Evaluating the Economic Impact of Water Regulation and Sustainability on Urban Supply Chain Facility Planning

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***Abstract*— Supply chain facilities, specifically manufacturing plants that are located near urban areas, are often regulated by distinct local municipalities, state ordinances and federal regulations. This transcript highlights one of the more heavily regulated type of facilities - a meat food processing plant – that requires a special permit for its industrial use of sewer services as it meets one or more criteria of select discharge regulations. This type of facility is heavily regulated by a local municipality to avoid water shortages and is using penalties and taxes to encourage conservation and raise revenue. For scenario description purposes, we highlight sample data from a plant facility in the east coast in the lower southeastern part of the United States. We incorporate the tax and penalty scenarios from a municipality in the state of Georgia. This research describes the steps and processes used by the plant facility to make certain that it complies with the rules and regulations of the sewer service permit, along with ensuring compliance with environmental regulations and policies, while providing evidence of the economic benefits for plant facilities to incorporate sustainable practices in the overall wastewater treatment process.**

***Keywords*—** *supply chain facility, water regulation, wastewater treatment, sustainability, predictive modelling, cost benefit savings*

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1. Introduction

In 1972, the Clean Water Act was enacted to federally regulate the discharge levels of contamination entering U.S. surface waters. Since its inception, federal, state and municipal legislation has emerged to further define the Act through increased regulations of industrial disposal of waste waters entering the watershed. Specifically, effluent limitations, pre-treatment, the National Pollution Discharge Elimination System (NPDES) permit program, sewage sludge rules, and Total Maximum Daily Loads (TMDLs) have all been affected by additional legislation.

Much of the increased regulation of industrial water use in the state of Georgia has been due to recent water resource issues, including an increase in the number of droughts and the tri-state water battle between Georgia, Florida and Alabama. Small, local governments have also tightened regulations to reduce industrial water consumption and waste water discharge. The enforcements materialize as lower water limits imposed for future permits, thereby forcing plant facilities to remain in compliance with the new, lower water consumption and waste water discharge amounts to avoid paying hefty fines. The new regulations require various industries to reduce the amount of water consumed from current sources (surface or groundwater) and recycle plant facility wastewater. Additionally, further pre-treatment measures must be supported prior to plant facilities discharging their treated water back into the watershed.

Industrial recycled (treated) waste water can be utilized for cooling loops, boilers, fire-fighting, washing, rinsing, and process water, while non-potable water can be used in restrooms, landscape irrigation and decorative water features. Treated water can also be used to replenish groundwater basins, (Sookbirsingh 2007), sources which many facilities pull water from for use in their processes.

This study evaluates current legislation and recent violations, the processes and methodologies used in industry to reclaim, recycle and repurpose wastewater, as well as the economic benefits for plant facilities to incorporate sustainable practices in the overall wastewater treatment process.

2. Background

2.1 Urban Plant Facilities and U.S. Water Regulations

Municipalities enforce regulations to reduce both the pollution levels and discharge of wastewater into the water streams and the quality of the recycled water for reuse and recycling. There are various examples of states and municipalities which have recently tightened their limits on pollution entering local waterways. In April of 2014, the New Jersey Department of Environmental Protection enacted new storm water management regulations, effective in October of 2013, requiring an initial storm water draining control plan, by October 2014 and a final plan 12 months later, which included monitoring hazardous substances to prevent entrance into storm water (NJ DEP 2014). This also limits possible contaminate drinking water sources and pollute other waterways. Fines up to $40,000 will be imposed for major offenses from large facilities. New Jersey industrial recyclers will have to prepare for the changes, but a food processing company in Port of Sunnyside, WA has already violated changed in regulations for wastewater discharge. In 2011, the Washington Department of Ecology worked with Johnson Foods Inc. to bring them to compliance for low pH levels in their waste water (discharged to the local municipal facility) by March 15, 2013. However, violations were cited from March 2013 to November 2013 for failing to achieve effluent limits for pH and failing to report violations within 24 hours. The fine was assessed at $14,000 USD. (WA DEP 2014)

Although this facility was fined for sending its non-compliant waste water to the municipal plant, for treatment, more egregious errors have been committed by facilities who failed to properly treat their waste-water and pumped the effluent directly into the watershed. On May 22, 2013, the EPA announced a Clean Water Act Settlement for $83,000 USD with Fluid Recovery Services LLC for violation of their discharge permit for treating waste water utilized in petroleum extraction activities. (Fluid Recovery Services was discharging low levels of radioactive particles into local streams) (U.S. EPA Region 3 2011). For FRS to renew their permit, they will have to invest as much at $ 30 million USD to upgrade their facilities to comply with the new Pennsylvania Department of Environmental Protection standard which includes effluent levels of 500 mg/L for total dissolved solids.

Given the changes to state and local legislation, and non-compliance across industries, ensuring that our waters remain clean and within set contamination limits is an immense challenge. A surprisingly large fine of $120,000 was handed down to BioMarin after its Navato, California facility violated the clean water act various times by discharging low pH (lower than 5), industrial water into the Novato Sanitation District and the Ignacio Wastewater Treatment Plant, which discharges into Northern California's San Pablo bay, a tributary to the San Francisco Bay (US EPA Region 9 2011 Administrative Order), and this isn't the first. However, one of the largest fines of $82 million USD went to Walmart, for dumping Hazardous Wastewater resulting from in both Missouri and California. (US EPA Regions 7 and 9 Administrative Consent Decree 2013). Ultimately, various US businesses and industries have violated regulations of 1972's Clean Water Act.

2.2 Industrial Water Regulation in Georgia

Since 2006, Georgia legislation developed guidelines encouraging water reuse and reclamation as a strategy of water conservation for industries in response to saltwater intrusion in wells along the Georgia coastline (GA EPD 2007). Rainwater harvesting guidelines were published in 2009 to decrease the amount of water facilities pull (Georgia Department of Community Affairs 2009). A grey water recycling systems guidelines was also produced by the state promoting its use for toilets, urinals and subsurface landscape irrigation (Georgia EPD 2009) A subsequent factor for promoting water reuse and reclamation is the ongoing water issues with Alabama and Florida, the resulting 2010 legislation was Senate Bill 370, requiring water conserving fixtures and high efficiency cooling towers for all new constructions after July 1, 2012 (Ashley 2011). The bill also encouraged industries to do their own water audits to find leaks and asses ways to decrease water usage. However, the bill doesn't impede on existing facilities, despite the industrial water demands using 5-10 % of the total state withdraws, which amounted to 532 million gallons per day in 2005 (Kenny 2009).

Metropolitan Atlanta and its surrounding municipalities are not the only ones receiving fines from regulatory agencies in regards to inappropriate wastewater issues, local industries are making their own violations. Consequently, the industries violate the wastewater regulations regarding the pre-treatment levels of effluents sent to the municipal wastewater plant. This is a serious contributor to the fines municipalities are paying. In July of 2010, the GA EPD fined Rockdale Water Resources, $46,000 for discharging industrial effluent from the Pratt Industries Visy Plant (Augusta Chronicle 2010). This was the result of the failure of a pre-treatment unit for the packaging manufacture, which boasts its global manufacturing process save 21 million gallons of water a year on due to its suitability efforts (Pratt Industries Sustainability). In 2010 the city of Dawsonville received a small fine ($1,300 USD) for violating the wastewater discharge level, and an environmental specialist with the GA EPD believes a poultry packaging plant, Gold Creek Foods was the culprit (Hester 2010). Pre-treatment of industrial wastewater is necessary because industries use higher levels of pollutants in their processes, and if they fail to pre-treat their wastewater, then the municipal plant will have challenges because they weren't designed to treat for industrial level pollutants. The industrial pre-treatment is mandatory under the Clean Water act to ensure that local businesses and industries provide information to the wastewater entities that they discharge to. In Gainsville, GA, (55 miles northwest of Atlanta) a significant industrial user is based on the criteria of: discharging more than 25,000 gallons of wastewater per day, contributes to waste stream of 5% or more of the average dry weather hydraulic or organic capacity of the treatment plant, contains a waste priority pollutant as defined as the Federal Pollution Control Act, impacts the treatment works, effluent quality in connection with the NPDES permit, is designate buy the city on the basis that the industrial user has the potential for negatively influencing the publically owned treatment plant receiving the waste or if the industry is subject to categorical pre-treatment standards (Gainesville.org). The city of Cumming, GA has similar qualifications for businesses in need of industrial pre-treatment permits, which are currently granted to Koch Foods and Smithfield Farmland Corporation (Cumingutilitied.com). The possible violations for the town of Braselton, GA include unpermitted discharge, non-permitted discharge, exceedance of local, state or federal discharge standards, reporting violations, failure to properly monitor, improper sampling, failure to install monitoring equipment, missing compliance schedules and more.

2.3 Case Study: Urban Food Plant Facility

Constructed in 1990, the Food Processor Manufacturer's facility in this study is a meat processing plant (processes pork cooked sausage) that occupies a total of 84,000 ft^2 (64,000 ft^2 production floor, 8,000 ft^2 warehouse space, and 12,000 ft^2 office and employee welfare area). The facility produces an average of 65,000,000 lb annually of partial and fully cooked sausage patties for the leading fast food restaurant chain, along with various other fast food chains and food service channels serving various diners, restaurants, and hotels. The sausage cooking process has an average cook yield of 95%, thus the finished average tonnage of 65,000,000 lb per annum, creates about 3,420,000 lb of material waste that is either in a solid or liquid (grease) state. This facility operates its lines following two basic production patterns: 67 hours and 17 hours.

The Food Processing Manufacturer entered into an agreement with the municipality in which it is located, which states that wastewater discharges are allowed under the terms of an Industrial

Wastewater Discharge. The permit is valid for 18 months and has some defined guidelines regarding its longevity and allowable limits of discharge:

- The permit should be renewed 90 days prior to its expiration date;
- Daily Wastewater flow discharge is regulated by the Permit as follows (in Million Gallons Per day or MGD):
  - Daily Maximum: 0.085 MGD
  - 30 days average: 0.075 MGD

However, the facility has been informed that the municipality will be changing the terms of the permit once it expires. The new permit will lower the Daily Maximum Flow allowed to 0.075 MGD, as the permit will no longer allow a 30-day average flow as flow measurement.

2.4 Industrial Wastewater Treatment

The meat processing plant facility in this study requires a conservative wastewater treatment plan. Based on water interactions, many other industrial plant facilities do not require the same number of treatment steps to remain within regulated guidelines. Therefore, most plant facilities are expected to obtain a higher cost savings in the water reuse process overall. Wastewater Treatment Plants (WWTP) are designed to treat wastewater via a multi-stage treatment process prior to the water being discharged into the environment or further use. Such process is accomplished via a three-fold system involving primary, secondary, and tertiary treatment. Metcalf and Eddy [1] defines the Primary treatment as the initial stage of the treatment process, where physical unit operations remove solid materials. The wastewater is screened to remove large, inorganic material, such as, paper and plastics, and then further screened for finer grit and silt particles. Once the preliminary treatment is completed, wastewater is then transferred to primary sedimentation tanks where solid particles of organic material are removed from suspension through flocculation. Primary sludge is allowed to settle out from wastewater through gravity. Even though a large amount of solids is removed in this stage, the treated effluent remains high in biological oxygen demand (BOD), suspended solids, and nutrients [1].

The next step is for treated wastewater to undergo a secondary treatment, a process that entails the biological break down of dissolved and suspended organic solids facilitated by naturally occurring micro-organisms. At this stage, settled wastewater enters aeration tanks or lagoons and is mechanically aerated [1]. The injection of oxygen promotes the growth of micro-organisms and helps to maintain their suspension in the wastewater. During growth and multiplication phases, the active biomass consumes oxygen and organic pollutants and some nutrient constituents of the wastewater.

During this stage, the microbial biomass settles under gravity to the bottom of the tank as secondary sludge. A portion of the settled sludge is retained in the secondary aeration tanks to maintain a healthy microbial population while the remainder is pumped to anaerobic digesters for further treatment through the solids waste stream [1]. The wastewater and the microbial suspension are then processed into clarification units that remove any remaining microbial biomass and suspended solids. Once wastewater has passed clarification, it will then undergo tertiary treatment where disinfectants are used to reduce pathogen (microbial counts) levels that may otherwise pose a health risk [1].

Nemade, Kadam, and Shankar [2] describes that the common methods of disinfection include ozone, chlorine, ultraviolet light (UV), or sodium hypochlorite Chlorine is commonly dosed into the treated wastewater stream for disinfection purposes.

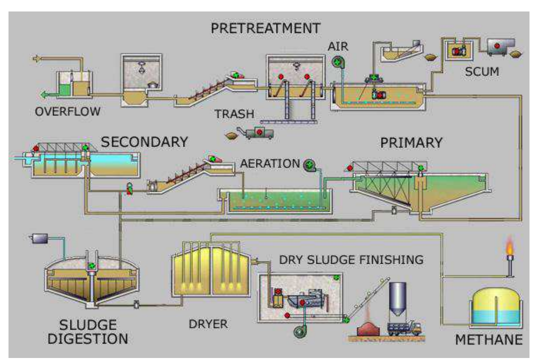

Figure 1. Wastewater Treatment Plant Process Flow (Source: Metcalf & Eddy, 1991)

2.5 Best Practices

In order to create a functional, feasible, and effective Best Practices guide for the Food Processing Manufacturer, research was conducted to evaluate other industries where best practices were already in place. The majority of such practices are interchangeable between industries, as well as in the private sector. However, Food Safety and Parasite free water were considerations that were used while identifying the practical ability and use ability of such practices in a Food Processing environment. Furthermore, the Best Practices identified were not deemed confidential or intellectual property as their use, knowledge, and practices are known world-wide. Tate [3] indicated practices such as law enforcing regulations affecting the discharge of wastewater into the water streams and the quality of the recycled water for reuse and recycling. Williams [4] also discussed the encouragement for industries to reuse or recycle their process water whenever possible, or economic to do so and the substitution of potable water with non-potable water (such as treated sewage effluent, so called industrial water, rain water, sea water, etc) for non-potable use in industrial and commercial premises. Nemerow [5] listed simple but effective solutions such as the use of water saving devices (such as spring-loaded nozzles, constant flow regulators, self-closing delayed-action taps, thimbles, etc), water usage audit and trend line tracking, advice to customers. Maynard [6] revealed other practices such as water recycling system to reuse water for cooling purposes, the development of system for the collecting of rain water for non-potable usages, the development of water pre-treatment plant for boiler usage to reduce boiler blow-down, and the development of water recovery system for boilers, wherever possible, to recover condensate as make-up water.

The research background of Industry Best Practices yielded several opportunities that were deemed feasible and applicable for the Food Processing Manufacturer. Water conservation involves trade-offs between the benefits and costs of water-management options [7]. More recently, academics and water professionals have made a major effort to ensure that the term “water conservation” refers to reducing water use by improving the efficiency of various uses of water, without decreasing services [8].

A goal of this research is to identify solutions to assist similar food processing plant facilities in reducing its water consumption and waste water discharge rates in order to comply with future municipal regulations that could result in significant increase in financial implications. Water usage reduction is an objective of most companies when it comes to natural resources consumption and energy conservation. Sustainability is the responsibility of any organization that is committed with a solid Corporate Social Responsibility Program that is interested in conducting its business while caring and preserving the environment.

3. Methodology

3.1 Hypothesis Statement #1

H0: The water reuse factor will not impact the supply chain facility costs.

H1: The water reuse factor will impact the supply chain facility costs.

The problem is comprised of four alternatives that were identified in the suggested best practices guide.

Alternatives:

1. Wastewater recycling for Evaporator Usage Purpose.
2. Condensate Water Recycling for Non-Contact Purpose.
3. Waste water Recycling for Plant Operation Usage Purpose, and
4. Other Process Considerations and Tools (Spring loaded devices- Nozzles), will be compared upon four attributes.
    a. Complexity
    b. Efficiency
    c. Ease of implementation and
    d. Cost

Test alternative 4 against an equation with the attributes

CNozzles = (1- PNozzles) *SNozzles * (1-SNozzles * PNozzles)

The test factor was the predicted water usage as determined using the regression equation below.

Constituent	Equation	S	R-Sq	R-Sq (adj)
1st Shift	Total = 4648 + 1.693 1st Shift	1210.24	51.80%	51.10%

Table 1. Regression Equation for Estimate of Water Consumption

3.2 Hypothesis Statement #2

H0: The water environment sustainability factor will not impact the supply chain facility costs.

H1: The water environment sustainability factor will impact the supply chain facility costs.

An alternative to reclaim, recycle and repurpose wastewater by plant facilities is to capture and reuse/infiltrate rain water.

3.3 Approach

Step 1: Identify the best practices that can be used for water treatment

Step 2: Identify which alternative can be implemented (Nozzle- Qualitatively)

Step 3: Measure performance prior to implementation (SPC and collecting water data)

Step 4: Evaluate cost benefit of using the alternative (Nozzle-Cost benefit)

Step 5: Measure the performance after implementation (after SPC)

Step 6: Economic model that combines Water factors and environment. Intellectual Merit is the Model that combines a direct cost savings from water reuse and indirect environment factors converted to direct savings

One of the most important steps in developing a best practice document is to identify the requirements and regulations that pertain to the operating practices. When implementing the operating practices detailed in a best practice document, all efforts must be made to follow and oblige all regulations and requirements. For most Food Manufacturers, the United States Department of Agriculture (USDA) governs the regulations of food manufacturing operating practices and procedures and the same is holds true in regards to water recycling programs [9].

Several opportunities were deemed feasible and applicable for the Food Processing Manufacturer with regards to water conservation and recycling practices. A review of literature, on-site knowledge exchange, and trial of techniques in a Food Processing Manufacture facility led to the development of a Water Conservation Best Practices guide. Two types of conservation measures were identified: improving water-use efficiency and substituting reclaimed water for some end uses.

Improving water-use efficiency includes behavioral and managerial improvements, such as adjusting a watering schedule, and technological improvements. Technological improvements usually involve replacing water-using equipment with newer technology that serves the same purpose utilizing lesser water [3]. Thus water usage efficiency improvement means reducing the amount of water needed for any goal while still accomplishing that goal.

In order to ensure that the facility complies with the terms and regulations stated in the city permit, it is necessary for the plant to utilize a statistical process control (SPC) to monitor water discharges on a daily, per shift, and per hour basis. The SPC tool serves as a gage, allowing the wastewater treatment personnel to react to the various situations that arise due to the water consumption and discharge of the facility, along with allowing management time to make pertinent business decisions on the wastewater system. The information used for the SPC charts is generated from meters located in the incoming water line into the treatment tank, as well as, the discharged end of the pit (this meter is the one that actually measures the flow of water been discharged to the city).

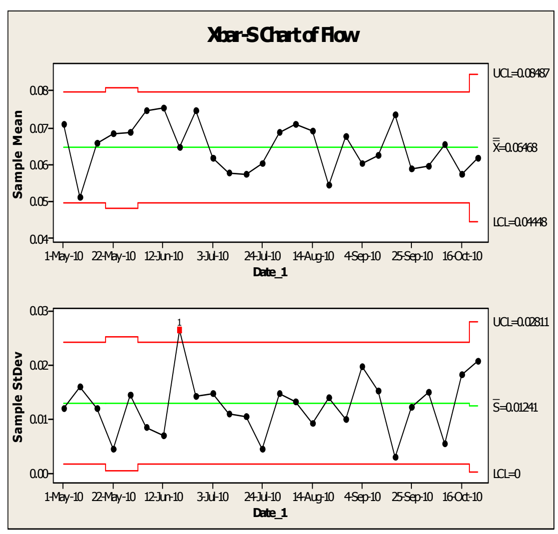

Figure 2. Average Daily Water Usage

The data was collected by developing a systematic approach where the waste water operator would record the discharges levels of the wastewater treatment plant (WWTP) in order to determine system performance, trends, anomalies, and/or any other situation, which would place the system out of control or compliance.

Regression analysis of the water usage data collected from May to September was used to estimate the water usage consumption demand for the Food Processing Manufacturer at any given time.

3.4 Water Harvesting Assistive Tool

A water harvesting system can be integrated into the plant facility and used as an assistive mechanism by which to remain within regulatory limits of water use. That is, reducing the amount of water that is extracted from municipal sources. A harvesting system allows for the capture and reuse rain water.

A water harvesting system consists of:

- Cistern,
- pipe network diverting rooftop runoff to the cistern,
- overflow bypass for when the cistern is full,
- pump and distribution network to deliver water to its intended use,
- the size of tanks or cisterns can range from quite small, less than 100 gallons, to more than 10,000 gallons for a small commercial site,
- Capital Cost- $5000 to $18000 (Depends on system size/materials)

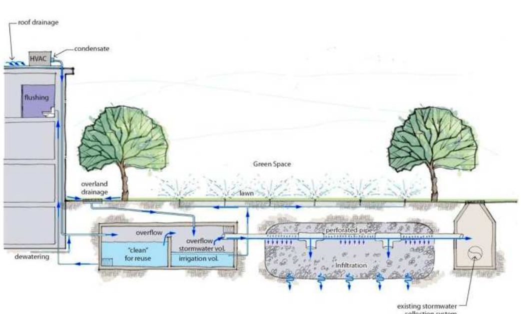

Figure 3. Sample Water Harvesting System

4. Results

The best practice guide was developed by combining the collected information with good engineering practices in order to attain a feasible and effective water conservation program. These best practices consist of recirculation and conservation systems that will allow the Food Manufacturer to effectively reduce water consumption.

A complete water conservation system will incorporate one or more options from three main categories listed below.

A. Wastewater Recycling for Evaporator Usage Purpose
B. Condensate Water Recycling for Non-Contact Usage Purpose
C. Wastewater Recycling for Plant Operation Usage Purpose.

The complete system also must include operational best practice considerations, tools and equipment along with their standard operating procedures, optimal condition for water usage, and strategies for achieving water usage reductions. This best practice framework provided the basis of the proposed method for selecting the best water conservation system for a given Food Processing Manufacturer.

The model proposed in this research provides management with a methodology that can be used to make more accurate decisions regarding the historical performance of the WWTP rather than just monitor its discharge levels. The regression analysis is used to predict the system's performance and its control level as the basis for further technique and control processes.

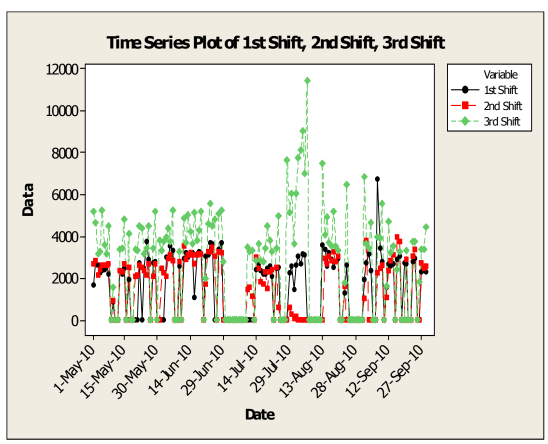

Figure 4. Time Series Plot for Water Consumption by Shift

With use of a water harvesting system to obtain additional water outside of municipal sources a lifecycle cost results:

Life Cycle Cost	Description of Costs	Estimated Costs
INITIAL COST	- Removal of previous gutter - Price of Large Cistern - Installation of Cistern - Price of Steel Cistern	$22,500 + $60,000
ANNUAL COST	- Cleaning Gutters and Check for Cracks - Clean Debris Screen - Winter Proofing - Check Cistern for Stability - Check water indicator - Check Pipe and Valve Leak - Check Cistern manhole accessibility - Fill take ½ of water if less than full (before a storm)** - Check Cistern for integrity & drain to allow 0.5" capture	$20,000
PROJECT LIFE	75 Years	$1,500,000
CALCULATIONS	$82,500 + (20,000 x 75 yr) = $1,582,500	
LIFE CYCLE COST	$1,582,500	

Figure 5. Lifecycle cost of Water Harvesting System (varies based on plant facility size; case study sample)

4.1 Cost Benefit Analysis

The use of low-flow nozzles and auto-shut off valves has savings potentials of 50 percent and can be simultaneously implemented at the same facilities (Esty & Winston, 2009). Clearly, the savings are not additive because if we implement both water use does not decrease by 100 percent. We describe technologies as complementary if they can be simultaneously implemented at one facility.

If the technologies have savings of S_i and penetration rates of P_i, respectively, the savings possible for each technology is:

$$C_{Nozzles} = \frac{(1-P_{Nozzles}) * S_{Nozzles}}{(1 - S_{Nozzles} * P_{Nozzles})}$$

The total savings from implementing both technologies is:

Total Conservation Potential % = 1 - (1 - $C_{Nozzles}$) * (1 - $C_{Auto\text{-}shutoff}$)

Generalizing for complementary technologies

Total Conservation Potential % = 1-Π(1- Cj)

The model proposed in this research provides management with a methodology that can be used to make more accurate decisions regarding the historical performance of the WWTP rather than just monitor its discharge levels. The regression analysis is used to predict the system's performance and its control level as the basis for further technique and control processes.

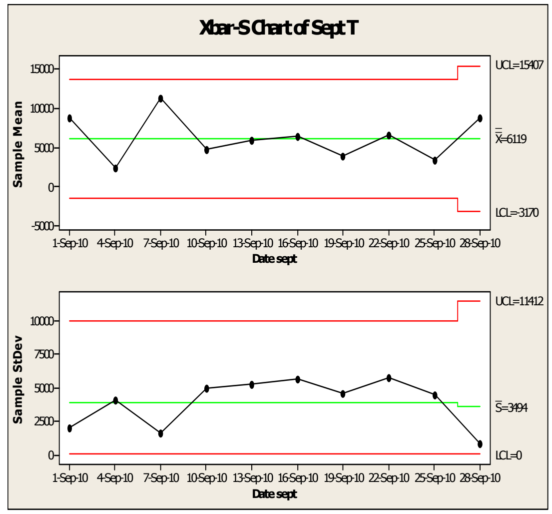

Figure 6. September Water Flow Analysis

In using a water harvesting system, a quantitative analysis of benefits was determined based on average water and sewer costs from 2013 in a municipal location in Georgia (Figure 7). Using the water harvesting system as savings of $2,294,177.76 per year is estimated to result.

Quantitative Analysis of Benefits

Current Charges: Water Use Charges	
Water Base Charge	$6.56
Water Usage	$215,586.80
Total Water Charges	$215,593.36 Sewer Use Charges
Sewer Base Charge	$6.56
Sewer Usage	$549,126.00
Total Sewer Charges	$549,132.56 Other activities & adjustments
Senior Discount	$0.00
Total activities & adjustments	$0.00
Total current charges	$764,725.92
Total amount due	$764,725.92

Figure 7. Quantitative Analysis of Benefits for Water Harvesting System (varies based on plant facility size; case study sample)

When the savings are evaluated over a 75 year time span the following major savings are expected:

Savings for 75 years

$2,294,177.76 x 75 years = $172,063,332.00

Total Savings after Capital Cost

$172,063,332.00 - $1,582,500.00

= + $170,480,832.00

5. Discussion

Despite the various egregious violations discussed in the background section of this paper, there are various changes being made. There is another facet to this story, as other companies are pushing their sustainability efforts to decrease the volume of untreated waste water a facility can output into the municipal system or the amount to treated waste water. Recently, industries have begun to look at waste water as a resource, instead of considering it extraneous waste (Gelick 2000*)* with regards to the increasing costs and regulations of industrial and commercial sewage disposal. The craft brewing industry, is stating that the full cost of water, to not only include the price of incoming water and the sewage service charge, but to also include the costs of energy and chemicals to process the water as well as labor and costs with processing and treating water (Steir 2013). The Eagle Brewing Company in Colorado a found seven common water loss faults within the brewing process and estimated their potential costs to total $43.75 USD per hour of fault (Steir 2013). The United States fracking industries are also discovering the economic benefits of repurposing water, by controversially, injecting it into groundwater wells or recycling it to save on disposal costs which can be as high as a savings of $200,000 USD over the lifetime of an average well, which can be up to 20 years.

Despite Georgia's California Green Innovation Index as one of the Next 10 green economies and the growing strength of the water and wastewater industries was mentioned. The new jobs supported supportive varies industries of water conservation (control systems, meters & measure devises, development of manufacturing of pump technology, research and testing, consulting services as well as the development of water treatment (Georgia Profile of the Green Economy).

The state needs its water professionals, because municipalities and institutions are paying heavy fines for violating Clean Water Act legislations. The focus of this work is on industrial water treatment, but the fines, that the municipal water systems of the City of Atlanta and its surrounding suburban counties are paying to the GA EPD and US EPA are worth noting, nearly $6 million USD from 1998-2012. Four separate Metro Atlanta systems from 19998-2012 paid fines totaling more than $500,000 USD and Fulton County paid $1.2 million alone. The City of East Point with a population under 35,000 paid more than $370,000 in fines, $333,000 was attributed to the Clayton county water authority, (250,000 residents), Dekalb county ranked in just under a million dollars, ($980,00 USD) for a population of more than 700,000 residents (Torres 2012). However, some water authorities rationalize that the better solution is to pay the fine, then to fix infrastructure. Many of these fines were attributed to combined sewer-storm water overflows' which is the result of an aging infrastructure. In 1998, the City of Atlanta signed a Federal consent decree from the result lawsuit (and subsequent fine) from its regulatory bodies as well the Upper Chattahoochee river keeper, to improve the treated effluent into the Chattahoochee and South Rivers (US EPA Region 9 Clean Water Atlanta Consent Decree 1998). From this the Clean water Initiative, the city would have to eliminate water violations, accelerate ongoing sewer improvements, including vast sewer inspections, the rehabilitation or replacement of defective or capacity limited sewer lines, the implementation of a fats greases, and oils management program as well as a capacity certification program for new development (U.S. EPA Region 9 Clean Water Atlanta Consent Decree) The total costs of the Clean water initiative were 4.1 Billion, authorized by the former Mayor Shirley Franklin. A 2012 Study found that 6% of its residents have defective water meters, which can be as many as 10,000 of the cities meters (McWilliams 2014), at a cost of $2 million USD, if the Clean Water Initiative investment. The funding comes from of sources including municipal sales tax, (the lions share), expansion of low interest state revolving funding, federal grants, tax-exempt commercial loans, current revenue financing and taxpayers. From 2003-208, the City of Atlanta residents saw an 189% increase in their water bills and pay some of the highest rates in the nation (Zeiss 2011). Henceforth, there is a large initiative for new water legislation, conservation and efficiency efforts, and ways to reutilize, reuse and recycle water and businesses that do so.

A local Atlanta business ran with the idea of harvesting rainwater – to brew beer. Rainwater is ideal for brewers because it lacks Chloride, an ion almost always used in American municipal water supplies as a disinfectant. Rainwater also lacks other minerals found in tap water (iron, sodium, calcium, potassium and magnesium) which create challenges in the brewing process. A six-sage collection and filtration device was employed by Rain Harvest Systems of Cumming, GA to collect the rain water that utilizes a 0.5 µm filter, followed by UV filtration to kill bacteria (http://www.rainharvest.com). The quality of water produced exceeded EPA and GA EPD standards, and the purity was confirmed by the University of Georgia's Soil and Water Quality Laboratory. Despite the sustainable practice and decrease in the use of water from the city of Atlanta, the brewery was told to cease production because no regulations existed for utilizing rainwater commercially (Holland 2009). Although there was no published information of how much the brewery saved by harvesting rainwater, the idea do utilize rainwater for commercial purposed is what Georgia guidelines are indirectly suggesting. There is a need for regulatory agencies to have permits for beverage companies to utilize rain water in their commercial processes. Despite the lack of legislation on utilizing rainwater which caused 5 Seasons Brewery to discontinue their operation, other Georgia industries have found ways to decease their dependence on the municipal water system.

Georgia's single largest agribusiness, the poultry industry is taking on initiatives to reduce the volume of water discharged into the sewer. A study in 2005 performed by at the University of Georgia's Institute of Ecology researchers found that by recycling chiller water with ultrafiltration, a plant could save $219,465 annually on water, sewage and energy costs (energy costs used to treat, heat or cool water) (Saravia 2005). Another agricultural industry – food processers are also taking recycling wastewater into account. Researchers from the University of Georgia's Food Science and Technology Department, recycled waste water from a fresh cut vegetable processing plant by with Polyvinylidenedifluoride membranes. The economic analysis benefits for a 18.9 kL/Day pilot plant could save $200,000 per year, using costs for maintenance, equipment, labor, cleaners, installation, energy, and money saved from reduced water use and sewer services (Nelson 2007).

Agriculture isn't the only industry that has been able to capitalize from repurposing wastewater, Georgia's manufacturing industry also has esteemed results. In 1995, Cartersville, Ga's Unilever Home & Personal care manufacturing plant created a water conservation task force to contribute to their global water stewardship initiative. From 1996- 2000, the program implemented the reuse of non-contact cooling water, utilizing collected rainwater in the manufacturing process, and installing automatic control of cooling water, resulting in reducing wastewater effluent by 90% saving 32 million gallons annually. This resulted in a $77,000 annual savings in water consumption and wastewater treatment, and an additional $85,000 annual savings in testing, maintenance and labor fees (Elfner 2002).

Another company with a manufacturing facility in Georgia , Golden State Foods, a foodservice company which engages in the processing, production and distribution of liquid products, meat products, produce and more (Bloomberg Business week). Also, Golden State is one of the largest suppliers to McDonalds. In a partnership with GA EPD, they set up a waste reduction/water conservation team which educated employed about conserving water. The outcomes of the program was a 2.7 million gallon reduction of wastewater to the on-site pre-treatment plant, resulting in a $19,000 purchased water cost and $25,000 wastewater pre-treatment savings in 1998 (Elder 2000).

6. Conclusion

The goal of this research was to meet three specific objectives. The first objective was accomplished through an extensive literature search along with data collection through on-site observations, interviews, and subsequent data analysis. This information was utilized to develop a water consumption reduction best practice guide to effectively manage wastewater discharge flow. The second objective was fulfilled by applying a simple regression analysis technique known to one of the best practices identified in the first objective. This research utilized a linear regression analysis in order to predict the system behavior with regards to water consumption and the impact on the wastewater plant as it relates to its current levels of discharge. The results of the analysis indicated that the system is in-control. However, the system is currently operating at its limit and any major change to the system or significant event will easily make the system to be out of control. The use of regression equations to estimate water consumption rate provides management with timely performance information feedback that was otherwise not available. The addition of a water harvesting and reuse tool to the plant's current water system provides an added means by which water overuse and violation of current and more stringent water limitations by the plant facility is prevented.

The third and final objective was to provide evidence of the economic benefits for plant facilities to incorporate sustainable practices in their overall wastewater treatment processes. When water capture and reuse assistive tools are incorporated into plant facilities, such as the water harvesting system introduced in this paper, not only are plant facilities contributing to environmental sustainability, but they are making beneficial cost reductions that result in increasing overall company profits and savings. This research provides management with tools to make informed decisions as to what type of water conservation system is most appropriate for their plant facilities and how they may additionally improve overall cost savings. By reducing the amount of water plant facilities require from municipal water sources, they are also reducing the chances of passing regulated limits and being charged hefty fines.

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