventional water treatment program must be controlled and monitored to insure that this dynamic system does not stray outside of the safe operational parameters. Operating systems outside of the safe range can be expensive in terms of increased energy costs, maintenance costs and shortened equipment life.

It is not unusual to find either that because of budget pressures two things happen. Expensive treatment programs are selected, resulting in the cooling towers being operated in an ultra-conservative manner at very low cycles of concentration, which increases the water loss and the cost of chemicals. Or the towers are not given proper attention, resulting in operation outside of safe parameters, which can lead to corrosion, scale, biological growth and higher energy costs.

Alternative methods of cooling tower water treatment are available and worth investigating as they can be environmentally superior to standard chemical programs and provide excellent value. The systems can include a combination of magnetic, electronic, rare earth, ozone, and ion removal technologies. Any application of alternative cooling water treatments should be thoroughly studied by qualified professionals, with all ramifications of that process (good or bad) understood by the customer. The good news is that it is possible to increase the efficiency of marginally operated system, save money in chemicals, water, energy, and maintenance, while reducing environmental impact.

GENERAL COOLING TOWER RECOMMENDATIONS

Most cooling tower water conservation efforts focus on the treatment and control of the water in the cooling tower to increase cycles of concentration and thus reduce make-up water demand, but not evaporation. Conservation of water should also include ways that cooling tower evaporation and other consumptive losses such as drift loss may be reduced. Three principles of reduced evaporation in towers include:

1. Reduced heat load
2. Efficient tower operation
3. Replacing evaporative cooling with air cooling or hybrid towers

The objective of reducing consumptive use is to reduce all uses that do not result in a return flow. People are another factor impacting heat gain in an air conditioned space. As our bodies metabolize, they reject heat. The amount of heat rejected depends on the type of activity and on the body size.

REDUCING HEAT LOAD

Any measure that reduces energy use or heat gain in the building envelope being air conditioned will reduce heat load on the towers. This will directly reduce evaporation and to a small extent drift loss, since the tower base flow is also reduced. Some of the methods that can accomplish this include:

- Energy efficiency – Any and all energy efficiency initiatives including improved lighting, more efficient equipment, weatherization, etc., reduce the work the chiller must do to cool a building. This directly impacts heat load to the tower and thus evaporation. This is a saving of approximately 1.7 gallons per ton hour when compressor energy is considered.
- Central control monitoring systems and isolation capability – Although this is an energy efficiency measure, it is important to emphasize the ability to shut down areas that are not being used.
- Pre-cooling – The thermal mass of buildings can be used to help reduce cooling load during much of the year. When night temperatures are 60 degrees F or less, the night air could be used to pre cool the building to below normal thermostat settings. The thermal mass of the

building would help keep the compressor from working as hard thus saving energy and water.

EFFICIENT TOWER OPERATION

Cooling towers consumptive loss can be reduced by reducing drift and by modifying other tower operations. These include:

- Drift loss –Modern drift eliminators reduce drift loss to 0.002 percent or less of tower flow for cross flow towers and 0.001 percent or less for counter flow towers. Since normal circulation rates are in the range of 175 gallons per ton hour, this is equal to a drift loss of 0.0034 gallons per ton hour or less. With poorly maintained drift eliminators, this use goes up, and towers with no drift eliminators can lose up to 0.2 gallons per ton hour. Drift loss represents a total loss from the system including chemicals. It is a source of air pollution and possible bacterial contamination including legionella.
- Wind loss – When towers are exposed to strong cross winds, water can be blown from the tower in ways that are similar to drift loss. Location of a tower on the downwind side of a building or wall can help reduce this loss. However the location should not impede air flow needed to operate the tower.
- Variable frequency fan drive – Variable frequency fan drives on tower fans can taper fan speed to meet specific conditions. This saves water by reducing entrained water that can become drift loss. Also, towers are designed to work as a predetermined approach to wet bulb temperature. This is the difference between the web bulb temperature and the temperature of the water in the basin that is being cooled. When a fan works at 100 percent capacity all of the time, this approach can become smaller than needed through “excess” evaporation. In net, variable frequency fan drives save significant amounts of energy and smaller amounts of water. The exact savings depend on local conditions, operational parameters and a number of factors.

HYBRID TOWERS AND AIR COOLING

Another type of tower that has found use is the hybrid wet-dry tower. It costs almost twice as much as a conventional tower, but it can work with air when ambient temperatures are lower, or with a combination. This allows some of the rejected energy to be dispensed by air and thus not contribute to evaporation. Hybrid towers cost 50 to 100 percent more than a conventional cooling tower, but offer similar energy efficiency to a conventional tower AND reduced water use.

Additional operational suggestions include:

- Maintain all water systems control equipment and periodically calibrate to ensure proper control parameters.
- Check for and repair if necessary, any valves (especially the float valve) and worn pump seals that may be leaking.
- Maintain make up and blow down meters to assure that evaporation credits are calculated correctly.

Continue RCW system testing, including chemical and biological testing.

BATHROOM FIXTURES

AUDITING

Kitchen faucet flow rate measured with a micro-weir container.

Water auditing is an essential part of any analysis for determining potential benefits from implementing water conservation measures. Not only does the audit identify the existing fixtures and volumes, audits uncover specific conditions related to any project that can greatly affect costs. For example the existing floor and flange conditions can greatly affect costs on a toilet replacement project. The rough-in (distance from the wall to the center of the flange) for the existing flanges on many properties can vary from 14 to 10 inches. A property may have multiple units with 10 inch rough-in toilets and the workers show up with only 12 inch rough-in toilets many hours of labor can be lost.

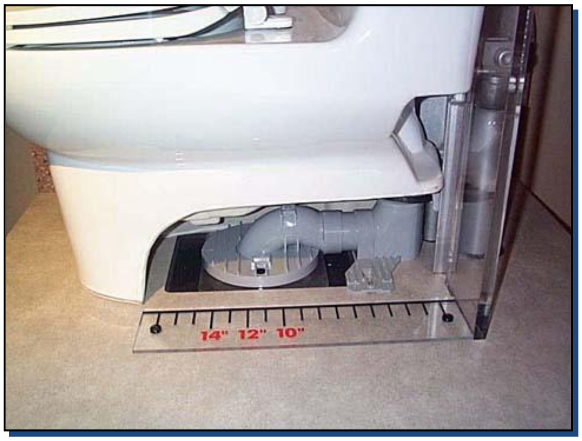
Auditor uses t-5 flushmeter to measure the flush volume of the toilet

To help calculate the consumption and potential savings for the suggested measures provided in the audit process, you should use a limited variety of consumption models that consider multiple factors. Many of these factors are discovered during the field audit. The number, type and flow rate of the existing fixtures help to determine the existing conditions. Fixture flow rates often differ from the designed flow rates, for example, some 1.6 gpf toilets actually flush between 2.0 and 4.1 gpf. Once you determine the existing flow rates, you can multiply the flow rate times the appropriate usage factors to determine the amount of fixture use.

AUDITING TECHNIQUES

Sanitary water use is calculated for each fixture type: toilets, faucets and showerheads. This is determined by measuring the flow rates and gallons per flush of a sample of each fixture type. Faucet and showerhead flow rates are measured using a calibrated flow bag or a calibrated micro-weir container. Faucet flow rates are taken by turning the valve a quarter turn, to standardize the accuracy of measurement between faucets.

Many types of toilets can be measured by using a t-5 flushmeter or by using a water meter connected to the supply line. For many tank type toilets, knowing the year that it was manufactured and the type of interior component parts being used will gave a general knowledge of the approximate volume of the flush. For example tank type toilets manufactured before 1973 volume was unregulated with most toilets consuming 5 gallons per flush, between 1973 and 1991 toilets were



regulated to 3.5 gallons per flush, toilets manufactured after 1991 were regulated to operate on 1.6 or less gallons per flush.

Usage of diaphragm valve type toilets can be estimated by counting the number of seconds in the flush cycle, by using the t-5 flushmeter or by measuring the flow into a calibrated bucket.

For commercial auditing there are various specific techniques WMI applies to commercial type toilets in order to obtain accurate measurements

For commercial valve type toilets WMI may utilize a calibrated bucket and remove the vacuum tube connection and flush the fixture into the calibrated bucket with a flexible hose connection.

Another technique to measure commercial toilets is to insert an inflatable ball into the trapway of the toilet inflate the ball to prevent any water from escaping, empty the bowl, and then flush the toilet and pump out the total flush volume into the calibrated bucket there by obtaining an accurate flush volume.

Rough-in distance measurements are an essential part of any audit involving a possible water efficiency measure that includes toilet replacement.

Auditor uses calibrated flow bag to measure showerhead flow rate.

Smaller water meters are frequently utilized to audit toilet volumes accurately.

For determining flow rates for showers and faucets at many properties one can use a standardized 5-second metered flow-bag. The flow-bag is calibrated in ½ gallon increments. To make a measurement the auditor encapsulates the water source and then turns on the water for five seconds, the amount of water registered on the calibration of the flow-bag equates to the flow rate of the fixture in gallons per minute.

By obtaining accurate measurements the average flow rate and flush volume for each fixture type can then be used to represent the baseline flow rates.

WATER USE CALCULATIONS

Domestic water use calculations are an essential part of water auditing. The amount of consumption attributed to domestic fixture usage can vary widely depending on the type of facility or property being audited.

For an extended example the percentage of water use by end-use category (domestic, kitchen, laundry, etc.) varies considerably from one facility type to the next.

Calculating the amount of consumption for each individual category enables users to take the audit from the general assumptions to the specific use calculations and allowing you to quantify the effect of individual water conservation measures and then project return on investment numbers for the individual measures.

Fixture use is affected by many factors: the population of a facility, the hours of use, the average number of times a person will use the facilities and the split of the population between male and female. Studies have shown that on the average during working hours people use bathrooms an average of once every two hours and when available.

<u>The basic formula is as follows:</u>

- Existing Usage model = Population x uses per day x days of use per year x the average existing flow rates of the fixtures.
- Post program usage model = Population x uses per day x days of use per year x the average proposed flow rates of the fixtures.
- The post program annual gallons saved = the difference between the two.

In our model, we link faucet use to the flush usage. The faucet calculations are based on a six second wash for each flush in the common area bathrooms. There is a small amount of energy savings associated with the hot water use. Where hot water exists, we estimate that 30% of the water used by the faucets is hot water. Lavatory use in the guest rooms is 6 minutes per day. Shower use average is 10 minutes per day.

Based on industry standards for commercial and industrial buildings, employees use the restrooms 4 times per day or 1 use per 2 hours. The number of uses per day (NUPD) for female staff is 4. Males use the urinals 50 percent of the time and the toilets 50 percent. It is assumed that with each toilet or urinal use, all people wash their hands for at least 6 seconds per use.

The number of uses per day (NUPD) for staff and visitors is totaled by each fixture type and each group of users to give total uses per day (TUPD). The TUPD for toilets and urinals is multiplied by the average sampled flow and occupancy to give baseline water consumption. Similarly, the TUPD for lavatories and showers are multiplied by the average sampled flow rates, minutes per use and occupancy.

TOILETS

There are two main types of toilet fixtures that are standard to the toilet industry: gravity tank and bowl (residential style with a china tank on top of a china bowl), and diaphragm valve and bowl (commercial style with an exposed chrome pipe flush system connected to a china bowl).

In 1991 Federal Law mandated lower volumes for domestic water fixtures. Recently the EPA adopted new standards to lower volumes on domestic water fixtures to a new lower volume standard. Below is a listing of the current Federal Law standards and what the standards are to qualify as an EPA WaterSense product.

Current Standards and Goals

Fixture	Current Standards	EPA WaterSense goal
Toilets	1.60	1.28
Urinals	1.00	0.5
Showerhead	2.50	1.5 - 2.0
Sink faucet residential	2.20	1.0 - 1.5
Lavatory faucet public	0.50	0.5

FIGURE 59: EPA STANDARDS

To acquire a WaterSense certification a products must be 20% more water efficient than the Federal standard and must be at least as effective as the standard product(s).

VALVE TOILETS

In the majority of the commercial toilets, the most common flush valve system employs the diaphragm valve, manufactured by Sloan. Diaphragm valves present a maintenance challenge: debris in the water line can clog the equalization port as well as decrease the life span of the rubber diaphragm. Both of these situations require the disassembly of the valve and cleaning or replacement of the diaphragm. With the implementation of new standards in water treatment nationwide, these diaphragms should be replaced every two to three years. If the valves are not maintained properly they can cause the valve to short flush or stick open causing a continuous flush.

Some of the newer buildings have toilets that are rated at 1.6 gallons per flush, but based on our audit we observed that many of those 1.6 gpf fixtures were flushing on 3-5 gallons per flush. We have observed older commercial toilets rated for flush volumes of 3.5 to 4.5 gallons per flush that were flushing on volumes of 2.5 gallons per flush or less. In summary a wide range of flush volumes (1.5 gpf up to over 5 gpf) during the audit of many facilities that have commercial toilets. In order to better understand how this wide range of toilet flows has come about, it is helpful to have a basic knowledge of flush valve diaphragm operation.

The diaphragm operates on the principle that supply pressure acting on a surface area exerts a force directly proportional to the amount of surface area. For example 60 psi of pressure acting on 1 square inch of area exerts a force of 60 lbs; the same 60 psi acting on a 2 square inch surface area exerts a force of 120 lbs, acting on 3 square inches would exert a force of 180 lbs and so on. The manual flush valve is designed so that the surface area on top of the diaphragm is greater than the surface area underneath the diaphragm. Consequently, when equal pressure is exerted on the upper zone and lower zone, the greater force on the upper zone pushes the diaphragm on its seat and water flow is shut off. The valve is actuated by releasing the pressure in the upper zone through the relief valve (white, green, or blue) via the valve handle; when pressure is released in the upper zone the diaphragm lifts off of its seat and water flow to the fixture begins. Water flow shuts off when pressure in the upper zone builds back up (equalizes) through a fixed orifice in the diaphragm.

Sloan is able to deliver different volumes to the fixture by 3 methods:

1. Variable length of the relief valve (white is longest, green is shortest, and blue is in between). The longer the relief valve; the more pressure is released in the upper zone when the valve handle is actuated. Thus it takes longer for upper zone to re-pressurize, so a larger volume of water reaches the fixture.
2. Variable shape of the refill head. The refill head is a small plastic ring that is positioned at the bottom of the diaphragm; it moves up and down with the diaphragm and its shape and design affect the amount of water that is allowed to pass between it and the valve seat when the diaphragm is open. There are 3 different types of refill heads, only one of which can be turned over to increase or decrease flow by one gallon. Bevel side down on this type refill head allows more water to pass through the valve.
3. Presence or absence of a flow ring. The flow ring is a hard plastic ring with a square cross section that fits loosely over the guide. When in place it limits the amount of water that can be delivered to the fixture by approximately 1 gallon.


Many toilets need to be flushed twice to properly clear the bowl

Many ULF toilets (< 1.6 gpf) are around that use well in excess of 1.6 gpf; this can easily occur when a white relief valve is used instead of a green relief valve. When this switch takes place, the flush cycle goes from 4 second duration (1.6 gpf) to 8-10 second duration (4.5—5 gpf).

Also, you will see some toilets where diaphragms with blue relief valves were being installed on high volume toilets (> 3.5 gpf) in an attempt to reduce volume. This is not a good idea and will cause performance problems. In fact many older toilets have shown signs that a toilet auger is frequently required. When the blue relief valve is used on an older diaphragm and the refill head has the bevel side up (side 1) it only delivers 2 gallons to the fixture. This set up needs at least two flushes just to clear 18 linear feet of single ply toilet paper. When the refill head bevel was placed in the down position (side 2 down); 3 gallons of water was delivered to the fixture. This is adequate for most of the older commercial toilets.

There are a significant number of low-flush commercial valve toilets that do not flush at 1.6 gpf. There are a variety of reasons a low-flush toilet would use more than 1.6 gallons. In many cases there are problems with the operational plumbing parts is the use of chloramines in the treatment of drinking water. The use of chloramine is affecting a multitude of plumbing parts that were never designed to withstand the corrosive effects of this chlorine substitute. Chloramines have been identified as the most cost effective alternative for reducing trihalomethane (THM) formation. They have been embraced by the water treatment industry, most notably water authorities under regulatory pressure to reduce levels of THMs.

The controversy surrounding the use of chloramines as a disinfectant arises out of several studies on the effects of chloramines on the vast array of elastomers (rubber) found throughout a typical water distribution system. A study published in the August 1993 issue of the American Water Works Association's Journal outlines the corrosive effects of chloramines. It concludes that, "With few exceptions, solutions of chloramines produced greater elastomer swelling, deeper and denser surface cracking, more rapid loss of elasticity, and greater loss of tensile strength than equivalent concentrations of free chlorine."

The problems created as a result of chloramines being used in the water treatment process and the overwhelming consensus from our field tests has been that the seals, gaskets, washers, and other plumbing parts degrade at a much higher rate in a chloramine environment than in free chlorine.

You need to use parts that are designed to resist the corrosive effects of chloramines. This means that often special arrangements need to be made with manufacturers to produce higher quality parts and use special materials that are not readily available. This approach carries a high price tag initially but the life cycle cost is considerably less.

Trihalomethanes (THM), the by-products of free chlorine and water, are a known carcinogen to humans. They are tightly regulated by Federal drinking water standards. The irony of the situation is irresistible: Adding chlorine to water during treatment for disinfection produces an organic chemical known to cause cancer in humans. Of the major contaminants regulated by drinking water quality standards, only THMs trace their source to the water treatment process.

Toilet flapper valves are a good example. Flappers made of natural and synthetic rubbers deteriorated several times faster in the presence of chloramines. This deterioration leads to cracking and warping of the flapper's seating surface, leaking toilets, and tremendous water loss. The same consequences apply to toilet flush and fill valves, faucet washers, o-rings, and a variety of other points throughout the typical water distribution system. The Sloan

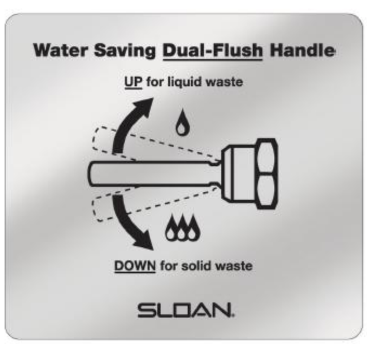
Company has reacted to the problem with chloramines and as a result has designed a different valve (Royal) for these conditions.

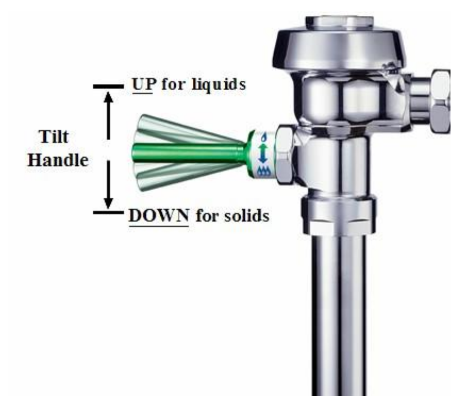
The Royal diaphragm is made of permex rubber, has better (dual) filtration with a grey ring on the outer top surface of the diaphragm and a white ring on the outer lower surface of the diaphragm and is chloramine resistant. The Royal valve from Sloan and the Aqua Advantage valve from Zurn are both more expensive, but they work better and last much longer.

The most common types of diaphragms observed in our auditing are the less expensive Regal diaphragm. Since all of the flush valves bodies in the past 50 years from Sloan and Zurn fit either diaphragm the tendency is to replace diaphragm with the less expensive Regal diaphragm. The Regal is made with natural rubber, has less filtration – little tiny brass pinhole in the diaphragm, and is not chloramine resistant. Problems occur when the water pressure is low or if it has sand, grit or is treated with chloramines.

It is important to note that whenever you change a diaphragm you must also change the inside plastic cover, because over time they will become married to each other. Pre 1964 valves had a brass cap, caps since 1964 have a plastic cap.

The **Dual flush handle** is a good idea and was invented by Sloan, but now other companies (Zurn) also offer a dual flush handle. The dual flush system will work with any diaphragm system but we suggest that if a dual flush handle is installed then the diaphragm should also be changed to either a Royal or Aqua Advantage diaphragm. The way it works is that when the handle is pulled up the lever has a shorter throw and thus deflects the diaphragm less.





Toilets that have a Dual-Flush feature can save up to a 1/2 a gallon of water per flush. Depending on the need, you can either tilt the handle up for a reduced flush – this is for times when you are only flushing liquid and light paper waste. Or, you can tilt the handle down for a full flush. The dual-flush handles can save a tremendous amount of water, if used properly and if the consumer does not mind if the water in the bowl does not do a complete exchange.

There is also another type of flush valve that should be noted it is the piston valve. Some of the features of piston valves are:

- 15-125 psi range of operation

- Discharge varies <6% over pressure range
- Piston travel is controlled by a fixed diameter hole
- Self-cleaning feature reduces run-on operation
- Piston valves have less vulnerability to chemical treatments in the water.

Experience has shown that piston actuated valves have a mean time between maintenance of five to seven years, compared to two to three years for the traditional diaphragm valve. The newer dual filtered Royal diaphragm valves should eliminate most of the problems typically seen with the traditional Regal diaphragm valves.

We strongly recommend that all 1.6 gpf toilets be retrofitted with dual flush handles with Royal Valves or replaced with 1.6 piston valves. For commercial toilets that use more than 1.6 gpf we recommend that these toilets be replaced.

TANK TOILETS

Inferior Initial Parts: Toilet manufacturers have designed much better flushing 1.6 gpf toilets in recent years; however many times these toilets come with inferior parts from the manufacturer. Some manufacturers to save money still use float arm ballcock that is set when the toilet is installed, and in a matter of a few weeks the washer that seals the oncoming water off has become indented or broken-in from the pressure from the float arm and water pressure in the line. This causes the water level to creep up towards the top of the over flow tube increasing the flush volume to more than 1.6 gpf, and in many instances will start to leak out of the tank into the over flow tube. Also many toilets will come from the manufacturer with inexpensive vinyl flappers that succumb to the chloramines and ammonia used in water treatment, and begin to wrinkle and warp within a year, causing leakage and early maintenance needs for a new flapper.

Incorrect Settings: Many people believe that more is better especially in the case of flushing toilets, if you allow a greater quantity of water for the flush it is guaranteed to improve the flushing performance. Manufacturers designed these toilets to flush at 1.6 gallons. Most of these toilets derive their flushing power from siphon action, as the volume of water increases in the bowl a siphon is created in the trapway sucking the water out of the bowl and down the drain. The best way to kill a siphon is to throw water into the middle of it, the flapper should close at the same time as the siphon is strongest, if the flapper is still open at the same time the siphon is the strongest then you are killing the siphon action. Most 1.6 gpf toilets will have a poorer quality of flush on 2 gallons.

<u>Flappers:</u> Almost all of the original equipment flappers that come with new 1.6 gpf toilets are a specialized flapper; these "early closure flappers" are what regulate the toilets flush volume to 1.6 gallons. The size and design of these flappers can vary greatly depending on the make and model of the toilet. In most cases to the untrained eye toilet flappers appear to be generally the same, and for the majority of general maintenance personnel and the average "Harry Home Owner" ability to identify the proper flapper for a specific toilet is beyond their experience, leading to the selection of a different flapper than the toilet was designed to use, intern causing poor flushing dynamics and in many cases increased volume. Additionally early closure flappers utilize an insert in the cone of the flapper known as the "bubbler". The bubbler will regulate the rate at which the flapper will close, by allowing more or less air to enter the flapper cone speeding up or slowing down the closing process. There are several sizes and makes of bubbler inserts for early closure flappers, having the wrong bubbler can severely affect the dynamics of the flush.

Early closure flapper for 1.6 gpf toilet.

Pre 1.6 gpf toilet high volume flapper

In years before the 1.6 gallon toilets when toilets were 3.5 or 5 gallons per flush, flapper types were more general and uniform to the industry, the flapper would stay in the open position until most of the water had left the toilet tank.

Displayed here is an assortment of bubblers for early closure flappers.

Many sites will install new toilets on an as need basis, causing the property to have a need for a number of different flappers for specific toilet makes and models. Many times a property will cut corners in the maintenance department by buying one flapper that will work on all of their toilets. In these cases the selected flapper will be the older high volume flapper that stays inside the toilet tank. This retrofitting of the 1.6 gpf toilets with spread in general maintenance practices and increases the flush volume to near 2.5 gallons per flush.

Fill Valves: Most of the manufacturers original equipment float arm ballcocks that were installed when toilets were manufactured will be replaced with Fluidmaster 400-A fill valves. Most people rely heavily on the fluid master fill valve for retrofitting existing 1.6 gpf toilets. Fluidmaster fill valves control a very significant portion of the fill valve sales in today's market; they manufacture a reliable product that is known for its dependability. A number of years ago Fluidmaster changed the percentage of incoming water that goes to the fill hose attached to the overflow tube, from 20% to 25%, this extra water is not needed in most 1.6 gpf toilets and just causes over filling of the bowl increasing consumption and waste. In almost all instances 1.6 gpf toilets that have had Fluidmaster fill valves installed in them should be equipped with flow restrictors in the fill tube to minimize waste and over filling. Care should be taken when installing the flow restrictors. In addition, when reducing the volume of water to the bowl too drastically, it will keep the bowl from filling all the way and cause short flushing (where a significant amount of the water in the tank goes towards filling the bowl completely before the flush cycle starts, resulting in a poor flush or double flushing).

Fluidmaster 400-A fill valve with green flow restrictor inserted in fill tube attachment opening.

Assortment of varying flow volume restrictor inserts for Fluidmaster 400-A fill valves.

For a listing of the best toilets refer to the MaP (Maximum Performance Testing) report that can be found at the following link http://www.cuwcc.org/MapTesting.lasso

Another consideration for tank type toilets is the pressurized flush toilet. The pressure tank toilet energizes the water within its tank. When the water supply line is connected to the closed, sealed tank that is full of air, it flows into the tank. The air inside the tank, with no means of escaping, becomes more and more compressed until its compression produces a counter pressure equal to the force from the supply line. When these forces become equal, the water flow stops.

Independent testing and studies, such as MaP Testing, show that pressurized tank toilets perform great and have excellent drain line carry.

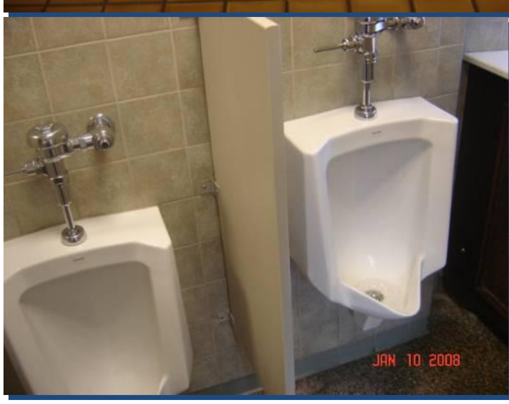
The pressure flush system requires very little maintenance and the manufacturer provides a parts warranty for 10 years from the date of installation. Pressure toilets eliminate the need to replace deteriorating flush and fill valves or seals every 18-24 months. New pressure flush toilets are even able to effectively operate using 1.0 gpf.

URINALS

In addition to toilets, urinals should be evaluated for water use. Urinals fall into the commercial flush valve category. Many of the same principles related to commercial toilets and diaphragm flush valves apply to urinals. Typically urinals use less water than toilets, but in some cases we see higher volume toilet diaphragms have been retrofitted into urinal flush valves.

Typically, urinal water consumption can be reduced by replacing only the flush valve. However many older styles of urinals have a bowl with a water spot that contains a significant volume of water; in these cases china replacement is necessary in order to achieve a substantial reduction in volume.

Flush volume on regular trough-like urinals cannot be reduced to less than 1.5 gpf. Water use can only be lowered to 1.0 gpf or less by replacing the china.



These urinals are ideal, they have a small water surface and can easily be retrofitted with new valves that flush on less ½ gallon.

A note about waterless urinals: In circumstances when waterless urinal installation is necessary, install the urinal upstream from the water flow from sinks to help keep the drain lines clear.

Waterless urinals are not typically favored because:

High O & M costs

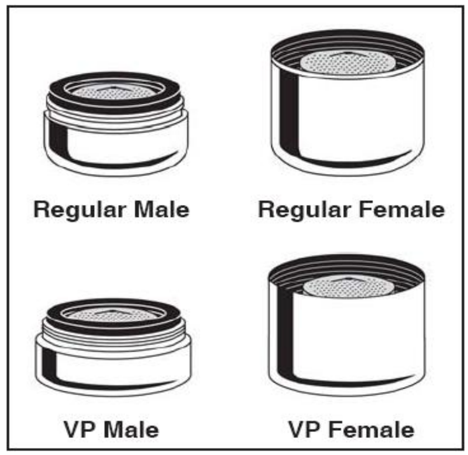
- Replacement fluid and cartridges are expensive
- Deposits can build-up in drainline

Customer/Custodian/Plumber satisfaction

- Odors can be a problem
- Clogged cartridges very unpleasant
- Custodians often do not like performing maintenance

SINK FAUCETS

Faucets account for more than 15 percent of domestic water use—more than 1 trillion gallons of water across the United States each year. Even though federal law requires that new faucets not exceed 2.2 gallons per minute (gpm), many faucets in US facilities still flow at rates as high as 3 to 5 gpm.



(VP=Vandal Proof)

As a standard, most new faucets have a flow rate of 2.2 to 2.5 gallons per minute (gpm). This may not seem like a lot of water considering people only wash their hands for a few seconds at a time. However the Center for Disease Control and The Mayo Clinic recommend that people should wash their hands for at least 20 seconds or two rounds of singing happy birthday to reduce the risk of transferring germs.

The Soap and Detergent Association (SDA) did a survey on the length of time people do wash their hands. SDA found that 38% of people wash their hands for 10-15 seconds, 23% wash their hands for more than 20 seconds, 21% wash their hands for 15-20 seconds, 16% wash their hands for less than 10 seconds, and 2% don't know. As for the amount of times people wash their hands: 36% of people wash their more than 10 times a day, 24% wash their hands 7-10 times a day, 23% wash their hands 5-6 times a day, 12% wash their hands 3-4 times a day, 2% wash their hands 1-2 times a day, another 2% don't know, and 0.1% don't wash their hands.

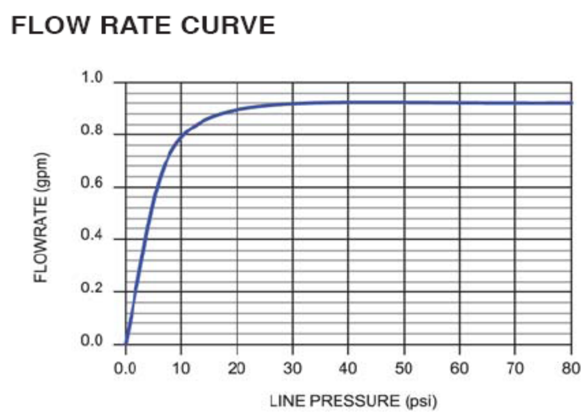
As a result high-efficiency bathroom sink flow controls can reduce the standard flow of 2.2 by 30-70 percent without sacrificing performance.

There are many instances where the restrictors on some of the aerators have been removed because of clogging, causing the flow rate to increase considerably.

The installation of 0.5 gpm flow controls in all public restrooms and 1.0 gpm laminar flow pressure compensating flow controls for the residential lavatories is recommended. The flow controls prefered are from Neoperl and come in many different flow rates and have conical screens to protect the device from getting clogged.

When considering water efficiency faucet flow controls are one of the most cost effective measures. Faucet flow controls are available in vandal proof models but because newer flow controls have a pleasant flow and do not clog, it is not usually necessary to install vandal proof models.

FIGURE 60: LINE PRESSURE VS FLOW RATE



IRRIGATION

This BMP is intended for industrial water users that irrigate landscape areas or use a significant amount of water in outdoor irrigation. Water conservation in the landscape can reduce water demands overall, reduce peak stress on water delivery systems, save energy, and reduce fuel and water costs. Landscape irrigation also offers the opportunity for water reclamation and reuse or useful disposal of water sometimes considered waste, such as air conditioning condensate.

For industrial water users, reducing water used for irrigation as an efficiency measure has the benefits of reduced water bills and landscape maintenance costs. Studies have shown that many plants that have undergone the stress of water constraints become more drought resistant and require less irrigation. Once an industrial water user decides to adopt this BMP, the water user should follow the process closely to achieve maximum water efficiency and other benefits this BMP offers. This BMP is not intended for cases where irrigation water is applied to mining reclamation projects, landfill closeouts, or other similar revegetation projects, but those projects should be done in an efficient manner with attention to water conservation.

If the water user has an automated irrigation system to irrigate turf grass, it will develop reference evapotranspiration (ETo)-based water-use budgets equal to a maximum of no more than 80 percent of reference evapotranspiration per square foot of irrigated landscape area. If irrigated landscape area exceeds one (1) acre, the water user should install a dedicated irrigation meter or submeter.

Some industrial users have found that ceasing all irrigation and allowing native groundcovers to grow amidst an existing turf grass landscape is an effective means of reducing water use. Others have used rainwater harvesting, condensate reuse, cooling tower blowdown, RO reject water or stormwater recovery to irrigate landscape areas. These approaches could be considered a substitute means to accomplish the water saving goals of this BMP.

LANDSCAPE DESIGN AND IRRIGATION

Good water use practice for landscapes begins before irrigation is considered. Proper shaping and amendment of the soil, plant selection and use and storage of precipitation are all key components of water efficient landscape design. Topics to consider include:

a) Design Landscape to keep water (rainwater, storm water, and irrigation water) where it falls. Coordinate with stormwater control features to maximize the capture of on-site stormwater.

b) Prepare soil shape and content to capture and hold the water

c) Design landscape to minimize the need for irrigation water (eliminate irrigation systems where possible)

d) Minimize turf areas and choose adapted and drought tolerant plant materials

e) Meter or sub-meter installed irrigation systems

f) Capture and use on-site sources of water and/or reclaimed water

g) Design efficient irrigation system using US EPA WaterSense principles

h) Practice proper maintenance

Florida has several excellent landscape water conservation guides available, including:

- **Landscape Irrigation & Florida Friendly Design (2006)**
  http://www.dep.state.fl.us/water/waterpolicy/land_irr.htm
- **Best Management Practices for the Enhancement of Environmental Quality on Florida Golf Courses**
  www.dep.state.fl.us/water/nonpoint/docs/nonpoint/glfbmp07.pdf
  fyn.ifas.ufl.edu
  floridaswater.com/waterwiselandscapes

MAINTENANCE OPTIONS

Verify that irrigation schedules are appropriate for climate, soil conditions, plant materials, grading, and season. Water only in the early morning to minimize losses to evaporation. Watering during these hours will not only this save water, but it will also reduce the opportunity for fungus growth to develop. Note that the general rule is to water deeply with less frequency.

Monitor and inspect irrigation systems for effectiveness. These systems are considered high maintenance items, and limited resources sometimes prevent them from being maintained at the optimum level. Poorly maintained systems can waste large amounts of water and many systems end up being abandoned due to lack of maintenance. To facilitate maintenance it is advisable to have a maintenance contract on the system(s), or make certain inspection/testing/maintenance is included.

RAIN SENSORS

Install rain sensors that shut off automatic irrigation systems in response to rainfall. This option can save an estimated five to 10 percent of irrigation water. Rain sensors cost between $15 and $45 each, with installation costs varying by geographic location and site-specific condition.

HEAD AND NOZZLES REPLACEMENT

Irrigation systems are provided to supply supplemental irrigation to the landscape in the absence of rainfall. If catch cups were placed out over an area on a property during a rainfall event, most if not all the cups would have exactly the same amount of water in them after the rain event. Irrigation systems are built with the intention of providing as even a distribution of water across the landscape as rainfall. The factors affecting distribution uniformity are the selection of sprinkler heads, spacing of sprinkler heads, wind speed and direction, and operating water pressure. Distribution uniformity of an irrigation system is important when irrigating turf because the roots of turf are close together forming a continual surface where water is needed for the turfgrass roots.

With new technologies in head and nozzle designs there are much more efficient ways of applying the water. An MP rotator is a nozzle on a spray body which shoots slightly more powerful streams of water and rotates. The benefits of this nozzle are very low application rate which reduces runoff, especially on slopes and tight soils. The nozzles are designed to have match precipitation rates (MPR) which will improve distribution, and with a more powerful stream, it reduces evaporation and runoff in windy areas. Also you can replace many high application rotors, when the rotor spacing is close to the distance needed for better performing head installations, the rotor heads will be replaced with new spray bodies and multi-stream nozzles.

CONTROLLERS

Automatic in-ground irrigation systems at most facilities utilize controllers. Properly programmed these controllers can save as much as 10 to 15 percent of the irrigation water demand. If new controllers are required they can cost $50 to $250 for small systems and up to several thousand dollars for large or central controllers. Installation costs vary by geographic location and site-specific conditions.

In order to optimize irrigation water usage, ET-based "smart" controllers are recommended to replace the existing clock controllers. While rain sensors do a good job of turning off a system once it has rained, they do not turn off the system for other weather variables, and generally restart the watering program too soon after a rain event. A "smart" controller keeps track of these additional parameters that affect landscape, and turns on the system when the turf actually needs to be watered again. It is recommended to consider installing a centralized, web-enabled controller that would allow the facility manager to program and monitor the irrigation system from any computer—on-site or at home—or even from many of the newer mobile phones.

Web-enabled controllers allow for manually turning on the irrigation system for checks through the use of smart phones, or directly from the controller face plate. Flow measurement and on-site rain sensors allow for customized schedules for individual properties and an unprecedented amount of real-time command over the facility's entire irrigation system. The controllers can transmit with a radio antenna, and all the weather information would constantly be relayed to update irrigation controllers at a specified interval, several times a day. These controllers can issue alerts straight to the manager immediately if an irrigation valve failure or line breaks are detected via either text message or email. The controller is even more powerful when its data logging capabilities are considered. For instance, comprehensive histories of water use per zone for an entire year can be recorded and easily accessed by the landscape manager. The landscape manager will be able to see exactly how much water is being saved by linking the new upgraded system with more precise weather parameters.

Conversion to a water-wise landscape that emphasizes the use of native turf and plants can result in savings of 20 to 50 percent. The cost of redesigning a landscape depends on many factors: fees for a landscape architect; size of the area redesigned; quantity and type of plants purchased and installed; labor charges; and any irrigation system retrofits/replacements that are required. Implementing this measure could involve significant costs and should be attempted only with expert consultation.

FLOW CONTROL MEASUREMENT INSTALLATION

Measuring water flow when an irrigation system is operating helps to determine if the system is working correctly. In landscapes where water managers are not visiting the property every day, a visual recording of actual water use by a flow sensor will alert them to any breaks in pipes or missing irrigation heads. Real-time flow sensing creates an additional set of data that can be used in verifying water bills and meter accuracy and developing water budgets for future years. Wireless flow sensors with battery lives over 10 years are recommended to be installed in order to provide real-time data and measurement of irrigation use. The picture in this paragraph shows the wireless flow meter components. An interface to the one shown should be used in order to lengthen the signal and provide a robust signal all over facility. The flow sensors would also be used for measurement and verification of any water conservation program.

GENERAL RECOMMENDATIONS FOR IRRIGATION SYSTEMS

There are many benefits of turf removal in selected areas. In addition to saving approximately 40 to 50 gallons of water per square foot per year, it can also lead to substantial savings in labor, seed, and fertilizer. Though, whenever replacing turfgrass or any landscape, consider utilizing native fauna that needs less water to thrive.

Consider converting smaller landscaped areas—such as median and sidewalk strips—to drip irrigation, which can save water because very little is lost to evaporation or runoff.

Where there are large turf areas, consider the long and short-term benefits of regular aeration of the soil. Aeration allows oxygen to better infiltrate the soil and get to the roots allowing them to “breathe,” while also increasing the ability of the soil to evenly absorb and distribute water. This is an even more important consideration when dealing with clay soils. Regularly loosening compacted soil allows the same amount of irrigation to do more, or could mean that less water is needed for turf to grow.

There are many benefits to foregoing the establishment of winter lawns by overseeding with ryegrass. Overseeding with ryegrass prevents warm-season Bermuda grass from completing its life-cycle of storing energy before its winter dormancy, making it more difficult for the Bermuda grass to re-establish itself in the spring. Ceasing any winter overseeding program can lead to substantial savings in labor, seed, fertilizer, and water.

Additional assistance may be available from the following sources:

- Your local water utility.
- The water management district that serves your region.
- The Irrigation Association (http://www.irrigation.org).
- American Society of Landscape Architects (http://www.asla.org).
- Xeriscape (http://www.xeriscape.org), for information on water-wise landscaping.

ALTERNATE SOURCES OF WATER

Underlying Concepts

Before discussing the best management practices for use of alternate sources, the following must be considered:

1. The use of an alternate on-site source of water is a best management practice (BMP) in and of its self.

2. Alternate on-site sources of non-potable water are freshwater resources and should be used efficiently.
3. Any water source can be treated to meet the needs and conditions of a desired end use. Economics and volume of water available are the major limiting factors.
4. These sources of water are perfect candidates to use in conjunction with potable water, recycled water and self-supplied fresh water.
5. The potential of this resource is only limited by the limits of the amount available and the ingenuity of the user.

In addition to reclaimed water, alternate on-site sources can include:

- Rainwater harvesting
- Storm water harvesting
- Air conditioner condensate
- Swimming pool filter backwash water
- Swimming pool drain water
- Cooling tower blowdown
- Reverse osmosis (RO) and Nanofiltration (NF) reject water
- Gray water (shower, bath tub, hand washing lavatories, and laundry water only)
- On-site treated wastewater systems
- Foundation drain water

Just as there are many sources, there are many possible uses of alternate sources of water, including:

- irrigation,
- green roofs,
- cooling tower makeup water,
- toilet and urinal flushing,
- makeup for an ornamental pond/fountain,
- swimming pools,
- laundry,
- industrial process use, and
- any other use not requiring potable water.

The use of alternate sources of water is one of the most dynamic areas in water conservation and resource management today. These sources include both reclaimed water provided by a local wastewater authority and on-site sources. Florida is a national leader in municipal reclaimed water reuse and is one of eight states with gray water regulations. In addition, Florida law provides for the following regulations:

- Fla. Rev. Stat. § 187.201 - It is state policy to (1) promote the use and reuse of water of the lowest acceptable quality and (2) develop alternative methods of treating, disposing, and reusing wastewater .

- Fla. Rev. Sta. § 373.1961 This statute encourages water management districts to share their tax revenues with consumers and water suppliers to develop systems that use reclaimed water and other alternative water sources.
- Florida Rev. Stat. § 375 provides for the reclamation of water.

New national level codes and standards that provide code guidance for implementing the use of all types of alternate sources have been developed in the last two years. These include:

- International Association of Plumbing and Mechanical Officials (IPMO) Green Plumbing and Mechanical Code Supplement, 2012,

- International Association of Plumbing and Mechanical Officials (IPMO) Green International Code Council (ICC), International Green Constriction Code, 2012.

- NSF/ANSI Standard 350: On-site Residential and Commercial Water Reuse Treatment Systems, NSF International, 2011.

- NSF/ANSI Standard 350-1: On-site Residential and Commercial Graywater Treatment Systems for Subsurface Discharge, NSF International, 2011.

When considering using an alternate source, it is important to keep in mind that each type of source is different. The table below summarizes some of the water quality characteristics that the various sources may have.

Water Quality Consideration for Alternate On-site Sources of Water						
Possible Sources	**Water Quality Considerations**					
	Sediment	**(TDS)**	**Hardness**	**Organic (BOD)**	**Pathogens**	**Other considerations**
Rainwater	**1-2**	**1**	**1**	**1**	**1**	*None*
Storm water	**3**	**?**	**1**	**2**	**2**	*Pesticides & fertilizers*
Air conditioner condensate	**1**	**1**	**1**	**1**	**2**	*May contain cooper when coil cleaned*
Pool filter backwash	**3**	**2**	**2**	**1**	**2**	*Pool treatment chemicals*
Cooling tower blowdown	**2**	**3+**	**3**	**2**	**2**	*Cooling tower treatment chemicals*
RO & NF reject water	**1**	**3+**	**3**	**1**	**1**	*High salt content*
Untreated Gray water	**For subsurface application only. May need lint screening**					***Detergents and bleach***
On-site wastewater treatment	**3**	**2**	**2**	**3+**	**3+**	*Human waste*
Foundation Drain Water	**1**	**?**	**?**	**2**	**2**	*Similar to stormwater*
Other Sources	**?**	**?**	**?**	**?**	**?**	*Depends on source*

The use of pass-through (once-through) cooling water is also a possible source of on-site water, but should be discouraged because of its huge potential to waste water, but it does provide a very clean source of water. For that reason, it is not included in this list.

1. Low level of concern
2. Medium level and may need additional treatment depending on end use
3. High concentrations are possible and additional treatment likely

? Dependent on local conditions

FIGURE 61: WATER QUALITY CONSIDERATION FOR ALTERNATE ON-SITE SOURCES

When deciding on the type of treatment for an alternate source of water, remember that it is necessary only to treat to the level needed for that application. The table below summarizes treatment methods that may be employed for various end uses of these sources.

Types of Treatment That May Be Employed Depending on Intended End Use Quality Needs						
Source	**Filtration**	**Sedimentation**	**Disinfection**	**Biological Treatment**	**Softening & Other**	**Other Considerations**
Rainwater (non-potable)	?		?			Depends on end use
Rainwater (potable)	x		x			Follow local code
Storm water	x	?	x	?	?	Oils and heavy metals
Air conditioner condensate	?		x		?	Copper? and bacteria
Pool filter backwash	x	?	x		?	Sediment, bacteria, & pool chemicals, salts
Cooling tower blowdown	x		x		x	High dissolved solids, bacteria, sediment
RO & NF reject water			?		?	High dissolved solids
Gray water	x	x	x	?		Bacteria, BOD, sediment
On-site wastewater treatment	x	x	x	x	?	Bacteria, BOD, sediment
Foundation Drain Water	x		x		?	Hardness, bacteria, sediment

FIGURE 62: TYPES OF TREATMENT THAT MAY BE EMPLOYED

METERING AND SUBMETERING

This BMP is intended for industrial water users that do not already have submeters on all significant water uses. Submeters are an effective method to account for all water usage within a facility in order to determine the amount of water used in specific processes and lost to leakage and to identify water efficiency opportunities. Before deciding to adopt this BMP, the applicant may want to determine the relative flow volumes to be measured by using estimation methods to determine the potential cost-effectiveness of installing a particular submeter.

METERING

A key component of every water conservation program is the setting of benchmarks and measuring to make sure that these benchmarks are being reached. Doing engineered calculations is one way, but the best way to do this is to install water meters wherever possible that are easy to read. The savings stated in this report were all calculated savings. A great deal of time and energy was invested just to be sure that the numbers all matched up.

The problem often with calculating or stipulating the savings is that it underestimates the water savings that can be realized from leaks and it has to make assumptions based on run time of equipment and habits of people. Typically savings projections that are calculated are underestimated because they do not take into consideration all of these factors. Improved data collection and record keeping will go a long way in setting up benchmarks and tracking usage in the future.

Leakage Rate	
Rate	**gal / month**
1 drip / second	263
5 drips / second	1,314
1 cup (8oz) / minute	2,738
1 quart (32oz) / minute	10,950
1 gallon / minute	43,800
4 gallon / minute	175,200

FIGURE 68: METER LEAKAGE RATE

Installing water meters throughout the facility to an AMR (Automatic Meter Reading) system is highly recommended. The cost per meter is based on the size of the meter (cost is typically between $1,000 to $4,000). Each of the new meters would then be equipped with a radio end point that would communicate to a central computer. This new system would provide an interactive meter reading screen, programmable alarms and the capability to keep 12-24 months' worth of data logging for each meter.

SUBMETERING

Sub-meters would be an effective method for facilities to measure all major water uses including but not limited to each process, sub-process or piece of equipment using water. Meters should be installed permanently where the meters could be regularly read and the data used for water management purposes. Also, keep in mind that proper sizing of sub-meters is an important consideration as large meters likely do not accurately measure water usage during low-flow periods.

Submeters should be installed at each cooling tower, boiler, cleaning equipment, and for irrigation. Information from submetering can improve the effectiveness of leak detection methods and equipment inspections.

Submetering data can be used to identify water use patterns and variability within the cannery and relative consumptive and non-consumptive uses of water. As water efficiency measures are implemented, the user can monitor the impact and resulting water savings.

FOOD SERVICE OPERATIONS

Food service operations are found in many commercial and institutional facilities ranging from prison kitchens, to fine dining restaurants. Water use in commercial kitchens includes water use for cleaning, cooking, scullery operations, and related activities. The following list provides guidance for purchasing and using equipment, appliances, fixtures and water using devices in commercial kitchens.

Scullery Operations All kitchens must clean plates, pots, pans, utensils and equipment used in the preparation of food. The following lists equipment commonly found in scullery operations and provides guidance for their purchase and use.

1. **COMMERCIAL PRE-RINSE SPRAY VALVES** The flow rate for a pre-rinse spray valve installed in a commercial kitchen to remove food waste from cookware and dishes prior to cleaning should not be more than 1.28 gpm (0.08 L/s) at 60 psi (414 kPa). Where pre-rinse spray valves with maximum flow rates of 1.0 gpm (0.06 L/s) or less are installed, the static pressure should be not less than 30 psi (207 kPa). Commercial kitchen pre-rinse spray valves should be equipped with an integral automatic shutoff. Once the US Environmental Protection Agency's WaterSense program issues its guidance on pre-rinse spray valves, WaterSense flow rates should replace those recommended in this section.

2. **WARE WASHERS** Dishwashers are found in many food service operations. Many are leased equipment, especially in restaurants. Institutional facilities tend to purchase such equipment. Whether purchasing or leasing equipment, it is the responsibility of the establishment leasing the equipment to ensure that the equipment is efficient. For leases, the efficiency of the equipment should be stated in the lease. The US Environmental Protection Agency's Energy Star program provides lists of such equipment including information on water and energy efficiency for Under the Counter, Door-type, and Conveyor type ware washers. The Energy Star program recommends the following:

Table 1: Efficiency Requirements for Commercial Dishwashers

Machine Type	High Temp Efficiency Requirements*		Low Temp Efficiency Requirements*	
	Idle Energy Rate	Water Consumption	Idle Energy Rate	Water Consumption
Under Counter	≤ 0.90 kW	≤ 1.00 gal/rack	≤ 0.5 kW	≤ 1.70 gal/rack
Stationary Single Tank Door**	≤ 1.0 kW	≤ 0.950 gal/rack	≤ 0.6 kW	≤ 1.18 gal/rack
Single Tank Conveyor	≤ 2.0 kW	≤ 0.700 gal/rack	≤ 1.6 kW	≤ 0.790 gal/rack
Multiple Tank Conveyor	≤ 2.6 kW	≤ 0.540 gal/rack	≤ 2.0 kW	≤ 0.540 gal/rack

* Idle results should represent **tank heater** idle energy rate measured with door closed and rounded to 2 significant digits. Gallons per rack results should be rounded to 3 significant digits.

**Includes pot, pan, and utensil machines.

FIGURE 69: DISHWASHER EFFICIENCY REQUIREMENTS

Rack type dishwashers typically are limited to use in institutional and commercial settings where a large number of people are fed. The US EPA has stated that they plan to rate such equipment in the future. In the interim, it is recommended that flight type machines use no more than 170 gallons per hour for each as specified by the manufacturers for single width machines. In all cases, fill and dump warewashing equipment should not be used.

3. **DISPOSAL FOR FOOD WASTE** In recent years, all have realized that food wastes are actually "misplaced resources." Composting of food waste has become commonplace is some communities. Composting facilities tend to fall into four categories:

   1. On-site composting,
   2. Off-site composting facilities,
   3. Composting at sanitary landfills and waste disposal facilities, and
   4. Collection and composting of sewage sludge that contains waste from garbage disposal.

Composting is not specifically a water efficiency measure even though compost helps save water in the landscape. The choice of disposal methods, however will influence the food waste handling technology used in the kitchen

Commercial and institutional entities have several choices of how to handle food wastes within their kitchen facilities. The use of scraping into collection bins and the use of strainer baskets to catch food waste instead of using mechanical systems has increased in recent years. The table below summarizes the operating characteristics of the options available. In addition to disposal equipment (grinders, mechanical strainers, pulper/compactors, and strainer baskets), troughs that are fed with either fresh or recirculating water are used in place of scraping into garbage receptacles to flush food waste down the drain to the mechanical types of equipment.

FIGURE 63: SUMMARY OF FOUR WASTE DISPOSAL METHODS

Summary of Four Waste Disposal Methods				
Parameter	Grinder	Mechanical Strainers	Pulper	Strainer Basket
Solids to Sewer	Yes	No	No	No
Recirculate	No	Yes	Yes	No
Strain Solids	No	Yes	Yes	Yes
Compost Produced?	Potentially at Waste Water Facility	Yes	Yes	Yes
Solid Waste Produced?	No	Yes	Yes	Yes
Flow Restrictor?	Yes	No	No	N/A
Horsepower	1-10	0.75-7.5	3-10	0
Potable Water Use (gpm)	3-8	1-2	1-5	0
Sluice Trough (gpm)	2-15	2-15	2-15	0

COOKING EQUIPMENT Steamers, combination ovens, pasta cookers, and steam kettles and similar equipment all use water in the cooking process.

1. Steamers: Steamers are used to cook food with steam generated either in an external boiler or from water in a pan with a heating element under it at the bottom of the pan. Boiler type steamers must be connected to both a water supply and a drain to the sewer. Boilerless types do not need such connections, unless they are connected to an automatic refill valve. Boiler type steamers find use in restaurants where the door is opened often and temperature recovery time is critical. Boilerless types do not recover temperature as fast but are significantly more energy and water efficient.

   Boiler type steamers sometimes are required to have cold water lines drain into the sewer to keep temperatures in the sewer drain below 140^{o}F. Many such "tempering water" lines are simple copper or plastic tubes connected to a valve. Water runs continuously all day. The best practice is to set the discharge from the steamer so that tempering water is not needed. If that is not possible, a solenoid valve that only opens when the boiler is in operation should be installed.

2. The recommendations for steamers are as follows:
3. Use a boilerless steamer where ever possible. Most institutional facilities can use boilerless steamers.
4. Boilerless steamers should not use more than 2.0 gallons of water per hour per pan.
5. Boiler type steamers should not use more than 5.0 gallons of water per hour per pan.
6. Combination Ovens: Combination ovens, as the name implies can cook in several modes including baking, broiling, and steaming or a combination of the three. Combination ovens should not use more than 3.5 gallons of water an hour.
7. Pasta Cookers: Pasta cookers are used where large volumes of cooked pasta are prepared. They look much like a commercial fryer, but are used to bring water to a boil and cook pasta. They can be continuously filled with some water overflowing to the drain to maintain starch levels in the water. Pasta cookers should be equipped with temperature controls to keep them at a simmer rather than a rolling boil. If overflow is practiced, it should be minimized.
8. Steam Kettles: Steam kettles are used to cook large volumes of food. The steam enters a chamber surrounding the cooking vessel (pot) and condenses. This heats the cooking vessel and its contents. Steam can either be supplied by a remote boiler or by a self-contained boiler. In both cases, the steam condensate should be returned to the boiler. Cooking pot valves at the bottom of the cooking vessel are used to drain liquids and cooked foods from the pot. These valves tend to develop leaks if not maintained and should be checked routinely for leaks.

REFRIGERATION, ICE MAKERS, FROZEN CUSTARD AND SIMILAR EQUIPMENT: All of this equipment uses mechanical refrigeration to remove heat from food products to cool them or freeze them. Three recommendations regarding this equipment will help reduce both water and energy use.

1. All once through (pass through) cooling should be eliminated,
2. All ice machines should be EPA Energy Star Listed,
3. Flake ice machines should be used where possible since they are the most energy and water efficient types,
4. Cube type ice machines and others producing hard ice should use less than 20 gallons per 100 pounds of ice,
5. Air cooled equipment should be used exclusively,
6. Remote systems will reject heat to the outside thus reducing heat load in the building, and
7. Where water cooled equipment is used, it should be connected to a chilled water or cooling tower loop, but water cooled equipment of any kind is strongly discouraged.

An example of why once through cooling is completely discouraged in the use of water cooled ice machines. Based on the latest information from the US Department of Energy, water cooled ice machines reduce electric costs 13.7 cents per 100 pounds of ice made at 10 cents per kilowatt hour, but these machines require from 85 to 200 gallons of cooling water for every 100 pounds (12 gallons) of ice made.

Even at a combined water and sewer cost of $2.50 per thousand gallons, a very low cost, water and wastewater costs far outweigh the energy savings for making ice with water cooled machine. The table below illustrates this. Most Florida cities charge far more than $2.50 for combined water and sewer costs so the savings by using an air cooled machine are even greater.

Air Cooled Cost Savings Using DOE Latest Recommended Energy Standards for Ice Machines.			
Gallons of water needed per 100 lb. of Ice Made*	***Cost of Water and Wastewater Combined $2.50 per kGal (Cents/100 Pounds)***	***Energy Savings per 100 Pounds With Water Cooled Equipment at 10 Cents per kWh. (Cents/100 Pounds)***	***Net Savings per 100 Pounds with Air Cooled Equipment (Cents/100 Pounds)***
85	21.25	13.7	7.6
100	25	13.7	11.3
150	37.5	13.7	23.8
200	50.0	13.7	36.3
** Based on a survey of all water cooled ice machines available on the US market.*			

FIGURE 64: AIR COOLED COST SAVINGS USING DOE ICE MACHINES

OTHER EQUIPMENT:

Wok Stoves: A wok stove is a Chinese pit-style stove. In a conventional wok stove, the burner chimney and ring are affixed to the top of the stove; as a result, heat is trapped under the cook top. Water jets are installed to enable cooling water to flow at approximately 1.0 gpm per burner across the cook top to absorb the heat. Waterless wok stoves, a relatively new technology, are cooled with air, and thus do not require the use of cooling water. These wok stoves' function by creating an air gap between the burner chimney and ring and the top of the stove so that the heat can be released directly from beneath the cook top and vented to the kitchen exhaust. Commercial kitchens using woks should investigate using this new technology that saves both water and energy.

Grease Interceptors. Grease interceptor maintenance procedures shall not include post-pumping/cleaning refill using potable water. Refill shall be by connected appliance accumulated discharge only.

Dipper Well Faucets. Where dipper wells are installed, the water supply to a dipper well shall have a shutoff valve and flow control. The flow of water into a dipper well shall be limited by at least one of the following methods:

Maximum Continuous Flow. Water flow shall not exceed the water capacity of the dipper well in one minute at supply pressure of 60 psi (414 kPa), and the maximum flow shall not exceed 2.2 gpm (0.14 L/s) at a supply pressure of 60 psi (414 kPa). The water capacity of a dipper well shall be the maximum amount of water that the fixture can hold before water flows into the drain.

Metered Flow. The volume of water dispensed into a dipper well in each activation cycle of a self closing fixture fitting shall not exceed the water capacity of the dipper well, and the maximum flow shall not exceed 2.2 gpm (0.14 L/s) at a supply pressure of 60 psi (414 kPa).

Practices and Policies: Simple, effective practices are the cornerstone to sustainability and water conservation. Integrating water efficiency into employee training and company policies set a tone that the organization is committed to sustainability and conservation. Most water conservation practices require simple, low or no cost changes by staff and management that quickly integrate into employee's daily routines. There are literally hundreds of ways to save water in foodservice operations. A few are listed here:

1. Defrost meats in refrigerators rather than under running water. If you must use running water, keep the water flow to a minimum rate that circulates the water. The faucet (using an efficient aerator) does not need to be fully on.
2. Keep lids on boiling water during slow times
3. Use dry cleaning techniques (broom and mop) rather than spraying water to clean floors or use a waterbroom instead of a hose
4. Do not use running water to melt ice. Put the ice in the mop sink or dish sink where it will melt during regular use.
5. Implement proper fat, oil and grease handling best practices
6. Serve water to guests only on request

LAUNDRY OPERATIONS

Laundry operations in commercial and institutional facilities generally can be grouped into three types of operations:

1. Self-Service (coin or card operated) laundry equipment found in facilities such as laundromats, dorm, self-serve hotel laundry rooms, and at apartment laundry rooms
2. On-premise laundry equipment found at hotels, hospitals, prisons, nursing homes and other facilities that wash clothing, bedding and food service toweling in a common laundry facility
3. Industrial laundry operations that take in laundry from a variety of entities

Self-Service laundry equipment was once dominated by "single load" top loading washers. With the advent of front loading equipment, clothes washers have become much more efficient.

For single load self-service equipment, the US Environmental Protection Agency Energy Star program recommends a Water Factor (WF) of 4.5 gallons per load of clothes per cubic foot of capacity and an energy factor (EF) of 2.2 cubic feet per kilowatt-hour (kWh) per load.

Many laundromats now have multi-load equipment able to wash more than the standard 20 pounds of laundry per load. Equipment meeting a water factor (WF) of 4.5 or less is available. At a minimum, a water factor of 5.5 or less is recommended.

Most self-serve clothes washers are leased from "rout operators." The contract and service agreement with the rout operator should specify that all clothes washers have a water factor of 4.5 or less.

On-Premise laundry equipment is rated by the pounds of laundry that can be washed in a single load. Sizes range from 50 pound to 800 pound machines. The common term used to describe these large clothes washers is "washer-extractor" since they both wash and "spin-dry" the clothes. Unlike self-serve equipment that have a set wash cycle, on-premise equipment can be set to the type of laundry being washed. Variable factors include formulation of detergent and chemicals used, number of wash, rinse and additive cycles, water level, water temperature, and wash (dwell) time.

To maximize the efficient operation of commercial washer-extractor equipment, consider the following:

1. Consult manufactures literature and compare energy and water efficiencies of equipment when leasing or purchasing new washer-extractors.

2. Separate and wash laundry based upon the extent to which materials are soiled and type and color of materials. Set water levels, number of cycles and formulation accordingly. This can have a significant impact on total water use. Highly soiled materials can typically require over 3.0 gallons of water per pound of laundry, while sheets and lightly soiled materials require only about 2.0 to 2.5 gallons of water per pound of laundry.

3. Work with the equipment manufacturer and supplier to provide an ongoing service and maintenance program.

4. Consult service personnel and the laundry's supplier of chemicals for the wash equipment to ensure that equipment is operating at optimal efficiency.

Industrial Laundries are similar to on-premise systems, but offer laundry services to mainly commercial entities that do not wish to operate on-premise systems. For washer-extractor equipment, the recommendations are the same as that for on-premise laundries. For very large operations, continuously operating tunnel washer can be used in place of washer-extractors. Tunnel washers maximize energy and water efficiency. Dirty clothes are continuously loaded on one end into the "first flush" chamber, while fresh water enters the final rinse chamber at the other end. This water is cascaded. These systems are capable of washing over 2,000 pounds of laundry an hour. Even heavily soiled materials use under 2.5 gallons per pound of laundry and overall operations reduces water use to about 2.0 gallons per pound of laundry or less for lightly soiled materials.

Tunnel washers are very efficient, but also very expensive. Each industrial laundry operation will need to conduct a cost - benefit analysis to determine if a tunnel washer is an option for their operations.

Water Recycle, Reuse, and Ozone Addition are other ways to reduce potable water use. Recycle refers to recycling water with little treatment. An example of this is the recycle of final rinse water for first flush or for surfactant (soap) cycle. Reuse involves some level of treatment before the water is reused. Ozone is used as a disinfectant and a way of reducing other chemical use.

- Recycle systems are the least expensive type systems. They can be installed on washer-extractors for a few thousand dollars.
- Reuse equipment can treat and reclaim water used by washer-extractors. Some systems only reuse various rinse waters while others treat all water discharged from washer-extractors. Recovery ranges from 20 percent of water use to 85 percent of water use depending on the sophistication of the system. Cost can range from a few $10's of thousands of dollars to hundreds of thousands of dollars for large systems that recover over 80 percent of the water.
- Ozone is a powerful disinfectant and whitener. For lightly soiled clothes, it can reduce water use by reducing the number of wash cycles a washer-extractor must use. Water savings in the range of 20 to 30 percent have been reported. Heavily soiled material, especially cloth solid with grease or oil will still require the use of detergent cycles. Ozone systems can be easily disconnected or left off. Management will have to ensure that workers are trained so that the full benefit of these systems can be realized.

The selection of recycle, reuse or ozone systems is encouraged, but each laundry operation will have to conduct its own cost - benefit analysis.

WATER TREATMENT

Water treatment is needed in the institutional and commercial sectors to:

- Treat water to improve the longevity and function of water using equipment,
- Treat water that is being recycled,
- Treat alternate sources of water,
- Pre-Treat wastewater to meet discharge standards to a sanitary sewer, and
- Treat wastewater for disposal on site.

Treatment needs range from the need to soften water for laundry operation and commercial dishwashers, to grease traps to pre-treat restaurant wastes, to recycling water at car washes, to treating water at hospitals for kidney dialysis. The following shows examples of water treatment used in example commercial and institutional operations.

Examples of Water Treatment								
Operation	**Sediment Filtration**	**Act. Carbon**	**Softening & Ion Exc.**	**Membrane Process**	**Distillation**	**Disinfection**	**Biological Treatment**	**Other**
Food Service	X	X	X	X		X		X
Laundry & Dry Cleaning	X		X	?		X		X
Industrial	X	X	X	X	X	X		X
Car Wash	X		X	X		X	X	X
Cooling Towers & Boilers	X		X	X		X		X
Pools, Spas & Water Features	X			?		X		
Office and Non - Process Uses	X	X	X	X		X		X

FIGURE 72: EXAMPLES OF WATER TREATMENT

When considering treatment of water for commercial purposes, protection of public health should always be a primary consideration. Licensed plumbers, and those licensed to install point of use/point or entry equipment are trained to properly install water treatment devices. For more complicated systems, the services of a licensed engineer may be needed. Treatment of the water should not exceed the level of quality needed for the intended end use. The following best practices will minimize water use. Again, the best conservation method is to not install water treatment equipment if it is not needed for the intended use of that water.

a) Filters: Sediment filters include sand, coated media such as diatomaceous earth, cartridge, bag, and membrane filters(micro and ultra-filters). All remove particulates by capturing them on their surface. At some point, the buildup of sediment will have to be removed. Sand and membrane filters are cleaned by backwashing. Coated medial filters are flushed of sediment laden filter material and recoated, and some cartridge and bag filters are removed and washed. For sand and membrane filters:

   - Backwash based on pressure drop, not timers
   - Size the filter to the need
   - Consider ways to reuse the backwash water

   For coated media filters:

   - Choose filters that have a recoat function so that the media (such as diatomaceous earth, perlite, or cellulose) can be "bumped off" and recoated several times before the pressure drop reaches the level needed for backwash
   - Backwash based on pressure drop
   - Size the filter to the need
   - Consider ways to reuse the backwash water

   For washable cartridge and bag filters:

   - Wash based on pressure drop, not timers
   - Minimize water use for the cleaning operation

b) Softening and Ion Exchange: These technologies are used to remove cations and anions. In the case of softening, sodium ions are exchanged for calcium and magnesium cations. Ion exchange devices actually replace cations and anions with hydrogen and hydroxyl ions.

   - Do not use timers to regenerate systems
   - For smaller systems, use flow meters that are set to regenerate based on average water quality. Actuation of regeneration of water softeners shall be by demand initiation. Water softeners shall be listed to NSF/ANSI Standard 44. Water softeners should have a rated salt efficiency exceeding 3400 grains (gr) (0.2200 kg) of total hardness exchange per pound (lb) (0.5 kg) of salt, based on sodium chloride (NaCl) equivalency, and shall not generate more than 5 gallons (19 L) of water per 1000 grains (0.0647 kg) of hardness removed during the service cycle

- In residential buildings, where the supplied potable water hardness is equal to or less than 8 grains per gallon (gr/gal) (137 mg/L) measured as total calcium carbonate equivalents, water softening equipment that discharges water into the wastewater system during the service cycle should not be used except as required for medical purposes.

- For larger systems, use analytical equipment to determine when softener or ion exchange beds are nearly exhausted.

c) Reverse Osmosis (RO) and Nanofiltration: Small, under-the-counter units tend to waste a large percent of water processed . Their use should be limited to absolute need. Some such systems will actually repressurize the reject water and reintroduce it into the potable water plumbing for use elsewhere in the building. When purchasing RO and nanofiltration equipment for larger commercial use, larger units should recover at least 75 percent of the feed water. Smaller systems will be less efficient. Careful selection to minimize the percent of reject water will maximize water efficiency. RO and Nanofiltration reject water should be captured and reused for irrigation, cooling tower makeup, and other appropriate uses where ever possible.

d) Distillation systems for water purification should have at least an 85 percent recovery rate for distilled water and not be cooled by once-through-cooling.

e) All other treatment devices should be sized properly. Most do not have reject streams or need backwashing. In the case of wastewater treatment for on-site reuse or recycle, choose equipment that treats to the quality needed.

LABORATORY AND MEDICAL FACILITIES

Laboratory and medical facilities include but are not limited to:

- clinics
- hospitals
- dental offices
- veterinary facilities
- medical laboratories
- university & analytical laboratories
- industrial/commercial laboratories
- any operations using similar equipment

Equipment of specific interest include:

a) Vacuum systems,
b) Sterilizers,
c) Instrument and Glassware Washers,
d) Vivariums,
e) Exhaust Hood Scrubbers,
f) Large Frame X-Ray Film Developers,
g) Water Treatment Equipment to Produce Ultra-Pure Water, and
h) Laboratory and Medical Equipment Cooling

In addition to the equipment listed above, most of these facilities have domestic, food service, cooling, heating, irrigation and related water uses. These uses are discussed in their own sections.

a) VACUUM SYSTEMS:

Almost all modern laboratories, hospitals, and dental offices have vacuum systems for either drawing vacuum to remove bodily fluids or to draw fluids and gasses. Very high vacuum pump systems find limited use in some special areas and are not the topic of this discussion.

In the past, aspirator or venturi vacuum systems were common. These form a vacuum using the Bernoulli effect. They are extremely wasteful ways to create a vacuum, but have been the mainstay for many chemistry labs since the fumes from organic compounds and acids are immediately mixed with water. The next most common type of vacuum system from the past is the liquid ring vacuum pump. These are mechanical pumps that use water to cool the pump and create the seal for generating the vacuum. For years, most hospitals and dental offices used these pumps.

Modern dry vacuum pump systems are both more energy efficient and eliminate the use of water. With the exceptions of explosive or very corrosive environments, dry vacuum systems should be used for all vacuum purposes. Currently the only exception are medical vacuum sterilizers in the United States. They are limited to liquid ring or venturi vacuum systems according to Federal Drug Administration requirement. However, laboratory and pharmaceutical vacuum sterilizers can use dry vacuum systems. In Europe and elsewhere, dry medical vacuum systems are now being approved.

b) **STERILIZERS**:

Based on Federal Drug Administration regulations, sterilizers are divided into medical, pharmaceutical, and laboratory categories. Medical sterilizers are further divided into gravity, vacuum and table type systems. Table top sterilizers are small systems that use little water and should not be of concern. These best management practice recommendations regard large, standalone gravity and steam sterilizers. These sterilizers require a supply of "high purity" steam which means that the boiler for the sterilizer is fed with distilled water. The two main concerns regarding sterilizers is the way steam trap discharge is handled, and the type of vacuum system used for vacuum sterilizers.

Steam Trap Discharge: For both types, the steam jacket surrounding the actual chamber in which instruments are placed is kept hot with live steam. Some of this steam condenses and therefore, several times a day, a small amount of steam condensate (pure water from steam) is discharged. Current plumbing codes require that water entering the sanitary sewer may not exceed 140°F (60°C). In the past, tap water was continuously discharged to the same trap that the steam condensate discharged to. The water never was turned off and significant volumes of water were wasted. There are five methods to reduce this use. They are arranged from least savings to most energy and water savings potential. These include:

1) Installing water tempering devices (since 2000 most systems contain these devices),
2) Using a chilled water loop to cool the condensate prior to discharge,
3) Install sterilizers with self-contained boilers that return all steam jacket condensate.
4) Capture waste heat for other uses,
5) Returning the steam jacket condensate to the mail high purity boiler.

Vacuum Sterilizer Systems:

1) Eliminate the use of venturi type vacuum systems,
2) Use dry vacuum pumps and systems for all non-medical vacuum needs, and
3) For medical sterilizers, use liquid ring vacuum systems until dry vacuum systems are approved for use as they are in Europe.

c) **INSTRUMENT AND GLASSWARE WASHERS:**

Instrument washer-disinfectors and laboratory glass ware washers are not rated for water use. However, when purchasing such equipment, compare models for water and energy use. The new 2012 Draft for the US Green Building Council's LEED recommendations for washer-disinfectors is no more than 0.35 gals per standard U.S. tray for instruments.

d) **VIVARIUMS**:

Vivariums are found in many laboratory, medical, pharmaceutical, and related research facilities. These can range from laboratory rat and rabbit operations to primate facilities.

Vivariums use equipment and practices specific to animal care, such as automatic animal watering systems. Vivariums and other animal maintenance facilities can consume large volumes of water because of the need for constant flows and frequent flushing cycles. If it is properly sterilized, this water can be recirculated in the watering system rather than discharged to drains. Where this water cannot be recycled for drinking because of purity concerns, if it is sterilized, it is still likely to be acceptable for other purposes, such as cooling water make-up, or for cleaning cage racks and washing down animal rooms.

Cage, Rack, and Bottle Washers are found in vivariums and animal research facilities. The equipment ranges from conveyor washers for mice and rat cages that closely resemble conveyor dishwashers to large compartment washers that can hold carts of cages or large primate cages. The following Best Management Practices information is provided as part of the U. S. Environmental Protection Agency's "Labs for the 21st Century" program.

- Replace older inefficient cage and rack washers with more efficient models. Look for models that recycle water through four cleaning stages using a counter-current rinsing process. In counter-current rinsing, the cleanest water is used only for the final rinsing stage. Water for early rinsing tasks (when the quality of rinse water is not as important) is water that was previously used in the later stages of rinsing operations.
- Retrofit existing cage and rack washers to make use of counter-current flow system to reuse final rinse water from one cage-washing cycle in earlier rinses in the next washing cycle.
- Use tunnel washers for small cage cleaning operations.
- Sterilize and recirculate water used in automatic animal watering systems instead of discharging water to the drain. Consider using water that cannot be recycled for drinking due to purity concerns in other non-potable applications, such as cooling water make-up or for cleaning cage racks and washing down animal rooms.

e) EXHAUST HOOD SCRUBBERS:

Liquid scrubber systems for exhaust hoods and ducts should be of the recirculation type. Liquid scrubber systems for perchloric acid exhaust hoods and ducts should be equipped with a timer-controlled water recirculation system. The collection sump for perchloric acid exhaust systems should be designed to automatically drain after the wash down process has completed.

f) LARGE FRAME X-RAY FILM DEVELOPERS:

Small X-ray film processors such as those found in dental offices use little water and are not of concern. Medical facilities that have not converted to digital systems for large X-rays should be encouraged to do so as soon as possible. Processors for X-ray film exceeding 6 inches (152 mm) in any dimension should be equipped with water recycling units.

g) WATER TREATMENT EQUIPMENT TO PRODUCE ULTRA PURE WATER:

Water treatment equipment that employs nanofiltration or reverse osmosis (RO) all have reject streams of water from the equipment. The general rule of thumb is that the larger the equipment, the more efficient it is. For this reason, where large volumes of RO water is needed, a single central large RO system that has a product water recovery rate of 75 percent or better can be used. For smaller operations that do not require a central system, product water recovery rates of 50 percent are possible. All systems should be shut down when not in use. Kidney dialysis systems, ultrapure water systems for laboratory use, and high purity steam requirements for sterilizers should all be designed using the water treatment best practices discussed in that section.

h) LABORATORY AND MEDICAL EQUIPMENT COOLING:

Once through cooling should be eliminated except for emergency conditions in medical settings. A detailed discussion of cooling is presented on the sections on Cooling and Boilers. For medical and laboratory equipment, the following best management practices should be followed:

- Use air cooling where possible,
- Connect equipment to chilled water loops,
- Use stand-alone chiller systems, or
- Connect to a cooling tower loop.

The type of system selected to eliminate once through cooling will depend on the specific circumstance.

7.0: COST EFFECTIVENESS CONSIDERATIONS

Much has been reported on the rise of energy costs, but most will be shocked to find that water and wastewater costs are rising at 2.8 times the rate of electricity and general inflation and that in the last two years, natural gas prices have actually declined.

This is dramatically illustrated in the graph taken from the Institute of Public Utilities, Michigan State University, TRENDS IN CONSUMER PRICES (CPI) FOR UTILITIES THROUGH 2011. This graph shows the price of the major utilities used by commercial entities indexed to the consumer price index. Clearly, water and wastewater costs are rising much faster than electric and natural gas energy prices - in fact, over 2.5 times faster than electric rates.

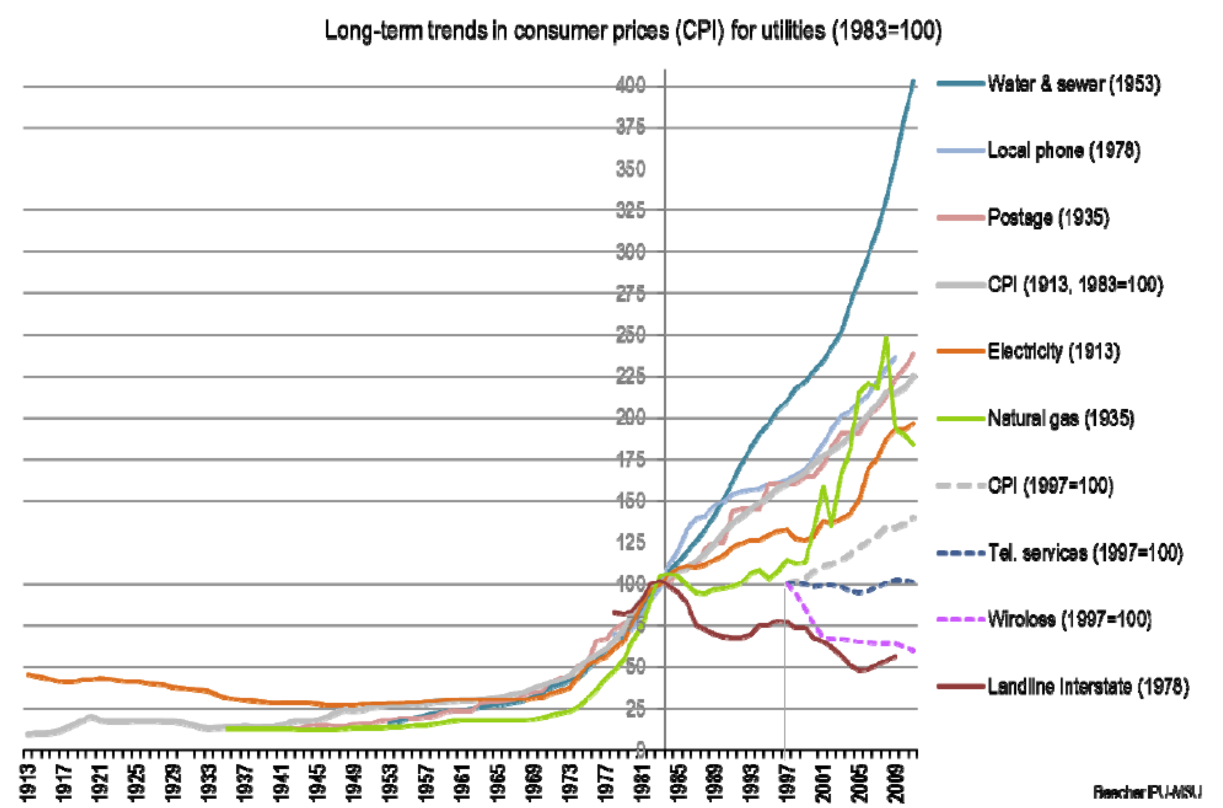


Exhibit 1. Long-term trends in the Consumer Price Index (CPI) for utilities (1913-2011).
The index is set to 100 for 1982-1984 except for telephone and wireless services, where the index is set to 100 for 1997.

FIGURE 73: LONG-TERM TRENDS IN CONSUMER PRICES

Many areas of the United States have, or will soon experience limits to conventional water supplies. In many areas of the Southwest, conventional water supplies are or are nearly tapped out. But, who would have thought of Georgia and Florida having water shortages a few years ago. This means that more costly sources such as sea water desalinization will be the future for supply. One recent

Federal Budget Office study shows that 36 states may face shortages of some kind in the near future. These shortages are being seen worldwide as water needed to fuel economic and population growth outstrips local water supplies.

Infrastructure costs are also certain to rise. The American Society of Civil Engineers in its 2009 report on infrastructure gives our aging water and wastewater infrastructure a grade D-. The Black and Veatch report of the cost of water and wastewater services for the top 50 cities in the United States (www.bv.com/Downloads/.../rsrc_EMS_Top50RateSurvey.pdf) shows that commercial water and wastewater rates have risen at an average of 5.6 percent since 2001. They predict that this rate of inflation will continue in the near future. The cost of upgrading existing system along with more stringent water and wastewater standards coupled with more costly raw water sources will all contribute to rising water and wastewater costs rising.

By contrast, natural gas prices are projected to stabilize or even decrease relative to inflation and electric costs will rise at a rate of about two percent over the next ten to twenty years according to the U.S. Energy Information Administration (http://www.eia.gov/forecasts/aeo/er/). The bottom line is that water and wastewater costs will continue to rise faster than energy costs for commercial buildings.

Water and Sewer Rate Increases for Selected Cities Between 2007 and 2008 *NUS Consulting Group*			
City	**Percent Increase**	**City**	**Percent Increase**
New Orleans, LA	51.9%	St. Louis, MO	32.4%
Fort Smith, AR	29.6%	Sioux Falls, SD	18.2%
Los Angeles, CA	17.9%	Binghamton, NY	16.6%
Kansas City, MO	16.3&	San Francisco, CA	15.8%

FIGURE 65: WATER AND SEWER RATE INCREASES FOR SELECTED CITIES

The figure below compares combined average commercial and sewer rates in the United States to selected Florida cities. Nationally, commercial water and sewer rates rose 29.5 percent between 2005 and 2010 according to Black and Veatch's survey of water rates.

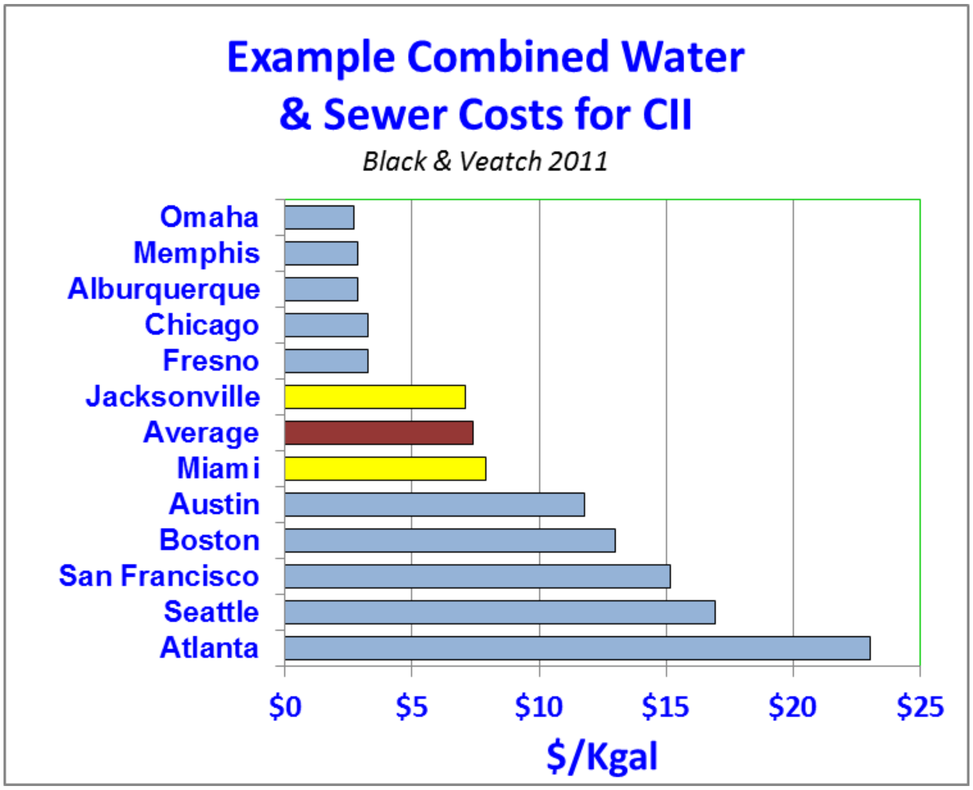


FIGURE 66: EXAMPLE COMBINED WATER & SEWER

Given the increasing water and sewer costs across the nation, it is important to complete water use audits and cost effectiveness consideration assessments. In order to perform the tasks outlined in audit process, the person performing the audit must complete the following five tasks:

1. Calculate the Unit Value of Water Used;
2. Identification of Water Using Equipment, Fixtures and Operations and
3. Determination of Applicable Water Efficient Practices and Equipment;
4. Determine Possible Water Savings; and
5. Calculation of the Savings Associated with Conservation Actions and the Cost of the Actions.

1. Calculate the Unit Value of Water Used: To determine the cost of water, first obtain the unit cost of water. This is usually expressed in dollars per thousand gallons or dollars per 100 cubic feet. Do the same for wastewater if it is charged based on the volume of use. Add these together to obtain the total cost of water. If costs are expressed in thousands of gallons it can be converted to gallons by multiplying by 0.748. In simplified terms that is thousands of gallons times 0.748 = Use in thousands of gallons.

EXAMPLE 1:

Question - The small facility used 52 thousands of gallons in a month. Convert to gallons

Answer - 52 X 0.748 = 38.9 thousand gallons or 38,900 gallons a month

To convert the cost of water or wastewater in dollars per thousands of gallons, divide the cost by 0.748.

EXAMPLE 2:

Question - Water cost $2.50 per thousands of gallons. What is that cost in dollars per thousand gallons?

Answer - $2.5/ 0.748 = $3.34 per thousand gallons

If the water is to be heated, determine the type of energy used to heat the water (gas, electric, etc.) and its cost per unit (Cents per kilowatt hour, or dollars per therm, or dollars per MCF[thousand cubic feet] of natural gas) etc. The two figures below show the cost of heating one thousand gallons of water with either electricity or natural gas for water which has it temperature raised either 55^{o}F or 120^{o}F, typical of water heated either for domestic use or for high temperature use in a commercial dishwasher in Florida

If the gas is billed in therms, the cost can be converted to dollars per MCF of gas by multiplying the cost of the gas in therm by 10 to convert it to dollars per MCF.

If propane is used, one MCF of gas contains approximately one million BTU's which is equivalent to approximately 11 gallons of propane. Therefore, if propane costs $2.00 per gallon, it would be equivalent to natural gas costing $22.00 and MCF!

***EXAMPLE 3*:**

Question - Natural gas cost $0.60 per therm. What does it cost to heat water by 55^{o}F?

Answer - $0.60 X 10 = $6.00 per MCF. It is equal to approximately $3.50 per thousand gallons.

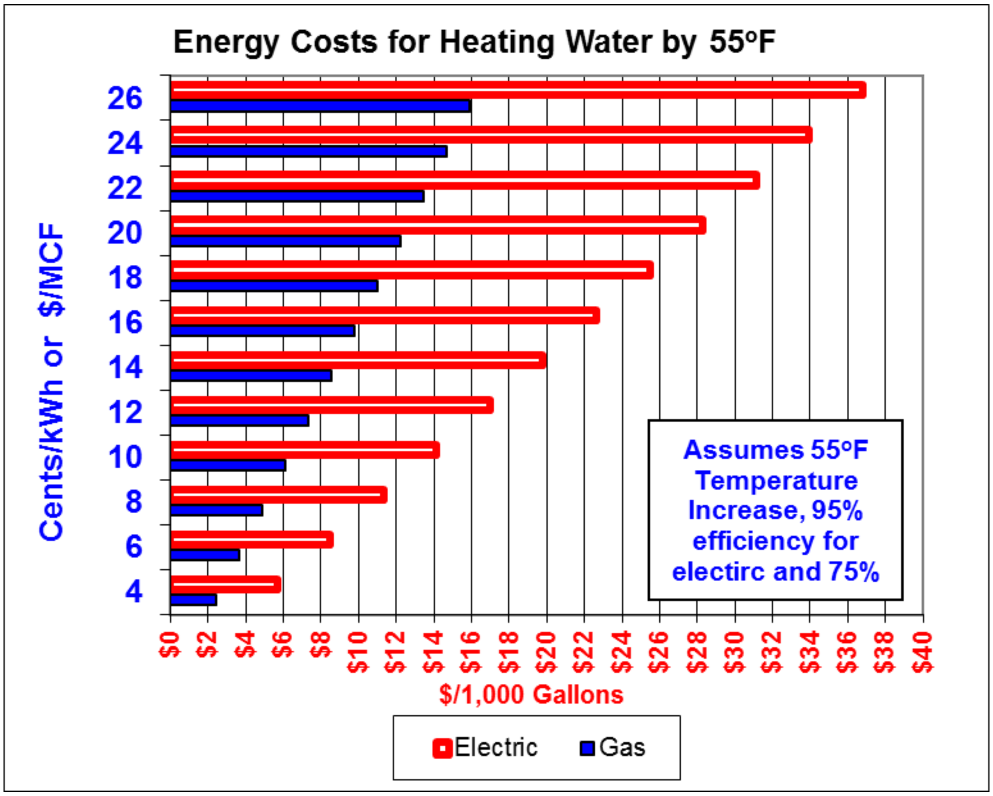


FIGURE 67: ENERGY COSTS FOR HEATING WATER BY 55 DEGREES

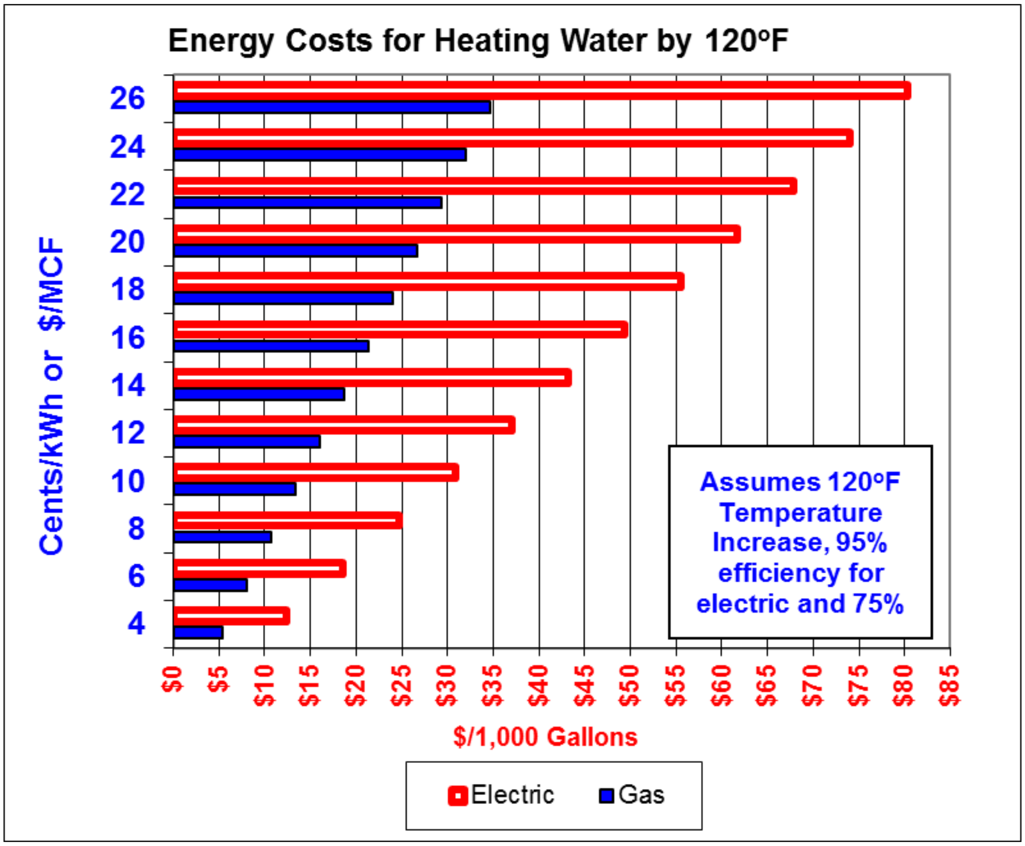


FIGURE 68: ENERGY COSTS FOR HEATING WATER BY 120 DEGREES

Additional costs for softening the water or other treatment must also be estimated. For example, for softening, the cost of the salt per month can be divided by the amount of water treated by the softener.

EXAMPLE 4:

Question - Water costs $2.50 per thousands of gallons *and wastewater costs $3.00 per* thousands of gallons. *The water is used for domestic hot water. The water is heated with electricity at 10 cents a kilowatt hour. What does it cost to heat water by 55°F?*

Answer - The water costs a total of $5.50 per thousands of gallons *($2.50 + $3.00). This is equal to $7.35 per thousand gallons. {$5.50 / 0.748 = $7.35}*

The cost of heating the water by 55°F is approximately $14.20 per thousand gallons. Therefore total water costs include energy costs plus water and wastewater costs.

Total Cost = $7.35 + $14.20 = $22.55 per thousand gallons or 2.255 cents a gallon {=($22.55 X 100 cents a dollar) / 1,000 gallons = 2.255 cents a gallon}
This can be rounded off to 2.3 cents per gallon for use in estimating savings.

If natural gas were used from the table below, the total cost would be $7.35 + $3.50 = $10.85 per thousand gallons. That is 1.085 cents per gallon.

Dollars per Year for Toilet Flushing ***$6.45 per 1,000 gallons or $4.82 per CCF***				
		Type of Facility		
Gallons per Flush	**Cents per Flush**	**Home** **6 flushes per day**	**Office** **35 flushes per day**	**Restaurant** **75 flushes per day**
5	**3.27**	***$72***	***$418***	***$895***
3.5	**2.29**	***$50***	***$292***	***$627***
1.28	**0.84**	***$18***	***$107***	***$229***

FIGURE 78: DOLLARS PER YEAR FOR TOILET FLUSHING

EXAMPLE 5:

The small facility uses 52 thousands of gallons *per month. They determine that 70 percent is only cold water and the other 30 percent is hot water. They heat with gas. The hot water use is to wash equipment and a two percent (2%) chemical cleaning solution by weight that costs $18.00 per pound. How much does the use of hot water actually cost?*

From example below, hot water costs $10.85 per thousand gallons. Thirty percent of the total use of 52 thousands of gallons *is hot water with chemical added.*

Hot water use = 52 X 748 gallons per thousands of gallons = 11,668.8 Gallons a month. It costs $10.85 per thousand gallons so the cost per month = [11,668.8/1,000] X $10.85 = $126.60 per month.

Another way to look at cost is to compare annual costs for use of fixtures with different flow rates. The table above shows a comparison of annual cost to operate a toilet in various settings over a 365 day year.

Developing the Benefit/Cost Estimate

When determining whether a BMP is cost effective, the customer will need to assess the financial costs and benefits of implementing the BMP. A variety of financial metrics may be used to determine whether a particular BMP makes economic sense from cost/benefit perspective. Some important considerations when calculating the costs of BMPs are:

- Water and wastewater savings
- Cost of the measure
- Energy costs decrease or increase
- Chemicals costs or savings
- Waste disposal costs associated with water treatment or use
- Labor costs or savings
- Liability
- Usable life of equipment or processes

Costs are typically calculated for each recommended BMP within a comprehensive CII water conservation audit.

There are several ways to calculate cost/benefit ratios for business/customer implementation of BMPs. When discussing cost/benefit analyses, some common terms used include "payback period," "return on investment": (ROI), and "internal rate of return" (IRR). These analyses provide guidance in the short term, and help to determine if a proposed modification is worth the investment. Longer-term analyses also consider lifecycle factors, such as net present value, inflation, and amortization.

The payback period is the time required for an investment in efficiency to pay for itself. The simple payback is calculated by dividing the total costs (including installation, capital, permitting, and equipment costs) by the annual benefits, giving a simple payback in terms of years. A two-year payback is generally considered to be extremely cost effective; many firms may choose a 3-4 year payback period. If a business using a more efficient device does not own the building or the equipment, some issues with the economics of payback become more challenging.

Another metric which is similar to payback is **Return on Investment (ROI).**

The return on investment (ROI) is the percent of payback the BMP produces per year. In the case of a one-year payback, the ROI is 100%. If the payback is in 1.6 years the ROI is equal to ($100%/1.6) or 62.6% a year.

The internal rate of return, or IRR, provides an indication of the efficiency of an investment. It is defined as the effective annual interest rate at which an investment accrues income. The IRR can be compared to the interest rate on borrowed funds or the rate of return that is possible from other investments. If IRR is higher than the agency's rate of return, then the investment is deemed to be worthwhile.

A business may also want to analyze the costs and benefits over the economic life of the BMP, particularly for large investments that may have longer payback periods. This analysis may be appropriate if the time for return on investments does not justify making the improvements in the short term and there is a long-term investment involved. A lifecycle analysis will take into consideration the costs and savings over the full life of the BMP device being installed. In this type of analysis the business would consider the time value of money, savings through the life of the equipment, and the costs of water, energy or sewage disposal over the life of the equipment. This analysis may also include labor, tax, and insurance savings.

Net Present Value (NPV) is among the most common financial metrics used in doing a life cycle analysis. It sums all of the costs and benefits over the lifetime of the device and reports their value at the beginning of the project. A positive NPV indicates that the benefits of the project exceed the costs over the life of the device. This approach has not been as commonly used by business as the ROI or payback approach, but may become more applicable in the future.

When making a decision to invest in water use efficiency, businesses may also consider other risk factors and benefits that are less quantifiable, such as potential future mandates, reliability of water supply, or reputational risks and benefits. They may also upgrade to more water and energy efficient equipment when making a business decision to replace outdated equipment.

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