

SUMMER 2010

CAROLLO ENGINEERS

research

SOLUTIONS

A Publication of the Carollo Research Group

Doing More with Less: Ideas for Stretching Your Dollars without Compromising Quality

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Special Edition

INTRODUCTION

Doing More with Less: Ideas for Stretching Your Dollars without Compromising Quality



Everyone is asking the same question, "Can we do more with less?" Chemical costs increased dramatically during 2008-2009, energy costs are anticipated to rise due to energy inflation and climate change regulation, many assets are reaching a critical age where risks increase significantly, and all of this is occurring against a backdrop of tightening EPA/State regulations and a limited ability to raise rates.

Your challenges are our challenges. Although sometimes difficult, we see these as exciting times. This *Research Solutions* Special Edition answers the question that we asked ourselves, "What cost-effective ideas have we developed and/or used to help our clients do more with less?"

The first article discusses approaches to chemical and energy procurement and use from a utility management perspective. The next article, on the integration of asset management with financial planning (page 4), shows how focused asset management can be cost-effective. Leveraging SCADA systems (page 6) and benchmarking with other utilities (page 8) highlights two ways our clients can benefit from capturing information, comparing with other utilities, and controlling facilities.

The final three articles (pages 10-12) focus on specific examples of low capital cost solutions that have allowed our clients to leverage existing infrastructure to gain significant energy and chemical savings.

Although all utilities have different challenges, we hope that you find these articles interesting and timely. Please do not hesitate to contact the primary authors, Research Group Manager Jess Brown, or me to discuss any of these articles.

— Vinnie Hart, P.E., Special Editor
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COMMENTARY

Chemical and Energy Procurement Options for a Utility



By Steve Walker
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Chemical and Energy Considerations

Facility owners are faced with reduced capital funding, shrinking O&M budgets, aging facilities, increased public expectations, more stringent permit requirements, and negative public feedback when implementing rate increases or service cuts. Chemical and energy consumption are the largest portion of facility operating budgets, so optimization of these cost centers may provide some relief for other programs.

Recent events have unsettled the traditionally stable commodity market. The collapse of Enron and other energy speculators rippled through both the power production and natural gas industries, which was then followed by the rapid escalation of oil prices. The "China Effect," tied to both the 2008 Summer Olympics and that country's sustained efforts to modernize and supply commercial goods, impacted raw material supplies and costs.

Chlorination pricing is tied to the cost of two ingredients: chlorine gas and caustic soda. The economic downturn, which

resulted in a drop in new housing and automotive purchases, caused a decrease in polyvinyl chloride demand, which weakened the demand for chlorine. Reduced demand for chlorine gas drove up the cost of caustic soda. For every ton of chlorine produced, 1.1 tons of caustic soda are produced. Polymer products are made from propylene gas, high-distillate oil, and acrylic acid (all made from crude oil). Metal salts such as ferric chloride are impacted by steel and chlorine production. The price of diesel drives transportation costs. Several producers invoked force majeure, thereby tightening market supply and placing customers on allocation while also triggering price inflation.

There are a few ways that facilities can try to control or reduce operating costs related to chemical and energy use.

Chemicals

Contract with More than One Supplier for Each Chemical

Multiple (or primary and alternate) supply contracts allow for flexibility. If the low-cost chemical supplier is unable to meet supply or performance requirements, the owner could quickly change to the alternate vendor. This arrangement makes additional chemicals readily available when the primary supplier cannot meet the contract requirements, when justified

by performance or cost conditions, or when vendor-supply disruptions occur. This option also diversifies the base of chemical suppliers, which can better protect against industry supply problems.

Conduct Performance Testing Regularly

It is not unusual to settle on one product that works and to

continue to use that product for many years. Although this approach may provide consistent performance, the advantages from technology changes or competition that may lower the unit cost of the product can be overlooked. If the performance testing is structured and documented well, the owner can find the most cost-effective product to meet specific performance requirements. This approach will take staff time to support the trials and evaluate the results, but engages them in both process optimization and decision-making. One contract requirement should be that the chemical must perform at the level that was demonstrated at the performance trials.

Include a PPI or Industry Index Clause in Each Contract with Review Timing and Adjustment

In order to address the concerns of the supplier and increase the reliability of supply, and to avoid paying an inflated price for the entire contract period, write the chemical supply contract to include a price adjustment clause that allows a price review every 3 to 6 months with adjustments, up or down, as driven by the Producer Price Index (PPI; which is calculated by the Bureau of Labor Statistics to benchmark price trends and changes) or another agreed upon index. Index options include:

- **Sodium bisulfite:** Any applicable adjustment can be made based on an evaluation of molten sulfur as referenced in the *Green Market Report*. The *Green Market Report* is a publication used in every state except California and reports the sulfur market trends and weekly updates on pricing.
- **Ferric chloride:** Base on market conditions as reported in the *Scrap Price Bulletin* (formerly *Iron Age*) – *Chicago No. 1 Busheling*. The *Scrap Price Bulletin* is a weekly magazine that outlines ferrous scrap and iron alternative pricing for the 18 major scrap markets.
- **Liquid or dry polymer:** Adjustments can be based on the DeWitt Propylene Report.
- **Chlorination products** can be based on the CMAI (Chemical Markets Association, Inc.) Chlor Alkali Market Report.

These reports can be expensive, so the contract can be written for the manufacturer or supplier to share the data with the owner.

Adjust for Seasonal Performance

As an example, various types of polymer are blended with varying ionic charges and molecular weights. A product may respond differently over time due to seasonal changes in water quality, biosolids characteristics, or process changes. Conducting seasonal trials may identify that using two different products provides a reasonable balance between performance and cost.

In order to address the concerns of the supplier and increase the reliability of supply, and to avoid paying an inflated price for the entire contract period, write the chemical supply contract to include a price adjustment clause that allows a price review every 3 to 6 months with adjustments, up or down, as driven by the Producer Price Index (PPI).

Energy

Tariff Management

Electricity providers can be very creative in defining methods to increase profits. An owner needs to closely examine the terms of the tariff that their electricity is provided under. Peak, shoulder, time-of-day, and seasonal constraints may be outlined. A facility can adjust process timing to match lower-rate times of day. For instance, the throughput for a power-hungry process like centrifuge dewatering could be increased during lower-cost periods, and idled or shut down during higher-cost periods. Practices such as starting or stopping aeration blowers for maintenance should be timed to leverage the peak and off-peaking power rate billing structure. A well-executed load shedding plan, devised around process constraints, can reap significant financial benefits.

Contracted Management and Acquisition Services

Natural gas pricing, once predictable and steady for years, has become volatile due to



Understanding the tariff impacts and coordinating large equipment starts can save significant money.

production, storage, pipeline, and weather issues. Contracted management and acquisition services reduce the variability of natural gas costs and can result in monetary savings. These service costs are relatively small compared to the unit cost and help reduce budgeting uncertainties.

Conclusion

Facility owners can gain process flexibility, reduce operating costs, and improve compliance assurance using these system management approaches. The chemical and natural gas markets will likely remain volatile. Using alternatives and making adjustments in a timely manner will benefit the owner and the ratepayers, and reduce reactive business practices.

About the Author

Prior to coming to Carollo, Steve Walker worked at Denver Metro for 25 years, including the last 9 years as Treatment Superintendent and Operator-in-Responsible Charge. He brings an end-user perspective to projects, having worked through over \$400 M in process and equipment upgrades since 1998. Steve worked closely with the Carollo Team that designed and is constructing the successful CaRRB process now in use for centrate treatment at Metro. Steve is tasked with an operations initiative called "O&M Support Services" (OMSS). The OMSS program has two main focuses — new project support and existing facility assessments or evaluations.

Steve holds State of Colorado A licenses in both Wastewater and Industrial Wastewater, and is a member of the State's Water and Wastewater Facility Operators Certification Board.

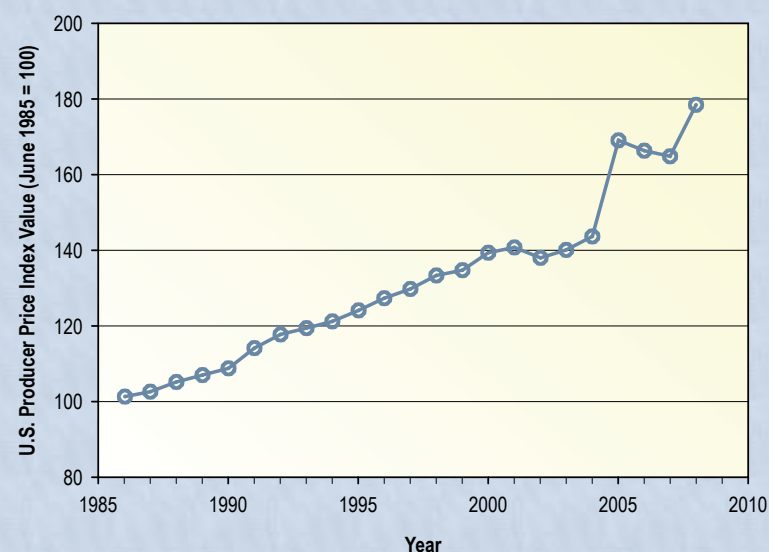


Figure 1. The rapid escalation of chemical costs has shorted many budgets.

MEETING CUSTOMER EXPECTATIONS WHILE MINIMIZING COST-OF-SERVICE: Integrating Asset and Financial Management



By Rebecca Overacre, P.E. (roveracre@carollo.com), Kaumudi Atapattu, P.E.

“Asset management” refers to a body of business principles aimed at balancing risk and minimizing life-cycle costs. For the water and wastewater industry, this pertains to the physical assets of a utility: pipes, structures, equipment, etc., many of which have long service lives.

Applying sound business principles can help a utility optimize expenditures across the capital improvement, operations, and maintenance of these assets. Additional objectives of asset management include organizational efficiency, knowledge transfer, and — perhaps most importantly — responsible planning for rehabilitation and replacement (R&R, or renewal) expenditures.

Over recent years, use of asset management has proliferated as a result of reductions in federal grants, natural aging (and failures) of infrastructure, and a transitioning workforce with the retirement of many Baby Boomers. Utility engineering departments have latched onto asset management as a way to better plan and manage material resources for reduced risk. Financial officers are increasingly seeing the benefit of asset management for renewal forecasting, enhanced cash flow analyses, and justification of rates.

The Crux of Asset Management Is Tracking the “Right” Information to Make Good, Compelling Decisions

There is a general misconception that a utility must invest significant dollars in the development of an asset management program before it can readily practice asset management principles. For some larger utilities, asset management indeed relies upon sophisticated management and data systems that link maintenance management with capital planning. For others, asset

management can be a simple database featuring basic knowledge of what assets are owned by the utility, what condition they are in, their remaining service life, and how much it will cost to replace the assets.

The key information pieces for the start of an asset management program are:

- Asset inventory, featuring functional components valued above the capitalization threshold.
- Estimates of asset conditions.
- Replacement cost estimates.
- Forecasted renewal spending, using the replacement costs as an upper benchmark or rehabilitation costs where known.

By focusing on these straightforward steps, Carollo has helped its clients establish the pillars of an asset management program with minimal project costs.

Utilities Can Do More with Less by Simply Tracking Key Information

The practical outcome, and often considered the most beneficial use, of the asset management planning process is identification of a solid rehabilitation and replacement plan that outlines the estimated costs and schedule. This allows financial planning for asset renewal needs.

Due to the fact that each water and wastewater system is unique, with its own system age, operation, maintenance, equipment types, and materials, there is no industry standard for how much renewal reserve a utility should maintain. Because the nature of renewal spending is erratic, it is more instructive to focus on a comprehensive funding strategy, such as cash funding a certain percentage of the total renewal needs, or debt funding certain types of renewal projects. With this approach, the cost ceiling is not as important as achieving the funding

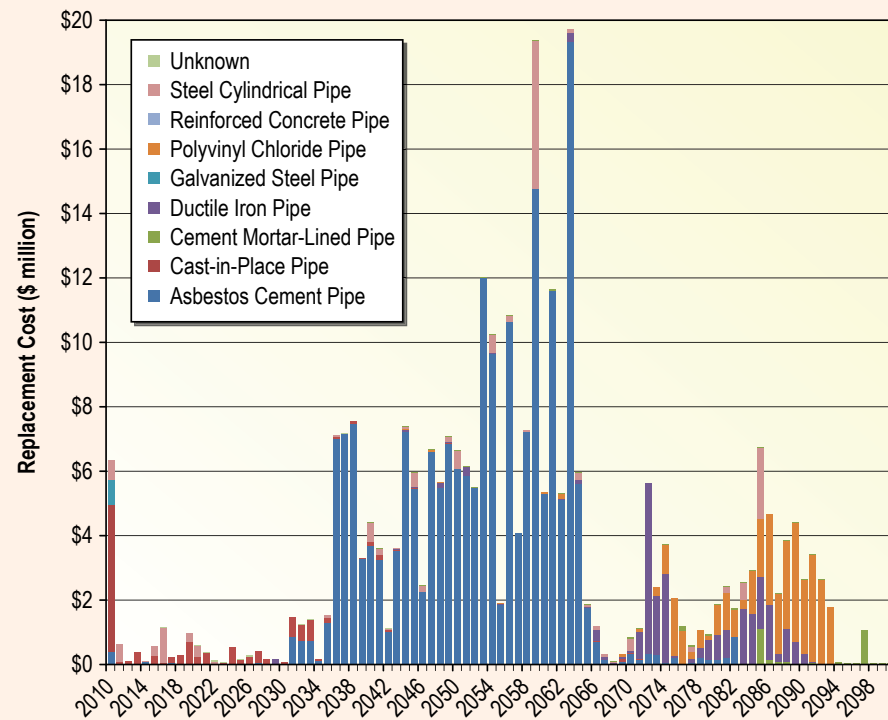


Figure 1. Nationwide, utilities are bracing for a peak in renewal expenditures relative to historic growth booms and regulatory initiatives. Integrating asset management and financial planning helps a utility to minimize risk and stabilize rates in the advent of these spikes.

strategy goals. This approach allows a utility to develop an appropriate plan to fund anticipated expenditure spikes that often occur in renewal spending in order to minimize the ratepayer impact. With more information and advance knowledge of these spikes, a utility can better anticipate and develop strategies to address them.

Linking Asset Management with Financial Management Optimizes Cost-of-Service while Improving Customer Satisfaction

Most water and wastewater providers strive to provide a high level of service, while minimizing the cost to users. Through a comprehensive asset management planning process, utilities are better able to identify reasonable renewal schedules and costs, optimize rates, enhance reserve management, and provide ratepayers more consistent small increases rather than large, intermittent rate hikes. This approach helps utilities better manage financial resources and minimize the need for borrowing. Additionally, integrating an asset management program with a financial plan helps reduce borrowing costs because the utility can achieve a better bond rating by demonstrating prudent asset and financial planning to potential investors.

In conclusion, asset management provides water and wastewater service providers the ability to maintain system reliability while being able to look ahead for enhanced fiscal planning. By linking asset management and financial planning, service providers are able to:

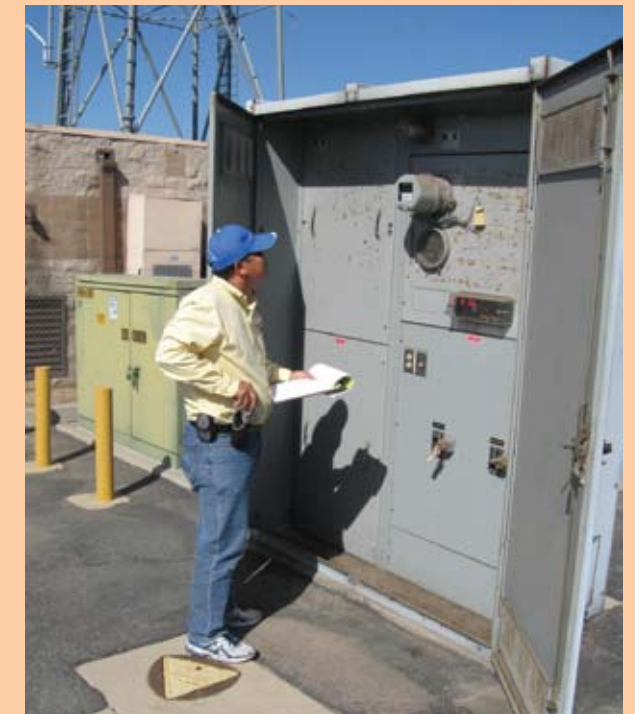
- Identify the financial requirements to maintain system integrity.
- Efficiently operate and maintain assets.
- Minimize costs by evaluating the financial perspective of renewal decisions.
- Achieve level-of-service goals while avoiding rate spikes.
- Communicate the methods and reasons to politicians, stakeholders, and ratepayers.
- Achieve the full benefit of a utility’s asset investments.

About the Author

Rebecca Overacre is the Asset Management Services Manager for Carollo’s Business Solutions Practice.

Case Study: Yorba Linda Water District

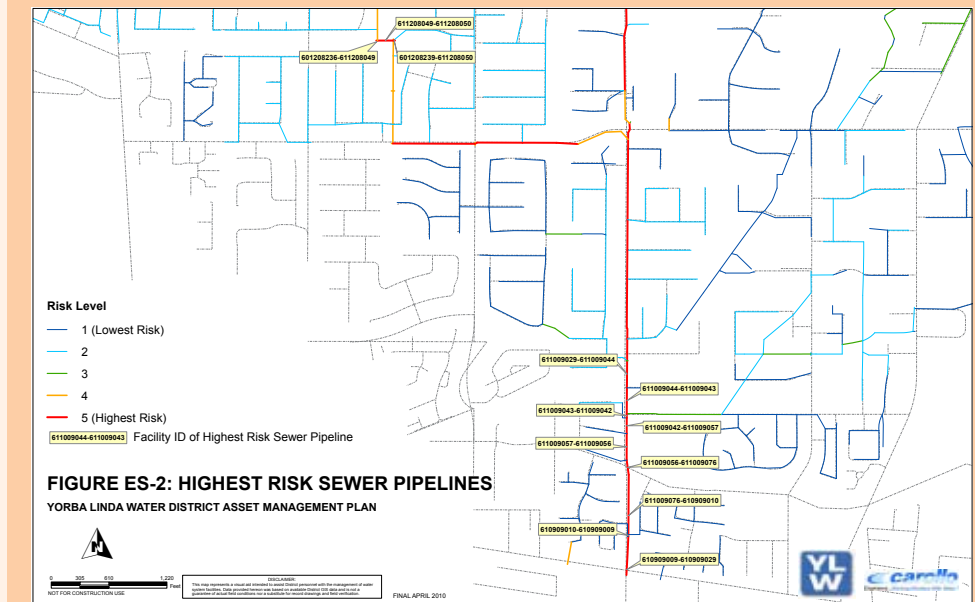
The Yorba Linda Water District in Southern California contracted Carollo to help initiate its asset management program. This involved establishing the first comprehensive inventory of above-ground assets (equipment and structures) and below-ground assets (pipelines, manholes, and valves) for the District. Carollo accomplished this by conducting field work, mining GIS data, and using Carollo’s in-house asset management tools.



Carollo’s rapid multi-discipline visual condition assessment approach was used to garner the condition and relative importance of major components at the District’s wells, reservoirs, and pump stations.

The output of the program showed the District where to focus its renewal efforts and what to expect down the road in terms of renewal expenditures. In summary, Carollo was able to give the District a snapshot of its assets, an assessment of risks, immediate R&R recommendations, and renewal projections through a small consulting effort. By putting above-ground and

below-ground assets into the same risk framework, the District is better able to prioritize projects across their differing needs.



Carollo’s Below-Ground Asset Manager (BAM) was used to readily analyze the District’s pipe data and project the risk results back into a geographic format. This Excel-based tool continues to help clients save money by avoiding licensing fees associated with commercial software.

SCADA

Shrinking Costs and Delivering Accolades



By Vinnie Hart, P.E.
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Bob Gillette, P.E.

Supervisory Control and Data Acquisition (SCADA) has become universally accepted and used for remote monitoring and control in most water and wastewater facilities. As an industry, we have done a great job incorporating SCADA into the day-to-day operations of a facility, but a poor job of leveraging this powerful tool to reduce labor, energy, and chemical costs.

The following are just a few examples of real-world automation tools and the resulting benefits:

Pumping Systems

Pump Optimization Algorithm

Pumping systems in water treatment facilities can account for 90 percent of the power used in a facility and a significant

portion of wastewater treatment facility power use. So focusing on pumping systems can result in significant cost savings without requiring significant expenditures. The Spring 2008 *Research Solutions* article “Saving Energy through Pump Optimization” discussed the use of a SCADA pump optimization algorithm to keep the pumps in a high-service pump system operating at the best efficiency point over a range of discharge pressures. The result of implementing this algorithm was a 10-percent reduction in power use over the period analyzed (Figure 1).

Timing Pump Rehabilitation

Knowing when to rehabilitate pumps is an important issue. Finding a time when a pump test can be performed (one pump operating) and dedicating the resources to perform these tests can be a challenge. A better solution is to use the SCADA system to capture when these events occur. Programming simple calculations using data from measuring pressure and level (determining total dynamic head),

along with measuring and recording flows, and using the pump affinity laws to back calculate the pump curve (if the pump is operating at less than 100-percent speed) can be combined to produce actual pump curve data points. These data can be compared to the original pump curves to determine when a pump should be rehabilitated.

Wellfield Maintenance

Due to the dynamics of wellfields, they afford the opportunity for SCADA to be used to reduce work effort and provide energy savings. The specific capacity of a well is the amount of water produced per foot of drawdown in the well. Every foot of additional drawdown in a well is another foot of pump energy required for the well system to transfer water. Typically, wells are rated on the amount of water that they can produce regardless of the drawdown in the well. Focusing on energy efficiency forces us to rethink the concept of well capacity based on the well’s specific capacity (and associated drawdown), rather than simply the amount of water a given well can produce. The desired wellfield flowrate divided by the sum of the total specific capacities of the wells is the minimum drawdown of the wellfield. This minimum drawdown results in the least amount of static head required and is the first step in the energy efficiency analysis for a wellfield. Other factors such as pump efficiency at the minimum drawdown, water quality considerations (well water quality can drive treatment costs), water rights constraints, and variable frequency drive operations must be considered in the overall evaluation as well.

Wellfield management can require a significant amount of investment in time and resources. One of the challenges associated with wellfield operation is performing drawdowns to verify well performance. SCADA systems can be automated to perform drawdown tests if the required instrumentation and recording

information is in place. The current specific capacity can be compared to the original specific capacity to assist the utility with the decision of when to rehabilitate the well. The City of Manhattan, KS, is currently incorporating these SCADA wellfield management features into their existing 30-mgd plant expansion project.

Chemical Feed Systems

SCADA systems can be programmed to incorporate features such as alerting the operations staff to the days of chemical storage remaining based on the current dose of chemical, and recent average flowrates. The predicted date when a chemical delivery (i.e., full tank truck) could be accepted can be highlighted, along with a follow-up reminder when the chemical system has the storage available to accept a delivery.

In addition to helping manage chemical deliveries, SCADA systems can be programmed to incorporate additional monitoring features to reduce chemical equipment requirements and to alert operators to abnormal conditions. Carollo introduced the concept of the “virtual day tank” to the water industry. This concept uses instrumentation to create a “virtual day tank” on the SCADA system and informs the operator when and how much chemical has been used, if a significant change has occurred in the use rate, and when the virtual day tank needs to be refilled (accomplished by pushing the refill button on the SCADA screen). This system eliminates the need for an actual day tank, the associated equipment, and the space in the plant facility (a virtual spill is also much easier to clean up). Calibrating chemical feed pumps by comparing the prescribed dose against the declining inventory also saves time and the hassle of employing calibration cylinders on a routine basis.

Residuals Management

As the Principal Investigator for the WERF Project 98-REM 03, *Optimization of Thickening and Dewatering Project*, Carollo was able to work with five wastewater treatment plants to demonstrate an average 20-percent reduction in polymer costs alone, while improving capture and cake solids concentration.

We learned that excellent instruments exist for measuring solids: infrared units for primary and waste activated sludge, and



By optimizing thickening and dewatering processes, five wastewater treatment plants demonstrated an average polymer reduction of 20 percent while improving capture and cake solids concentrations.

microwave units for dewatered cake solids with concentrations up to 50-percent solids. We also discovered multiple approaches to controlling the dewatering process. These include simple feed forward polymer dosing based on the mass of solids being fed to streaming current monitors, as well as control systems that make prescribed adjustments based on a measure of the excess polymer that is not needed for the dewatering process.

The bottom line: we now have good, reliable instruments to measure solids concentrations that, if used properly, in combination with SCADA systems, can reduce the polymer feed formerly required to keep the dewatering process from degrading when the operator was absent or when the sludge concentration changed too fast to allow for manual correction.

After completion of this report, we also worked with the other team members to develop a checklist for use in dewatering system design. This checklist is available upon request.

The authors would like to thank WERF for funding this work. In addition, they would like to thank Central Contra Costa SD, East Bay MUD, Orange County SD, Eastman Chemical, and Vallejo SFCDD for their participation in this work.

Solids Contact Clarifier Operations

The Winter 2009 *Research Solutions* included the article “Solids Contact Clarification: An Innovative Approach to a Seasoned Technology,” which focused on the proper operation and control of solids contact clarifiers and introduced a simple, straightforward algorithm for generating and maintaining the proper amount of solids in the center cone of a solids contact clarifier. This article is available upon request.

When solids contact clarifier automation and optimization are combined with optimizing finished water hardness and improved lime slaking, the synergistic effects improve the overall plant operations resulting in lower chemical and energy costs. Figure 2 shows the many positive, synergistic effects of automation and optimization that are not always recognized until after the project is completed.

About the Author

Vincent Hart is a project manager in Carollo’s Denver (Broomfield) office.

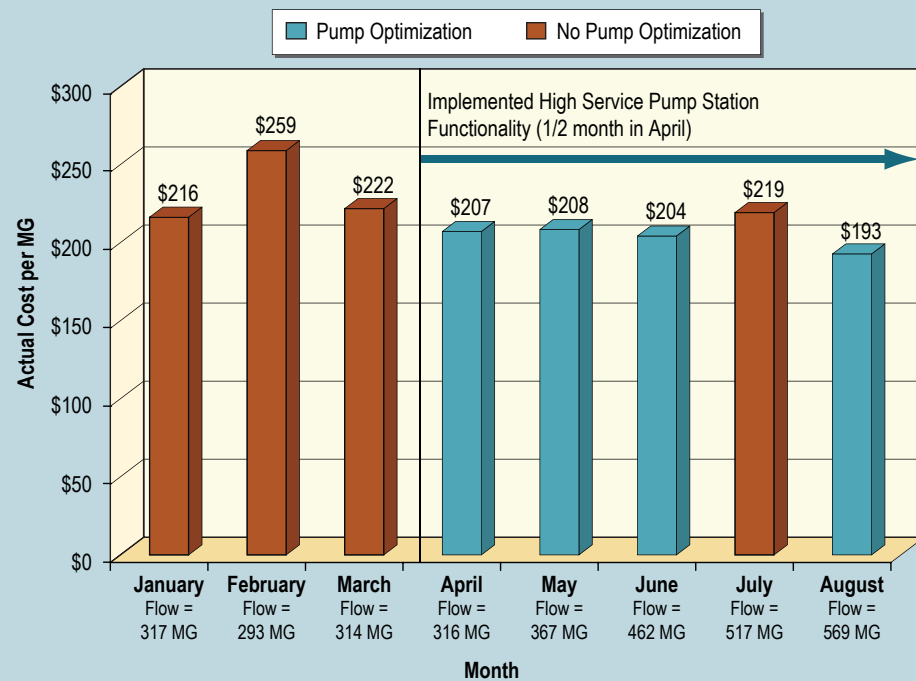


Figure 1. Data from the case study show actual power consumption measured over a 9-month period.

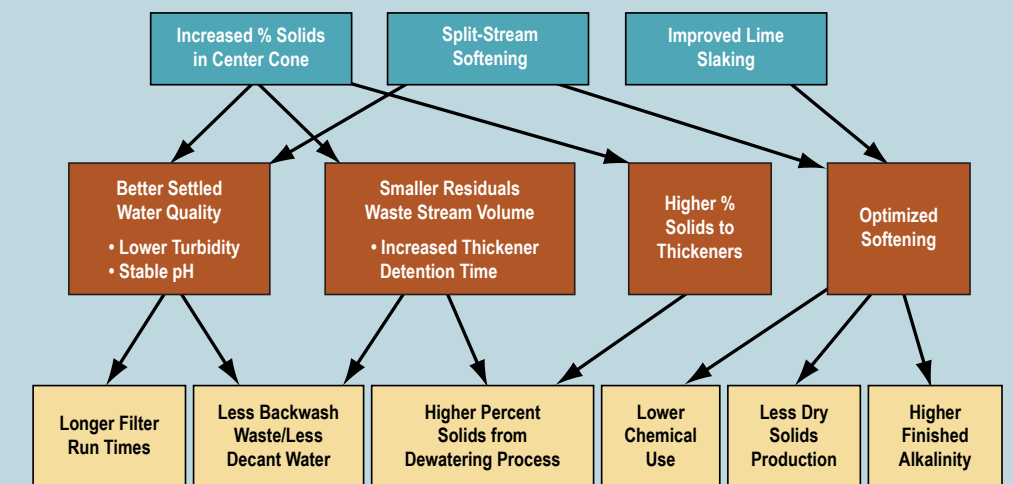


Figure 2. Integrating multiple optimization approaches to the softening process provides synergistic benefits resulting in improved plant performance and reduced operating costs.

QUAIL CREEK WTP – A Case Study in Energy Reduction and Cost Savings



By Brie Esplin (besplin@wccd.utah.gov), Shane Clark (sclark@wccd.utah.gov) [both WCWCD], and Clint Rogers, P.E. [Carollo]

Background

Operations staff at the Quail Creek Water Treatment Plant (QCWTP), operated by the Washington County Water Conservancy District (WCWCD) in St. George, UT, realized a \$20,000 power savings in 2008 by making just a few operational changes. Encouraged by these savings, QCWTP staff launched an in-house study focused on optimizing plant operations to reduce energy use and save even more money. In 2009, the savings on the annual power bill grew to over \$50,000. Perhaps even more impressive was the 45-percent reduction in average daily power use achieved. With ever-rising energy costs and current economic shortfalls, the ability to decrease energy usage is beneficial to all water treatment facilities. The energy savings tactics used by QCWTP staff are summarized in this article.

For reference, QCWTP is a conventional 48-mgd filtration plant designed to treat surface water. Pretreatment upstream of the filters is accomplished by dissolved air flotation and/or flocculation-sedimentation trains. Bulk sodium hypochlorite is added for disinfection. In times of low demand, the plant is operated in batch mode. Pumping of raw or finished water is not required.

Understanding the Power Bill

In order to identify the operational changes that would result in the greatest savings, QCWTP staff had to understand the monthly power bill, which includes four charge categories: base rate fees, usage, demand, and tax. The usage charge is based on the actual amount of power that is consumed (\$0.0503 per kWh). The demand charge is a fee applied by utilities in order to operate at maximum load and meet instantaneous power demands. The calculation of this fee varies depending on the power provider. Demand at QCWTP is billed at \$8.75 per kW calculated over 15-minute intervals throughout the billing period.

Plant staff worked with their local power director for insight on how power is billed. The power company agreed to send daily usage reports to assist QCWTP staff in their conservation efforts. Becoming familiar with the billing method and having the ability to view power consumption trends helped the staff recognize areas where the plant could cut energy costs.

Reducing Power Costs

Although the power cost involved in producing water has both fixed and variable properties, it behaves primarily as a fixed cost. Because power is a fixed cost, it takes nearly the same amount of energy to produce water at a rate of 10 mgd as it does to produce 20 mgd. Therefore, the less time the plant is online, the less power is consumed. In August 2008, the plant began batching production in order to reduce energy consumption.

Other changes also helped reduce overall usage. By programming the thermostats

to heat buildings to a lower temperature during off-business hours and weekends, the average offline usage was reduced by 50 kW. During the month of January 2009, it was estimated that the plant saved \$750 by making this change alone.

Simple things like turning off lights, removing heat tape from abandoned chemical lines, and optimizing chemical dosages and plant processes to minimize the number of backwashes required all reduced energy use. The plant also turned off the pretreatment blowers in September, 2008. The blowers provide additional defense against tastes and odors, but are not necessary if MIB and geosmin levels are low or PAC is capable of treating the taste and odors present.

Before the power study, the QCWTP averaged about 6,700 kWh of power usage per day. By batching production, shutting down pretreatment blowers, programming

Plant staff worked with their local power director for insight on how power is billed. The power company agreed to send daily usage reports to assist QCWTP staff in their conservation efforts. Becoming familiar with the billing method and having the ability to view power consumption trends helped the staff recognize areas where the plant could cut energy costs.

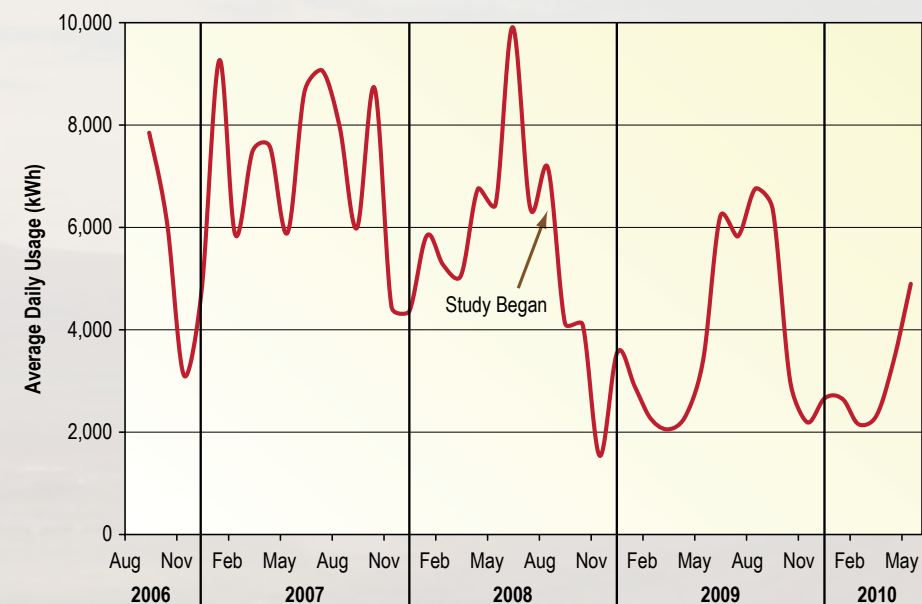


Figure 1. Average daily electric usage declined in response to an energy reduction study conducted by QCWTP operations staff.

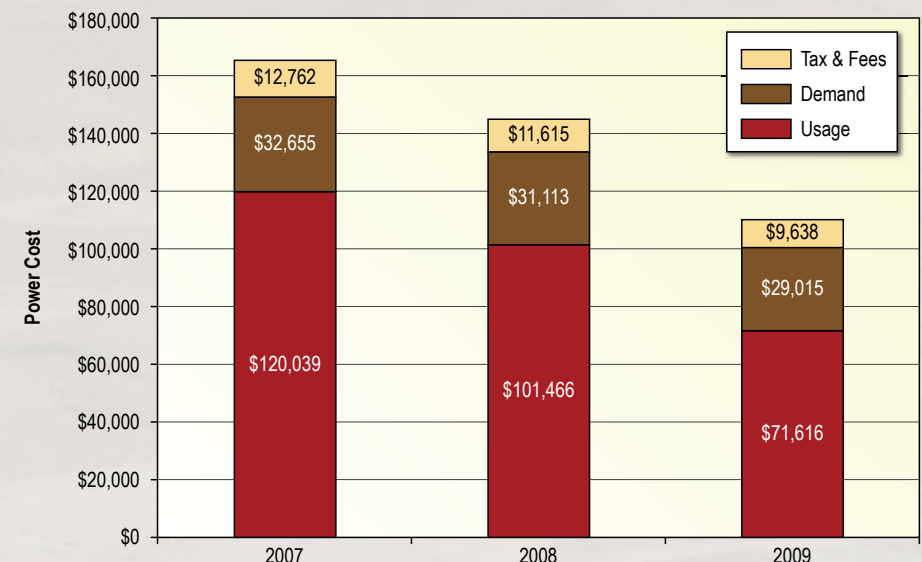


Figure 2. Summary of power savings by billing category.

thermostats, and eliminating unnecessary heat tape, the average daily power use was reduced to 3,700 kWh (a 45-percent reduction) (Figure 1).

The reduction of background use resulted in a decrease in peak demand, but reduction beyond that was more difficult. Identifying the cause of peak demand is the first step in reducing it. When motors are started, the demand for power peaks. According to Pacific Power, a motor typically requires 6 times as much energy during startup as it does to continue running. It usually takes a motor less than 5 seconds to start, accelerate, and reach operating speed.

Because plant startup is a common cause of peak demand, plant staff initially investigated options for spacing and slowing down motor startup. The elimination of the pretreatment blowers during normal operation drastically reduced plant startup demand. Each of the two blowers had 50-hp motors that would use up to 70 kW combined upon startup. The second largest consumers during plant startup are the flash mixers. In late October of 2008, plant personnel programmed the VFDs on the pretreatment mixers, flash mixers, and flocculators to reduce the start-up peaks. Start-up of mixers was also staggered by programming. Prior to October, plant startup occurred rapidly, often within

15 minutes. By bringing large motors online as far apart as possible, the increase in demand is now spread over a wider period, so not all are included in the 15-minute charge window.

Once the plant start-up procedure was optimized, filter backwashes caused the highest peak of power each month. During a typical backwash, a 40-hp blower starts up and runs for 10 minutes during the air scour phase. Then a 25-hp backwash water pump starts up, the blower shuts down after 1 minute, and the filter is backwashed at a high rate for another 10 minutes. Each filter consists of two sides, so this process causes two peaks in power. Soft starts on the backwash pumps were programmed in December of 2008. The backwash blowers did not have a form of start-up control. A soft start was purchased for the 40-hp blower motor. It cost nearly \$1,175, but resulted in an approximate demand decrease of 10 kW or \$88 per month, so the payback was just over a year.

Summary

In 2007, QCWTP spent over \$160,000 on power – \$0.0376 per 1,000 gallons of water produced. Power costs dropped to less than \$145,000 in 2008. By 2009, power costs were reduced to \$110,000 or \$0.0261 per 1,000 gallons (Figure 2). The changes that the plant made, such as batching production, shutting off the pretreatment blowers, and programming VFDs and soft starts, have significantly reduced energy consumption and have saved the plant over \$50,000 annually. By examining the electrical billing method and monitoring power consumption trends, plant staff realized areas of possible savings that were previously unnoticed. These simple in-house changes resulted not only in savings, but also in a push towards overall plant optimization.

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About the Authors

Brie Esplin is both a chief operator at the QCWTP and a chemical engineer for WCWCD. Shane Clark is a chief operator and integrated systems technician at the QCWTP.

Managing Organic Material During Wastewater Treatment – Balancing BOD Removal and Substrate Needs



By Anne Conklin, Ph.D., P.E. (aconklin@carollo.com), Tanja Rauch-Williams, Ph.D., P.E., and Susanna Leung, P.E.

For traditional facilities, primary biochemical oxygen demand (BOD) removal is generally less expensive than secondary BOD removal. Thus, in-plant organic matter reduction has focused on maximizing BOD removal in the primary clarification stage to reduce the footprint and operating costs of the secondary treatment process. This approach deserves reconsideration where biological nutrient removal is required as nitrogen and phosphorous removal may be limited by organic carbon substrate availability. Managing BOD during treatment for nutrient removal is complex and site-specific, but can result in significant overall operational savings for chemical carbon addition. Several key factors that need to be considered are the:

- Relative cost difference of BOD removal during primary and secondary treatment.
- Type of BOD removed during primary treatment (particulate or soluble, and its bioavailability).
- Organic substrate requirements for biological nutrient removal.
- Costs of external carbon substrate supplements (such as methanol or alternative sources).

The following case studies illustrate (from two different angles) BOD management solutions Carollo has developed.

Organic Matter Management to Support Nutrient Removal

Case Study: City of Northglenn, CO
The City of Northglenn is treating domestic sewage in an aerated lagoon system for BOD and total suspended solids (TSS) removal, followed by an activated sludge process currently operated for nitrification. Denitrification is expected to be required in the next permit cycle. A review of the

wastewater influent characteristics and the current lagoon performance indicated that methanol or another alternative carbon source is required to support denitrification using the existing lagoon and activated sludge system in series.

In order to avoid the expense of supplemental carbon (total construction costs of a carbon feed facility alone are estimated to be around \$1.4 M in 2010 dollars), blending of raw wastewater and lagoon effluent to raise the activated sludge feed BOD was evaluated. A calibrated process model was used to evaluate different flow split scenarios (Figure 1). Process modeling indicated that the effluent nitrate goal of 8 mg/L could be achieved at a lagoon effluent and raw wastewater blend ranging from a 40/60 split up to 100-percent raw wastewater being treated in the activated sludge process. The recommended blend of 40/60 in the aeration basin influent eliminates the need for carbon addition for denitrification while maximizing treatment capacity through partial peak flow dampening and solids settling in the lagoons.

Organics Management in a Traditional Facility

Case Study: City of Bellingham, WA
The Post Point WWTP in Bellingham, WA, operates a 20-mgd high purity oxygen treatment process. The City of Bellingham has been in the process of planning a plant

expansion for the last several years. As part of the expansion evaluation, Carollo compared the impacts of constructing a new primary clarifier against using chemically enhanced primary treatment (CEPT) in combination with the existing tankage for this combined sewer system. CEPT is a process by which chemical coagulants (such as ferric, aluminum chlorohydrate [PAX] and/or polymer) are added to the primary clarifier to increase removal efficiencies of previously unsettlable BOD during high-flow conditions without increasing the clarifier surface area.

Anticipating a low frequency of large wet weather events, the financial evaluation found that the 20-year total present value for a CEPT facility would be less than 25 percent of building a new primary clarifier. Carollo confirmed the performance of CEPT use at both the jar-scale level as well as with full-scale testing. Both jar and full-scale testing resulted in more BOD removal for high clarifier surface overflow rates between 1,000 gpd/ft² and 2,300 gpd/ft² than conventional clarification alone. By using PAX (25 mg/L) and a polymer in combination, BOD removal in the primaries was sufficient to eliminate the need for an additional primary clarifier.

About the Author

Anne Conklin is a process engineer in Carollo's Seattle office.

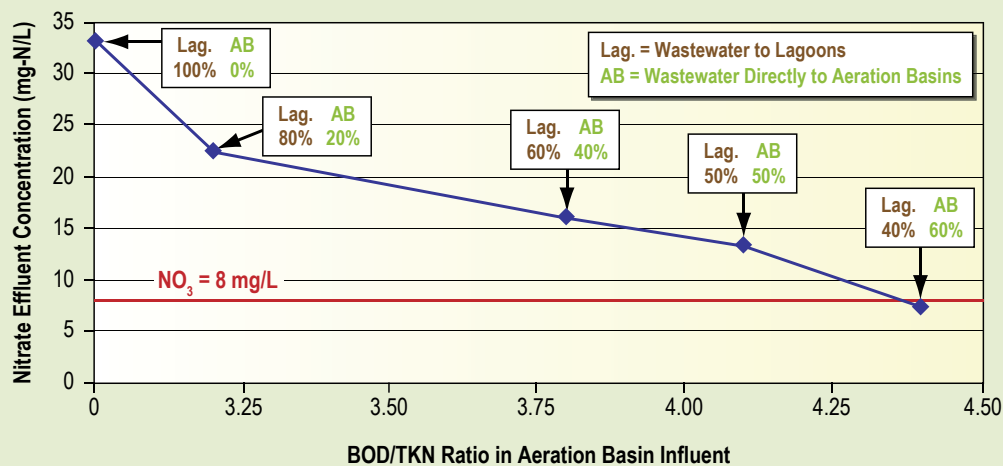


Figure 1. Decreasing the flow ratio through the lagoons provides more carbon for denitrification in the aeration basins.

ERDs Improve Sustainability while Decreasing the Cost of Brackish Groundwater RO



By Jennifer Stokke, Ph.D., E.I. (jstokke@carollo.com), Don DeMichele, E.I.T., Bradley Sessions, and Tom Seacord, P.E.

In Florida, over 140 reverse osmosis (RO) treatment plants produce approximately 515 mgd of potable water from brackish groundwater supplies. If energy recovery devices (ERDs) were used with all these RO systems, an estimated 3.4 MW of energy could be recovered in the concentrate stream. And that's just Florida.

In RO treatment, the concentrate stream (i.e., brine) typically has a residual pressure between 70 and 200 psig. Historically, this pressure has been reduced (typically to less than 30 psig) across a flow-control valve. This wasted pressure has inherent potential energy. ERDs can be used to recover a significant amount of this wasted residual energy, reducing production costs.

There Are Several Types of ERDs to Consider

There are two primary types of ERDs used in brackish groundwater RO applications:

- **Turbine Driven Pumps** – which include turbochargers and turbine assisted booster pumps.
- **Isobaric Devices** – which include the pressure exchanger device.

Carollo has designed brackish groundwater RO systems using both of these types of technologies. The optimal choice is one that recovers the most energy, is the least complicated to operate, and has the shortest payback period.

Cost Savings Can Be Realized after Only a Few Years

When using ERDs for a brackish RO system, production cost savings are primarily the result of reduced energy use. For the Jordan Valley Water Conservancy District's (JVWCD's) 7-mgd Southwest Groundwater Treatment Plant project in West Jordan, UT (a suburb of Salt Lake City), Carollo added ERD devices as a design change during construction. This provided the opportunity to directly compare the additional capital costs associated with adding the ERD based upon the contractor's initial bid and change order costs. From these capital costs and calculation of the operating costs, the payback period that would be realized through ERD use could be calculated (see Table 1). As indicated, the payback period for an ERD is only 5.6 years, resulting in substantial cost savings over the lifetime of the equipment.

The results of such payback analyses will vary with the cost of power and salinity conditions.

Table 1. Cost for Replacing Interstage Booster Pump with a Turbine Assisted Booster Pump

Parameter	Replacement Cost
Capital Costs	
Equipment	\$93,801
Electrical	(\$23,310)
Total	\$70,491
Electrical Costs (per year)	(\$12,542)
Payback Period	5.6 years

Notes:

ERD is a turbine assisted booster pump (LP-HEMI). Power costs are \$0.03/kW-hr.

has pioneered the use of isobaric ERDs in brackish applications, testing the first isobaric ERD process in a project funded by the Texas Water Development Board in El Paso, TX. Recent projects implementing ERDs include:

- **Lee County Utilities, FL.** As part of the North Lee County RO WTP expansion from 5 to 10 mgd, Carollo's design added turbine assisted booster pumps to both the existing and new trains, resulting in a 20 kW reduction in power use and a \$20,000 annual savings in power.
- **Collier County Utilities, FL.** Carollo designed an isobaric energy recovery system that will be constructed as part of Collier County's 20-mgd Northeast Regional RO WTP project. This system will recover 535 kW of energy, saving approximately \$470,000 per year in power costs.
- **JVWCD, UT.** The 7-mgd Southwest Groundwater Treatment Plant RO system includes turbine assisted booster pumps. Using this ERD technology, Carollo's design will reduce power use and power costs by 45 kW and \$12,500 per year, respectively.

About the Author

Jennifer Stokke is an engineer in Carollo's Sarasota, FL, office. She has experience in planning, piloting, and design of RO systems, and is currently part of the design team for the North Lee County RO WTP expansion project.



There are two primary types of ERDs used in brackish groundwater RO applications: turbine driven pumps (left and middle) and isobaric devices (right).

Carollo Is Leading the Way

Carollo is leading the desalting industry in implementing energy efficient and sustainable RO system designs and

Wastewater UV - Energy Hog or Simply Misunderstood?



By Andrew Salveson, P.E. (asalveson@carollo.com); John Burcham and Pete Klein [both City of Escondido, CA]; and David Stoops, Kumidini Dharmawardana, and Helen Ling [all City of Livermore, CA]

Dharmawardana, and Helen Ling [all City of Livermore, CA]

In today's economy, there is no budget to spare. Coupling the economic crunch with the desire to be more "sustainable" forces us to re-examine relatively high-energy processes, including ultraviolet light (UV) disinfection. Presented here is an evaluation of two wastewater reuse UV systems: the City of Escondido, CA, and the City of Livermore, CA. As described below, both systems underwent detailed performance scrutiny and substantial energy-saving steps were identified.

Escondido, California

For the City of Escondido, their reuse UV system was designed to produce 9 mgd of recycled water that meets California's Title 22 water quality requirements (UV dose = 100 mJ/cm²). Poor flow split, short-circuiting, and overly conservative assumptions resulted in a reactor capacity of only 4 mgd. In addition to a dramatic capacity shortfall, the system must currently operate with more than 100 percent additional energy input than planned and also must deal with increased equipment maintenance. Based upon the detailed analysis by Carollo, the City of Escondido is making the necessary improvements to increase system efficiency and realize the design capacity.

The major results from Escondido include the following:

- CFD modeling was used to diagnose hydraulic issues and evaluate a suite of alternatives.
- A full-scale bioassay test provided an accurate measurement of system performance, taking into consideration the upgraded hydraulics.
- Lamp aging and lamp-sleeve fouling are being measured.

In total, simple low-cost testing and analyses indicated that the energy efficiency can be nearly doubled and the capacity of the system can be ~8 mgd, not 4 mgd.

Livermore, California

The City of Livermore (City) owns and operates the Livermore Water Reclamation Plant, including a UV system disinfecting water for reuse. The City, working with Carollo, completed an evaluation of the UV system to assess its capacity and performance. During the investigation, it was determined that system performance far exceeded expectations. Detailed testing of disinfection efficiency, lamp aging, and lamp-sleeve fouling indicated that the system was overdosing by 41 percent. This evaluation allowed for a substantial reduction in energy (Figure 1) and lamp replacement, resulting in nearly \$20,000 in savings per year.

Author Credit & Acknowledgements

Andrew Salveson oversees wastewater alternative disinfection and advanced reuse treatment research and design in Carollo's Walnut Creek, CA, office. He was awarded the 2007 WateReuse Person of the Year honor for "bringing innovative technologies to market." Other Carollo employees that worked on these projects include Jeff Bandy, Ph.D., E.I.T., Dennis Wood, P.E., Rick Chan, P.E., and Ed Wicklein, P.E.

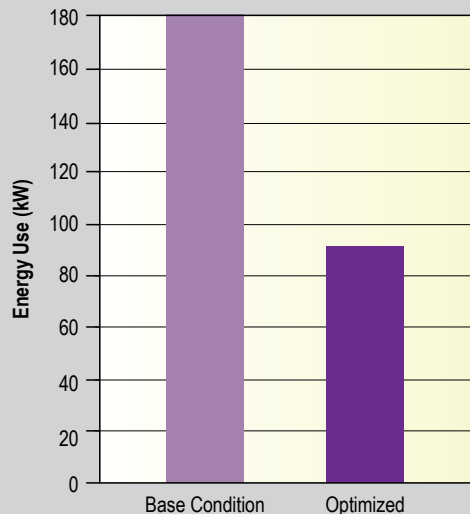


Figure 1. A better understanding of system performance allows for a dramatic reduction in energy use.

- Phoenix, Arizona
- Yuma, Arizona
- Fresno, California
- Inland Empire, California
- Orange County, California
- Pasadena, California
- Sacramento, California
- San Diego, California
- San Francisco, California
- Thousand Oaks, California
- Walnut Creek, California
- Denver (Broomfield), Colorado
- Denver (Littleton), Colorado
- Broward County, Florida
- Miami, Florida
- Orlando, Florida
- Palm Beach County, Florida
- Sarasota, Florida
- Boise, Idaho
- Kansas City, Kansas
- Las Vegas, Nevada
- Charlotte, North Carolina
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