Managing Industrial Water Reuse Projects For Success

A PROCESS TEMPLATE

(WATEREUSE RESEARCH FOUNDATION WRRF-12-03)

WATEREUSE

JUNE 2015

Contents

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FOREWORD

Each day, hundreds of millions of gallons of water are being recycled by industrial plants, processing units and manufacturing facilities around the globe. Sadly, only a small percentage of the total is in the United States. By contrast, Australia and Europe, according to some experts, are at least 10 years ahead of America in terms of widespread adoption of industrial water reuse.

This gap cannot stand.

With drastic water rationing in California, severe drought conditions, and strains on municipal water supplies throughout the United States, the economic and personal tolls are increasing dramatically. In the face of this undeniable reality, industrial water reuse is no longer optional – it is a necessity.

Fortunately, there is an increasing amount of momentum in that direction. Many of the initial barriers to industrial reuse have been removed through improvements in treatment technology, public policymaking, and financial incentives. Other, more subtle barriers remain, however, barriers that the methodology and tools in this document are designed to remove.

The overarching **strategy** is to close the organizational culture gaps that exist among water providers, industrial water customers, and wide-ranging regulatory bodies. The **objectives** are better communication, increased understanding of each other's needs, and the adoption of a shared framework for planning and executing successful projects together. The **rewards** include supply security, cost benefits, and quantifiable progress toward sustainability in communities throughout the country.

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ACKNOWLEDGMENTS

This work was inspired originally by a 2012 panel discussion among "pioneers" who had implemented water reuse at their companies' industrial facilities. The take-away from that event and others like it was, "It shouldn't be this difficult." The members of the Industrial Water Reuse Committee within The WateReuse Research Foundation came to the same conclusion. Their tireless efforts helped to garner support and sponsors for WRRF-20-13, the research grant under which this work has been produced. Thank you to the sponsoring organizations, in-kind contributors, and project champions.

This project has been funded by the **WateReuse Research Foundation** with sponsorship from **San Diego County Water Authority** and **Santa Clara Valley Water District**.

PROJECT ADVISORY COMMITTEE

Elise Goldman - West Basin Municipal Water District
Eric Rosenblum - Envirospectives
Maria Mariscal - San Diego County Water Authority
Ray Wong - Santa Clara Valley Water District
Val Frenkel - Erler and Kalinowski, Inc.

IN-KIND CONTRIBUTORS

City of San Diego Public Works Department:
Hooman Partow, Senior Civil Engineer
Jennifer Casamassima, Recycled Water Program Manager

Water Conservation Technologies International
Dan Duke, President

RESEARCH SUPPORT

Maria-Tzina (Gina) Leria
Master of Environmental Studies, Graduate of the University of Pennsylvania

INTERVIEW, CASE STUDY, AND INDUSTRIAL WATER REUSE CONFERENCE PARTICIPANTS:

Becky Rathbone, Systems Control/Recycled Division Manager, Eastern Municipal Water District
Cash Bryan, Facility Supervisor
Internap
Dan Pedersen, Manager, Reclaimed Water program
City of Austin
Hossein Juybari, Senior Civil Engineer, Recycled Water, Eastern Municipal Water District
John Wuerth, Principal Engineering Tech, Recycled Water, Eastern Municipal Water District
Ken Letwin, Senior Process Engineer,
Tesoro Los Angeles Refinery – Carson Operations
Lewis Sweeney, Maintenance Manager,
GE Energy, Inland Empire Energy Center
Walt Black, Facilities Manager,
BAE Systems, Austin, TX

In addition, sincere thanks go to the individuals who candidly shared their experiences with the research team. The courage to describe the miscues, misunderstandings, faulty assumptions and other "gotchas" that affected their projects is of tremendous benefit to the cause of water sustainability.

Rich Layton, Principal and Creative Director, Transform Communications — transformcom.com | June 2015
Joel E. Bowdan III, P.E., Senior Associate and Project Manager, RBF Consulting – A Company of Michael Baker Int'l

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1 Industrial Reuse Applications at a Glance

Here are highlights of primary industrial applications and a table summarizing water quality, corresponding treatment processes, and their cost differentials.

Industrial reuse applications can be classified as **cooling water systems**, **boiler systems**, and **process water**. Cooling and boiler systems are widely used in industries such as refineries, petrochemical plants, and power plants; also commercial and institutional applications with high volumes of nonpotable water consumption. Industrial process water reuse applications include but are not limited to carpet and textile manufacturing, commercial laundry, nonfood process rinse, and high-technology manufacturing. Each application determines water quality requirements and the level of additional treatment necessary to use recycled water effectively.

Cooling water systems are widely used in industrial, commercial, and institutional applications to remove heat from a process. Cooling water systems require a water treatment program to control corrosion, scale formation, and biological activities. Conventionally, chemical inhibitors and biocides are used as part of the water treatment program. Also, newer alternative green technologies significantly reduce chemical consumption and reduce make-up water demand. Substituting recycled water generally is accomplished through additional adjustment or change in the water treatment program, and potentially, corresponding adjustment to operating parameters.

Boiler systems are used mainly for heating water or producing steam for various applications. In high-pressure boiler systems, feed water requires both physical and chemical treatment to control corrosion and scaling in the system. Physical treatment of high-pressure boiler systems includes removal of minerals from the feed water utilizing reverse osmosis (RO) membrane systems, electrodialysis reversal (EDR) systems, or ion exchange (IX) systems. Use of recycled water as a source for boiler feed make-up water requires additional pretreatment system (i.e., filtration system) upstream of the existing systems to prevent fouling of these systems and condition the recycled water prior to use. In low-pressure boiler system applications, a pretreatment filtration system followed by an IX softening system are required to condition recycled water for use as feed water with chemicals added to control corrosion.

Process water has a wide range of applications. In the carpet and textile industry, finishing raw fabrics requires water for weaving mills, kiering, and bleaching operations. Recycled water can be used with the addition of chemical conditioning and removal of dissolved solids. Some facilities have their own water recycling treatment facilities that recover wastewater generated from the various unit operations and reuse it within the process. The goal is to use the higher quality recycled water in critical processes that need it, and then reuse the recycled water for those processes that require lesser quality water.

THE GOAL IS TO USE THE HIGHER QUALITY RECYCLED WATER IN CRITICAL PROCESSES THAT NEED IT AND THEN REUSE THE RECYCLED WATER FOR THOSE PROCESSES THAT REQUIRE LESSER QUALITY WATER.

High-technology manufacturing uses high-purity water – often referred to as “designer water”– for their proprietary processes. Use of recycled water for this type of application requires additional treatment to condition and pretreat prior to use.

With steady advances in treatment technologies, the range of industries able to take advantage of recycled water continues to expand.

The following table provides a summary of typical reuse applications and the associated treatment processes typically used to precondition the water for its successful use.

INDUSTRIAL RECYCLED WATER REUSE APPLICATION AND TREATMENT MATRIX

LEVEL	TYPICAL APPLICATION	TYPICAL RECYCLED WATER QUALITY REQUIRED	TYPICAL TREATMENT PROCESS	ADDITIONAL TREATMENT REQUIREMENT	COST IMPACT RELATIVE TO CONVERSION FROM POTABLE	
					CAPITAL COST	OPERATION & MAINTENANCE
1	Carpet and Textile Mfr Commercial Laundry Nonfood Process Rinse	Tertiary Disinfected TDS < 1500 mg/L	Adjustment to Chemical Treatment Program	Not Required	Low-Moderate	Low-Moderate
2	Cooling Tower System	TDS < 1200 mg/L Total Hardness < 500 mg/L as $CaCO_3$ Ortho-Phosphate < 3 mg/L as PO_4 Total Suspended Solids < 2 mg/L Ammonia < 2 mg/L as NH_3	Adjustment to Chemical Treatment Program	Generally Not Req’d *Nitrification may be necessary to remove high levels of ammonia*	Low-Moderate	Moderate
			Alternative Nonchemical Treatment Program	Not Required	Moderate	Low
3	High-Technology Mfr Low-Pressure Boiler System	TDS < 60 mg/L Total Hardness < 0.3 mg/L	Reverse Osmosis (RO) System followed by Ion Exchange Demineralization	Filtration Pretreatment	High	High
			Electrodialysis Reversal (EDR) followed by Ion Exchange Demineralization	Filtration Pretreatment	High	High
4	High-Pressure Boiler System	TDS < 5 mg/L Total Hardness < 0.03 mg/L	Reverse Osmosis (RO) followed by Ion Exchange Demineralization	Filtration Pretreatment	High	High
			Electrodialysis Reversal (EDR) followed by Ion Exchange Demineralization	Filtration Pretreatment	High	High

2 What Drives Industrial Water Reuse Projects?

Reasons to use of recycled water in industrial applications vary widely, with a marked distinction between water customers and water providers. With the aid of research, interviews, and case studies, however, two discreet sets of drivers emerge.

DRIVERS FOR WATER CUSTOMERS

In stark contrast to the "early days" of reuse, when the job of promoting recycled water fell exclusively to providers, more and more companies actively seek out options for access to recycled water. Some more progressive water treatment companies are also bringing increased awareness to customers, which leads to more customers interest and comfort with using alternative supplies.

Naturally, this dynamic varies from region to region as a consequence of the availability of potable water, its quality, and its cost. In general, however, industrial users who are considering applications for recycled water do so for four primary reasons:

1. **Supply Security:** Water shortages or drought pose an operational risk to plants and facilities that require large amounts of water to maintain production, whether for cooling and/or processing and production. As supplies are curtailed, there is a very real risk of periodic plant shutdowns and disruption of associated revenue streams. Over the long term, plant owners face the prospect of abandoning production facilities and taking huge capital write-offs if they are unable to secure the water necessary to operate.
2. **Cost–Benefit:** Depending on the economics in a given region, recycled water can offer potential savings over use of fresh water; when supply security is factored in, the combination of direct and indirect cost savings can be significant.
3. **Compliance:** Regulatory requirements in many areas stipulate industrial use of recycled water as a condition for new plant construction and other commercial development; additional policy changes likely are coming. Bringing operations in line with local, state, and federal regulations concerning water usage and discharge quality will continue to be a moving target that industrial operations must hit.
4. **Social Responsibility:** Corporations that have added sustainability, green initiatives, and environmental responsibility to their mission, vision, and value statements view water use as part of the formal strategy for achieving their goals in these areas. Water reuse may be pursued despite cost considerations, depending on the strength and scope of the organization's commitment to host communities and other stakeholders.

EVENTUALLY, WATER CUSTOMERS AND WATER PROVIDERS MUST CLOSE THE "CULTURAL GAPS" THAT SEPARATE THEM AND FIND COMMON GROUND TO EXPLORE POTENTIAL INDUSTRIAL WATER REUSE OPPORTUNITY.

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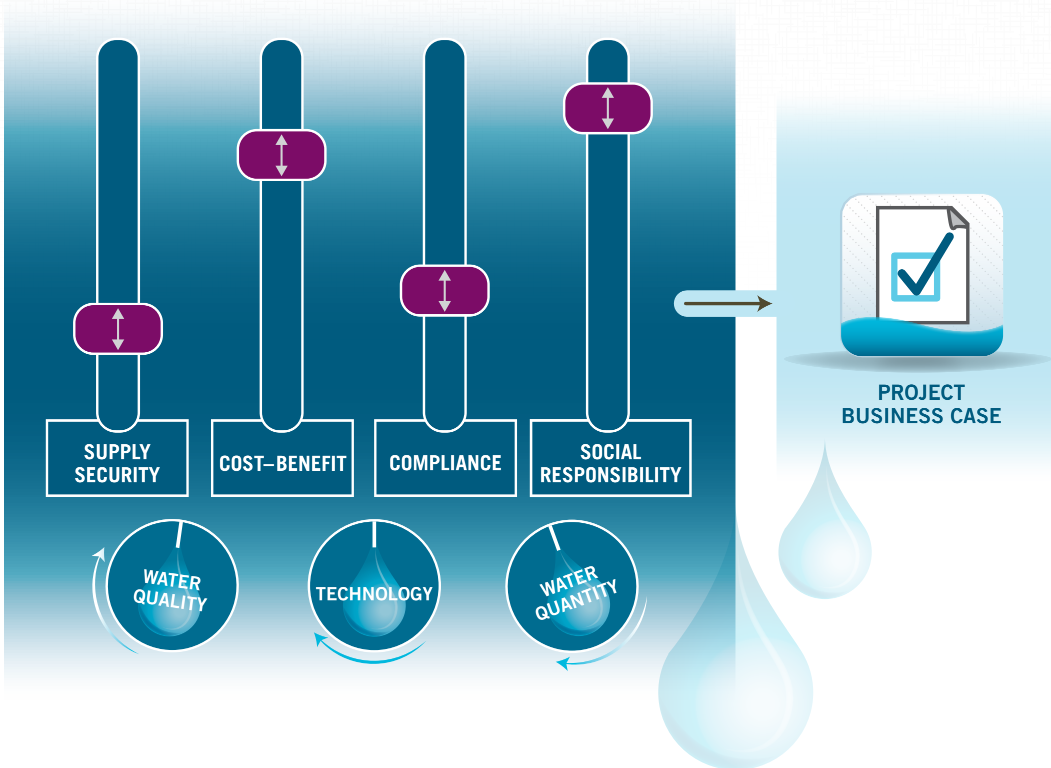
Rarely is a reuse project initiated on the basis of a single driver. It is more likely that several drivers will be "in the mix," and at varying degrees, as depicted by the adjustable sliders and knobs in Figure 1, Drivers: Water Customers.

Figure 1: Drivers: Water Customers



This conceptual illustration of primary drivers and three secondary factors – water quality, technology, and water quantity – shows the multiple factors that come into play to formulate the customer business case for industrial water reuse. Each customer will have priorities based on the set of drivers and secondary factors. The priorities and their associated objectives will be reflected in the range of stakeholders and decision makers, and in the final business case on which the project will be based. The ability of water customers to clearly articulate their business case to water providers is key to establishing a foundation for effective communication and, ultimately, project success. These drivers will be both articulated and documented by both the water customers and the water providers during the development of the Project Charter.

DRIVERS FOR WATER PROVIDERS

As noted in the introduction, customers and providers have a powerful common interest in industrial water reuse; yet, their reasons are not the same. In general, water providers are pursuing industrial applications of recycled water for a separate set of four primary reasons:

1. **Source Conservation:** Fresh water supplies are under increasing pressure in many areas of the country as a function of extended drought, development and/or population growth, changes in water quality, source water availability, and other factors. Industrial use of nonpotable water enables providers to make more efficient use of their fresh water supply.

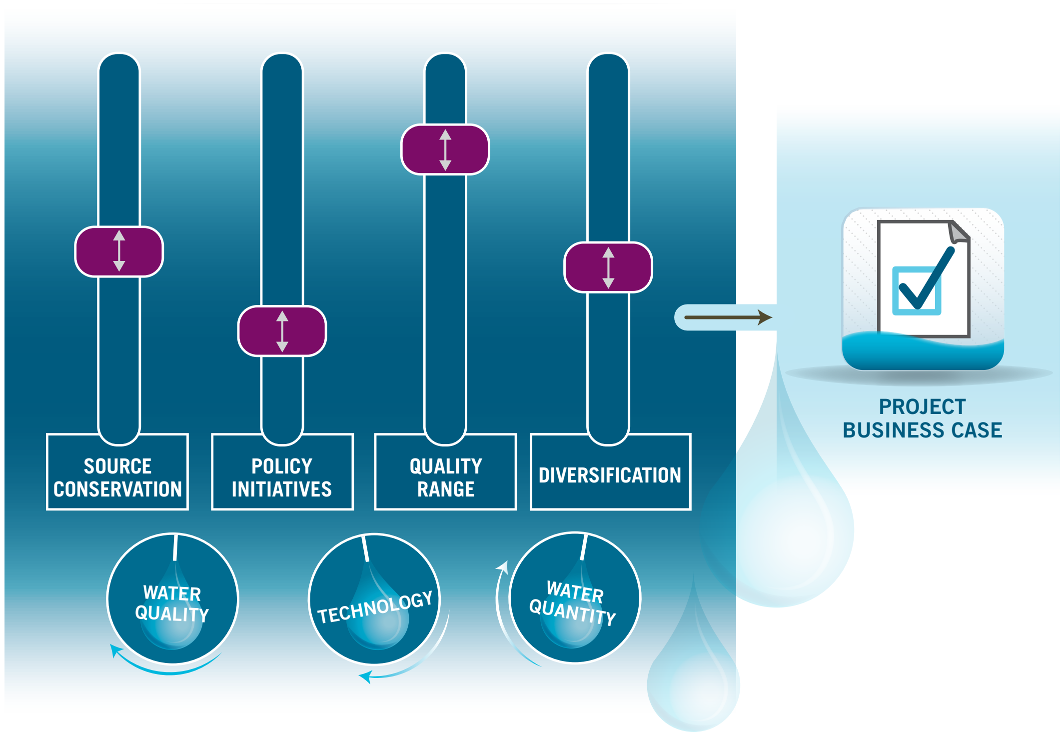
2. **Policy Initiatives:** In an effort to further the causes of both conservation and reuse, increasing numbers of state and local governments, regulatory agencies, service districts and other institutions have developed legislation and regulatory requirements to promote more use of recycled water. As public agencies, water providers are the de facto "implementers" of such policies on behalf of the governing bodies they serve.

3. **Quality Range:** Providers' treatment facilities may have limitations in terms of the quality of the source water available for recycled water production, i.e., the level of certain constituents may limit use of the water or require some level of pre-treatment be provided to ensure the water is of a quality suitable for its intended purpose. This may impact the types of industrial reuse applications or customers that providers can support effectively.

4. **Supply Diversification:** Providers may consider recycled water supply capability and IWR projects as additions to their "portfolio" of products, services, and revenue streams, as well as to satisfy a desire to derive more ROI from infrastructure or sunk costs

Figure 2, Drivers: Water Providers depicts these primary drivers and secondary factors that go into formulating the business case for providers developing industrial water reuse projects in their service areas. As with the customer equation, it is likely that several drivers will be "in the mix."

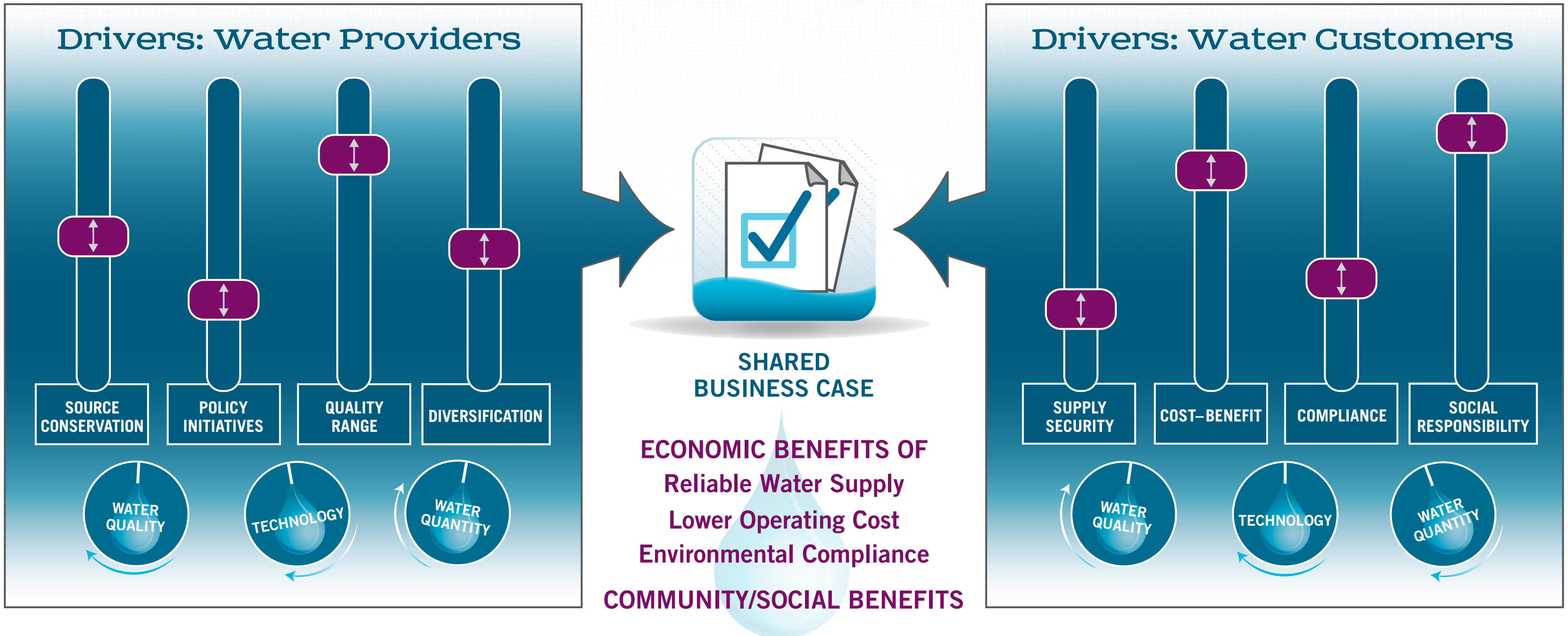
Figure 2: Drivers: Water Providers



IMPLICATIONS

Eventually, water customers and water providers must come together and seek common ground to explore any potential industrial water reuse opportunity. A comparison of the provider's drivers and the customer's drivers can be extremely helpful in revealing any potential direct conflicts or areas of misalignment. In scenarios with additional stakeholders (e.g., municipal water retailer or wholesaler) there may be value in identifying any additional drivers that may have bearing on the effort.

Figure 3: Shared Business Case



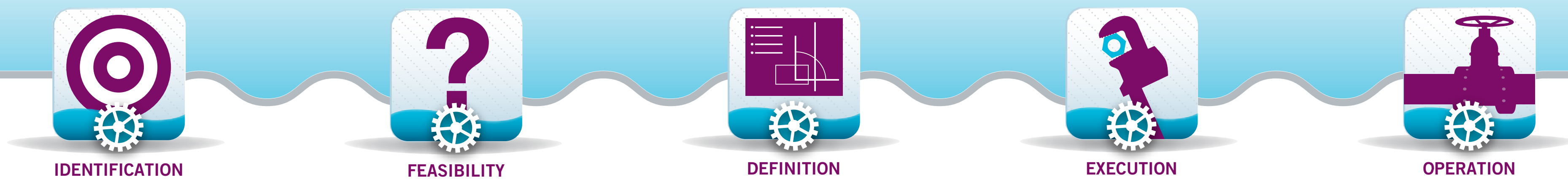
As depicted in Figure 3: Shared Business Case, the ideal scenario is for each party to fully develop its internal business case and then attempt to distill a combined business case that will inform subsequent planning and joint decision making. Beneath the seemingly diverse drivers are core common interests that every successful project can address to some degree.

3 The IWR Collaborative Framework

Although water providers and their industrial customers share common geography, they operate in very different worlds. Bridging the gaps between these different worlds empowers providers and customers to build a shared business case that better achieves a powerful common goal: efficient industrial use of recycled water.

The demands on privately owned and publicly traded companies can be diametrically opposed to those of public agencies and regulatory bodies. Although the differences can be challenging and complex, they are not insurmountable. This section introduces a project execution model designed to bridge the gaps. It incorporates proven best practices of global project management organizations, and it reflects the knowledge gained to date from Industrial Water Reuse research and associated case studies.

Figure 4: Multiphase Project Model



Although volumes have been written on similar types of stage/gate development models, dividing the project lifecycle into a set of distinct phases (Figure 4: Multiphase Project Model) delivers a universal set of benefits:

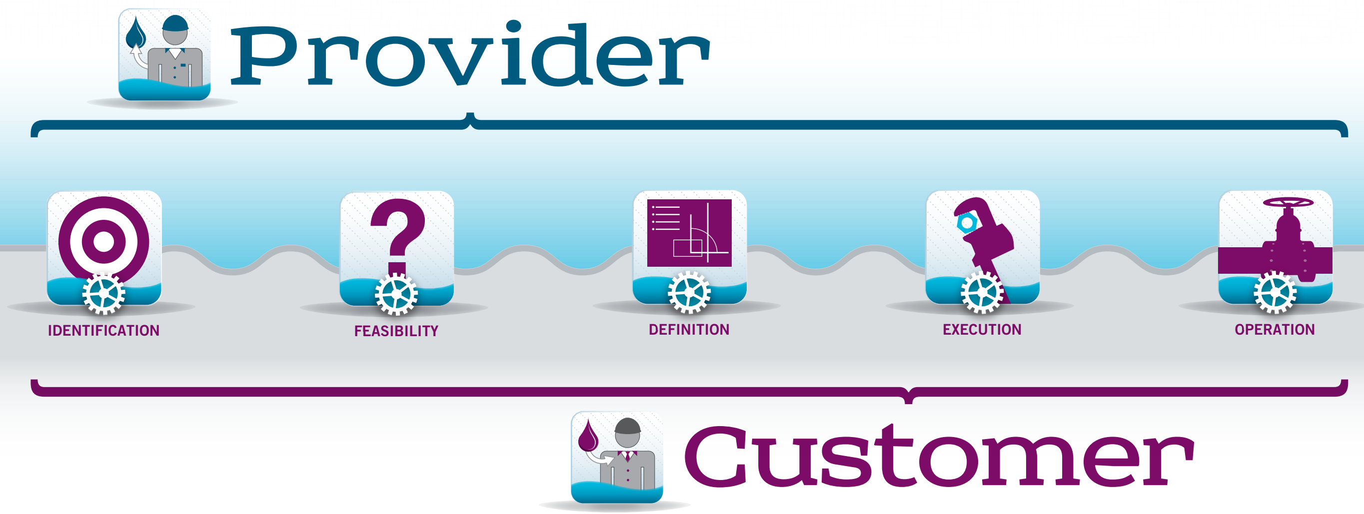
- Creates smaller, more manageable sets of activities
- Enables more efficient use of limited internal resources
- Allows for incremental funding
- Yields faster, higher quality decision making
- Fosters communication and coordination among project participants

Along with the model, other best practice tools are provided, including a project charter template for comprehensive, upfront planning.

Collaborative project development provides agencies and industrial water customers with additional benefits beyond those enumerated here, many of which are only evident once the process is underway. The remainder of this section details the phases and provides high-level guidelines for application.

FROM MODEL TO COLLABORATIVE FRAMEWORK

Like two sides of a coin, this model affords a two-sided view into a sequence of typical activities that culminate in a fully functional industrial use of recycled water. One view is through the lens of the water provider; the other is through the lens of the industrial water customer. The "secret" is this: the combination of two 180-degree views yields a 360-degree picture of each project. When all facets of a project are visible, virtually nothing can fall unnoticed through the cracks. The implications for speed and cost of completion are obvious.



IDENTIFICATION

Explore possibilities for IWR and determine potential scope of opportunity

FEASIBILITY

Determine whether IWR is practical, cost-effective and doable

DEFINITION

Develop IWR project options and select optimal concept for execution

EXECUTION

Plan and manage selected project concept to completion

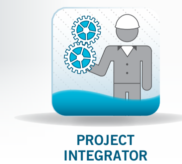
OPERATION

Start up, operate and maintain IWR system to meet user's operational and business goals

In terms of application, either party alone can initiate a potential industrial water reuse project before involving the other as a project partner. The explanation to follow will include both perspectives in an effort to show how the parties' respective activities parallel each other. This also is part of the underlying communications strategy to provide each audience, i.e., providers and customers, with insights into the other's perspective. ***(Note: additional communications insights are provided separately in a later section of the guideline.)***

How to Use the Framework

The model and phase descriptions have been distilled from the experiences of providers and industrial customers who had to "trail blaze" their IWR projects to successful completion. As such, the information here is intended to function as a "template" that users are encouraged to expand or contract and otherwise tailor as needed.



In addition, effective application of this framework always requires a designated "process owner." This can be a small team/work group with IWR knowledge and networks. This group should designate a project integrator who has formal responsibility for coordinating activities and developing deliverables for the appropriate decision makers. Other formal roles will emerge at the point a physical project takes shape. (See "Best Practices" section for more details.)

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PHASE 1: **IDENTIFICATION**

Explore possibilities for IWR and determine potential scope of opportunity

IDENTIFICATION

Provider Perspective

PROVIDER

Phase input: Review of project drivers

Focus: Research and identify potential customer candidates

Deliverable(s): Profile industrial customers' usage patterns and process applications

Key Decision(s): Confirm size of industrial user base to continue to Feasibility Phase

Description Research indicates that many water providers have competing interests and/or conflicting goals that can constrain efforts to promote industrial water reuse within their service areas. The Identification Phase for providers involves taking stock of their customer base and estimating the size of the potential IWR market it represents. The input to the activity in this phase is a preliminary review of IWR drivers (see previous section). The objective of the exercise is to rank and weigh drivers in terms of their influence on the current organizational direction. This information ensures alignment between existing priorities (e.g., source conservation as a top priority owing to persistent drought conditions) and subsequent "outreach" to customers.

Customer Perspective

CUSTOMER

Phase input: Review project drivers

Focus: Research and identify facilities and process applications suitable for reuse

Deliverables: Profile plants and/or business units that are candidates for IWR projects

Key Decision(s): Confirm scope of IWR opportunity to continue to Feasibility Phase

Description As mentioned in the Foreword, an increasing number of companies are actively pursuing reusable water solutions for their processing plants and manufacturing facilities. For this group, the Identification Phase also begins with input from a review of their respective IWR drivers to ensure alignment with corporate and operational goals. For example, does the company want to promote IWR as part of its corporate social responsibility agenda? Does it want to be able to use sustainability in its marketing and branding campaigns to consumers? Does a business unit need to invest in a reliable water supply to mitigate impacts of a potential drought? Any or all of these questions can come into play. Then, the focus shifts

PLEASE NOTE: Although shown side by side, the activities of providers and customers do not correspond one-to-one. The two-column arrangement is intended to help each reader appreciate what others are doing in a given phase.

PHASE 1: **IDENTIFICATION** CONTINUED

Explore possibilities for IWR and determine potential scope of opportunity

IDENTIFICATION

PROVIDER

The focus of the phase is "intelligence gathering" by appropriate departments and staff to answer such questions as:

+ How many industrial water users are in the provider's customer base/service area?
+ Which industries are these customers in?
+ What is the extent of water-dependent equipment and manufacturing processes at these facilities?
+ Are there IWR applications that can functionally replace fresh water usage in these plants?
+ Are any plants in close proximity to existing distribution systems?

Decision Criteria The resulting data is used to develop a set of informal profiles of those customers whose operations can take advantage of IWR options. If there is a sufficient number of such customers and commensurate savings of fresh water, then the process moves to the next phase, **Feasibility**.

CUSTOMER

to an overview of the company's operating assets to answer the following questions:

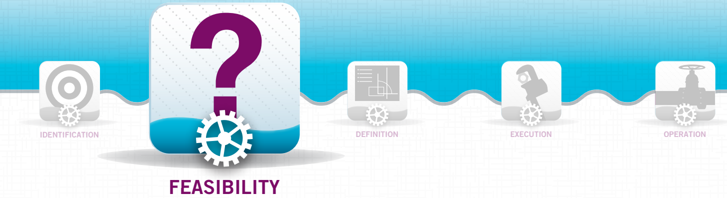
+ What is the extent of water-dependent equipment and manufacturing processes at these facilities?
+ How many applications are there in which recycled water can replace fresh water without compromising reliability, cost, and productivity?
+ Are the water providers serving these assets able to assist with IWR solutions?
+ What is the proximity of plants to recycled water sources or systems?

Decision Criteria The resulting data is used to develop a set of informal profiles of those facilities that can take advantage of IWR options. If there is a sufficient number of applications and commensurate savings of fresh water, then the process moves to the next phase, **Feasibility**.

WATEREUSE

PHASE 2: **FEASIBILITY**

Determine whether IWR is practical, cost-effective and do-able



PROVIDER

Provider Perspective

Phase input: Produce customer profiles and scope of opportunity

Focus: Assess whether IWR solutions be delivered within context of system infrastructure, capacity, and capability

Deliverable(s): Provide proof of concept and/or provider business case

Key Decision(s): Establish a reasonable expectation that IWR can be implemented to meet internal objectives and bulk of customers' requirements; advance to **Definition Phase**

Description

The focus of the Feasibility Phase is to move from *possibility* to *probability*. The research and analysis turns to finding potential "show-stoppers" relative to

+ The water system infrastructure
+ Capacity and/or customer demand
+ Other physical constraints

In addition, the same assessment is made relative to the provider organization and available resources. Are there sufficient "bandwidth," necessary skill sets and experience and available funding to support efforts to seek out customers for IWR solutions?

CUSTOMER

Customer Perspective

Phase input: Produce profiles of plants, process technologies, and systems

Focus: Determine whether IWR solutions can be implemented successfully within current infrastructure, capacity, and capability

Deliverables: Provide commercial business case or impact statement

Key Decision(s): Establish a reasonable expectation that IWR can be implemented to meet critical operational requirements and business objectives; advance to **Definition Phase**

Description

For an operating unit, the question is not whether IWR is a good thing, but whether it makes good business sense to implement. The focus of the Feasibility Phase is to create as full a picture as possible of the "total cost of acquisition" and associated ripple effects. These can include looking at such physical factors as

+ Assurance of water quality and supply
+ Shutdowns for plant tie-ins
+ Infrastructure upgrades
+ Required permitting

PHASE 2: **FEASIBILITY** CONTINUED

Determine whether IWR is practical, cost-effective and doable

FEASIBILITY

PROVIDER

Decision Criteria

If warranted by the results of this "self-assessment," the provider work group develops a summary business case to present to agency management. If there is confidence that the system and organization can deliver, then the process moves to the next phase, **Definition**.

CUSTOMER

Decision Criteria

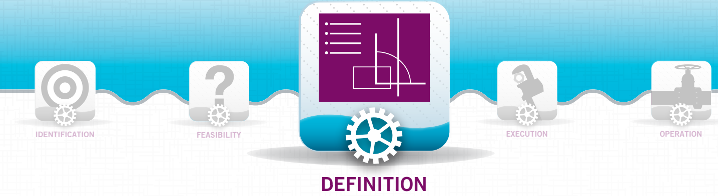
Following the assessment of practical aspects and risks to the business, the designated work group develops a summary business case to present to management. If there is confidence that the facility and staff can support a potential IWR project, then the process moves to the next phase, **Definition**.

Caveat

Budgets and organizational capacity are equally critical considerations. If operating personnel does not have the time available to support an IWR project, it is doomed from the start.

PHASE 3: **DEFINITION**

Develop IWR project options and select optimal concept for execution



PROVIDER

Provider Perspective

Phase input: Initial discussions with targeted customers re: IWR projects

Focus: Finalize provider business case and conceptual development of IWR options

Deliverable(s): Project concepts, preliminary cost estimates, project charter

Key Decision(s): Joint selection of optimum project concept for execution; determination of partner roles per concept

Description

Emerging from the Feasibility Phase empowers providers to actively “market” IWR to appropriate candidate or customers within the service area. The Definition Phase could be considered to begin officially when the provider connects with a “pre-qualified” customer, i.e., an industrial water user who has arrived at the decision to actively pursue an IWR solution.

CUSTOMER

Customer Perspective

Phase input: Initial discussions with water provider to explore IWR project

Focus: Conceptual development of IWR options

Deliverables: Profiles of plants and/or business units that are candidates for IWR project

Key Decision(s): Joint selection of optimum project concept for execution; determination of partner roles per concept

Description

Similarly, emerging from the Feasibility Phase empowers customers to actively pursue IWR. Depending on their level of knowledge and sophistication, they may contact water providers and treatment technology vendors directly to engage with an internal project team. These preliminary discussions are used to finalize the business case and get a general idea of project scope, cost, and schedule.

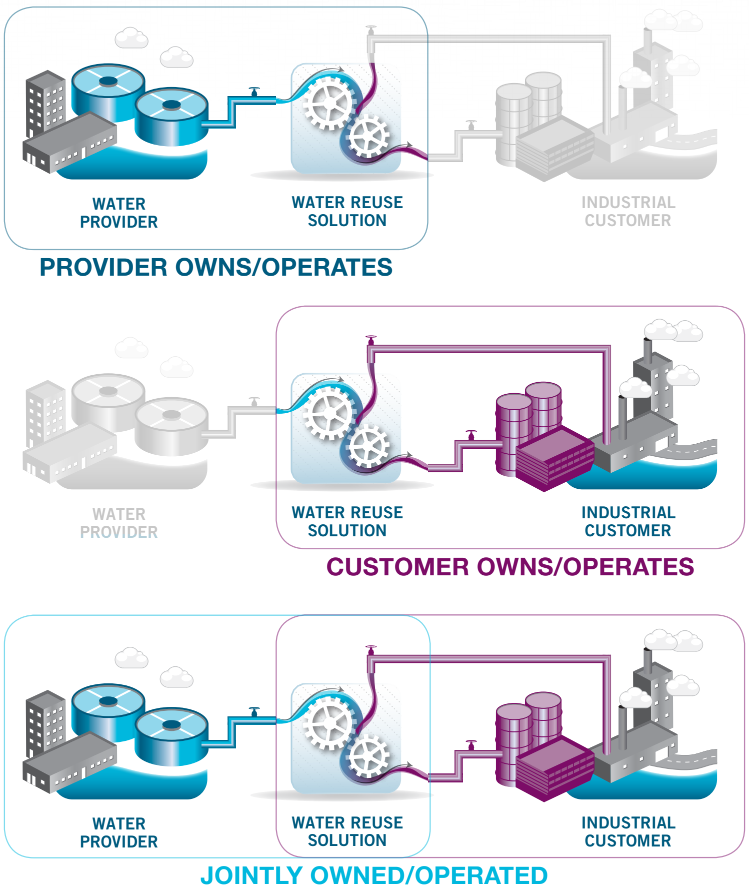
PROVIDER

CUSTOMER

Joint Activity

Although some projects may evolve with a degree of collaboration from the outset, the Definition Phase marks the emergence of a mutually committed project partnership. The primary objective is to determine the appropriate **commercial model** for the project. This refers to ownership and financing, location, and operational responsibility for the primary treatment facility. It generally will be a function of the respective sets of drivers of the project partners. Figure 5: IWR commercial models illustrates three typical scenarios.

Figure 5: IWR commercial models



1. **The first** involves having the water provider handle primary water treatment and deliver water to the facility per agreed-upon quality requirements.

2. **The second** involves locating the water treatment inside of the customer's operating facility, with technical support/assistance from the provider, along with make-up water supply.

3. **The third** scenario involves joint ownership of the water treatment facility as part of a larger strategy, e.g., leveraging financial incentives, providing additional capacity for other industrial users or demonstrating a corporate social responsibility commitment.

Once the concept has been decided, the leadership role for the subsequent phases goes to the partner who will own and operate the treatment stage.

PHASE 4: **EXECUTION**

Plan and manage selected project concept to completion

EXECUTION

(Note: Application activities are categorized according to which partner assumes lead responsibility.)

LEAD PARTNER

Lead Partner Perspective

Phase input: Project concept and requirements

Focus: Project design, engineering, and construction

Deliverable(s): Project charter, assessment of treatment options, Project Execution Plan (Engineering and Construction, permitting, contracting and procurement, etc.)

Key Decision(s): Jointly select treatment technology/vendor, E&C strategy, funding mechanism

Description

As described previously, the commercial model determines which party – provider or customer – takes on lead responsibility for project execution. Whether this is the water provider or the industrial customer, note that almost all subsequent activities are dependent on the type of water treatment technology that is selected to meet the industrial user's requirements. Making this determination will be the first priority. This phase also is the focal point for the set of project management concepts, methods, and tools on which the framework is based. (See *Best Practices*, page 22.) Some of these include

+ Formation of an integrated IWR project team
+ A kick-off workshop to assess risks and develop a project charter
+ Assigning a Project Integrator to manage regulation and compliance

SUPPORT PARTNER

Support Partner Perspective

Phase input: Needs for technical, design and permitting support

Focus: Seamless support of project

Deliverables: Funding contributions; providing subject matter experts and planning/decision support information for construction/startup of a functional water reuse solution

Key Decision(s): Joint participation in decision making and securing executive approvals (if required)

Description

Subject matter experts and technical professionals from the project partner's organization provide essential support throughout the phase. It is a key responsibility of the supporting partner to make these personnel available as requested to participate in planning, develop high-quality information for decision making and provide timely review, approval, and funding.

Another area of support is related to regulatory and compliance issues. Typically, the water provider staff will have the lead role in associated permitting and interfaces with regulatory agencies. Customers in highly regulated industries (e.g., oil and gas, pharmaceuticals, food and beverage, etc.) may need to provide additional support, e.g.,

+ Assign a "co-lead" or staff the role of project integrator to ensure that the IWR project is in full compliance with applicable regulatory statutes that are industry-specific
+ Enlist regulatory agency cooperation to help navigate issue resolution

PHASE 4: **EXECUTION** CONTINUED

Plan/manage selected project concept to completion

1 LEAD PARTNER

2 SUPPORT PARTNER

Joint Activity

Following technology selection, the remainder of the phase is devoted to completing the project on budget, on time and as specified. The deliverables produced by early-phase activities become the guiding roadmap for engaging external parties (e.g., technology vendor, E&C contractor, regulatory agencies, etc.), sequencing/coordinating activities and managing the project to startup/turnover.

Throughout the phase, open/effective communication among all project stakeholders is the ultimate “success factor.”

Decision Criteria

+ Mechanical completion of water supply connection and/or water treatment facility
+ Satisfactory testing and startup
+ Technical training and organizational preparation for turnover to operations personnel
+ Ongoing maintenance procedures in place

PHASE 5: **OPERATION**

Start up, operate and maintain IWR system to meet user's operational and business goals

IDENTIFICATION FEASIBILITY DEFINITION EXECUTION **OPERATION**

LEAD PARTNER

Lead Partner Perspective

Phase input: QA and QC documentation for all IWR systems and interfaces

Focus: Verifying performance and staffing/training personnel

Deliverable(s): Final business agreements; testing, quality and maintenance plans

Key Decision(s): Customer acceptance of water quality and operations interface; define ongoing relationship

Description

Assuming the lead partner remains the owner-operator of the IWR project at completion, the focus turns to reliable operation of the treatment stage on behalf of the industrial plant it serves. A partial list of operational elements includes

+ Staffing and training
+ Procedures for QA, compliance and maintenance
+ Supporting contracts with technology vendor
+ Business agreements between providers and customers

Decision Criteria

The provider and customer organizations also address the parameters of an ongoing relationship to help maximize the potential of IWR.

SUPPORT PARTNER

Support Partner Perspective

Phase input: Planning for document preparation and handover

Focus: Closing out project support and transitioning to operations support

Deliverables: Technical support planning for operations and maintenance

Key Decision(s): Determining post-project role to ensure IWR benefits are ongoing

Description

If the commercial model is one in which the water provider retains ownership and operating responsibility, the water customer organization will play a dual role. This will include startup support from in-plant operators and maintenance groups, quality control, compliance, and other departments. Once the project is fully operational, many of these same personnel will continue to interface with the water provider to ensure the quality of the water received for in-plant use.

Decision Criteria

Conversely, if the commercial model is one in which the water customer retains ownership and operating responsibility, the water provider organization will take on a consultative role through startup and operation.

4 Best Practices

In addition to applying the shared framework, IWR projects can benefit from a range of best practices widely used in capital project management. Following is a brief overview of applicable concepts and practices.

1. Engage the right people at the right time: Knowledge, experience, and effective communication are inextricably linked to project success. The surest way to provide this foundation is by harnessing the collective wisdom of all of the people who will be contributing to the project over the course of its lifecycle. A partial list would include representatives from the customer's maintenance, operations, procurement, and safety departments, along with process engineers and key managers; on the provider side, project discipline leads, environmental engineers, permitting specialists; third parties including treatment technology consultants, municipal health departments, other regulatory agencies, and building and construction divisions.

2. Hold a kick-off meeting and write a project charter: This involves bringing the expanded group of experts together with the core team in a facilitated workshop; the output of the event is a detailed project charter that serves as a repository of key assumptions and details about the project objectives, approach, risks, responsibilities and much more. (See Appendix for charter template.)

3. Assign a project integrator: In addition to having a project manager in the conventional sense of the term, projects with multiple stakeholders and permitting and oversight bodies should identify a single point contact to serve as the nexus for communications among these diverse groups; this prevents disconnects and provides for continuity and coordination; the integrator is the designated "process owner" for all facets of compliance. Generally, the most appropriate person for this role will be found within the water provider organization. In certain cases, that resource could be a highly experienced person from the customer organization or a third-party resource with the necessary high-level expertise.

THE MISSION OF EXPANDING IWR DOES NOT STOP WITH SUCCESSFUL COMPLETION OF ONE PROJECT. EACH ONE SHOULD SERVE AS A SPRINGBOARD TO THE NEXT, WITH INDUSTRIAL CUSTOMERS AND THEIR WATER PROVIDERS HELPING TO SPREAD THE WORD THROUGHOUT THE CUSTOMERS' INDUSTRIES.

WATEREUSE

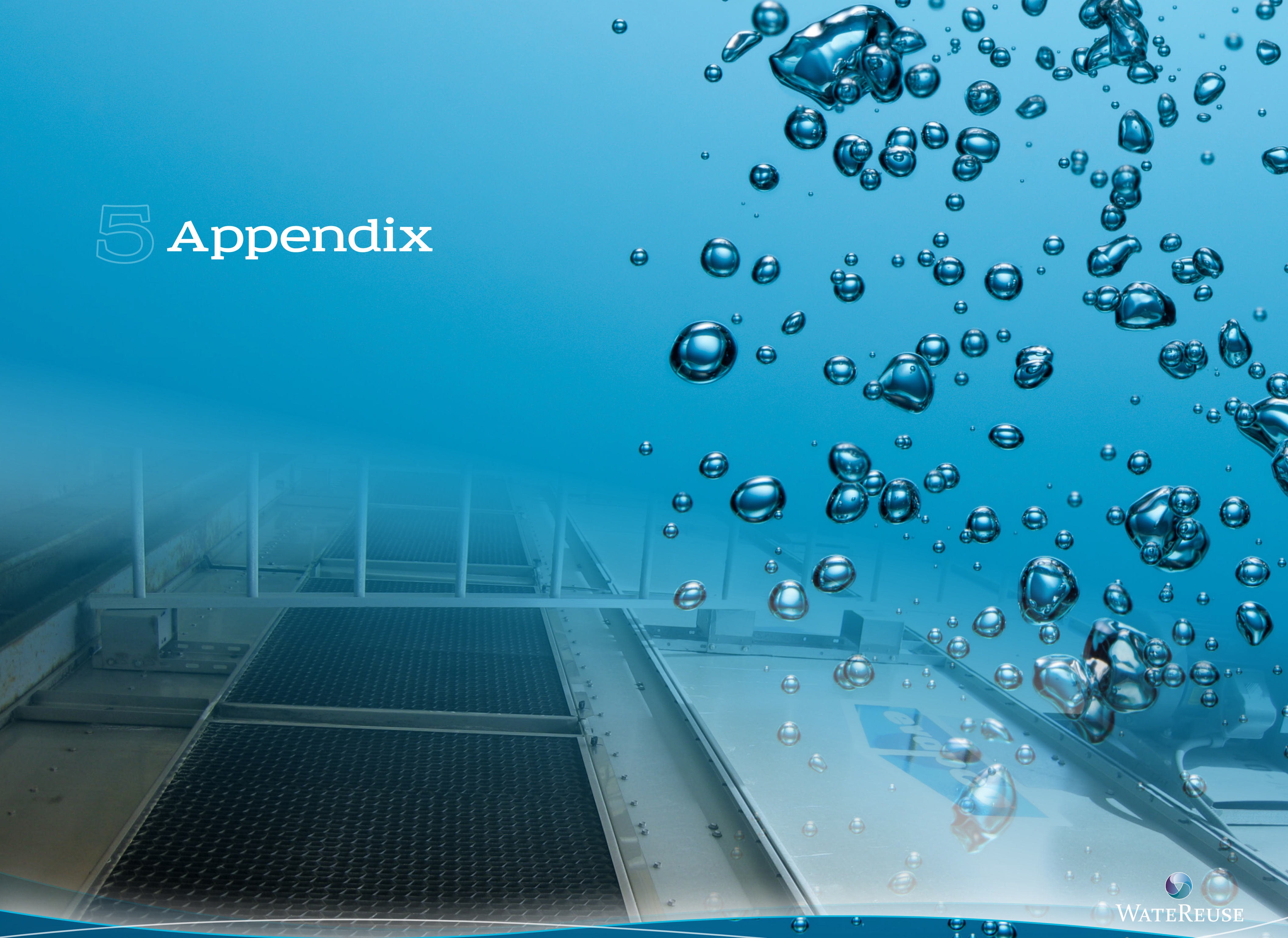
4. Foster awareness of and appreciation for respective drivers, motivations, and points of view: Providers and customers who recognize each other's cultural differences and commit to over-communicating can turn their points of departure into opportunities for shared understanding.

5. Support after completion: The completion of a successful IWR project is not the end of the relationship between providers and customers; it is the beginning of a new, more proactive shared path, dedicated to continuous improvement and stewardship of water resources. There is the potential for agencies to benefit from a long-term relationship with industry beyond water, into energy conservation, demand management, and others.

...THE COMPLETION OF A SUCCESSFUL IWR PROJECT IS NOT THE END OF THE RELATIONSHIP BETWEEN PROVIDERS AND CUSTOMERS; IT IS THE BEGINNING OF A NEW, MORE PROACTIVE SHARED PATH...

WATEREUSE

5 Appendix



Communications Insights

EMERGING THEMES

Through surveys, white paper reviews, conference panels and interviews with participants in successfully completed industrial water reuse (IWR) projects, a small number of consistent themes and issues emerged as contributing factors to miscommunication between water providers and their customers:

1. Project Drivers and Objectives
2. Views of Time and Money
3. Metrics and Measures of Success
4. Decision Making Processes and Styles
5. Regulatory Landscape
6. Language and Terminology

The list has been dubbed "points of departure" in consideration that the terms and concepts mean different things to customers and providers, respectively. Note that these reflect perceptions held by each group for the other and are, therefore, not necessarily true in every case. Nevertheless, recognizing the differences and working to clarify them early on minimizes disconnects, erroneous assumptions, and other risks to project success. The points of departure are summarized in the table on the next page and explored in more detail in the subsections to follow.

Note: the previous list does not imply absolutes: each project and group of stakeholders is unique. The aim here is to provide a few generalizations that can help build awareness of the different perspectives that participants bring to the table.

BEING ACCURATELY HEARD AND CLEARLY UNDERSTOOD IS THE BOTTOM LINE GOAL OF EVERY EFFORT TO COMMUNICATE.

ORGANIZATIONAL AND CULTURAL DIFFERENCES AT A GLANCE

POINTS OF DEPARTURE	WATER CUSTOMER	WATER PROVIDER
1. Drivers and Objectives	Primarily to achieve one or more of the following: supply security, cost–benefit, compliance, social responsibility	Primarily to achieve one or more of the following: source conservation, policy initiatives, range of water quality, diversification, minimal wastewater disposal costs
2. Views of Time and Money	Time *is* money. Things generally happen faster in the private sector, particularly once the project has been penciled out; single source funding and minimal approval process for relatively low-cost projects; likely to be frustrated by slow response times and absence of aggressive cost control	Used to several rounds of public hearings and regulatory approvals; deal with multiple sources of funding that require more time to secure; may have a "pass through" mindset regarding cost increases affecting the customer versus "not-to-exceed" approach
3. Metrics and Measures of Success	Looks for payback of 6–12 months from small capital projects; seeks cost savings, operational benefits, reliability, and other goals related to project drivers	Views infrastructure payback in range of 5–10 years; social and environmental benefits often take precedence over cost savings; focus on minimizing customer complaints
4. Decision Making Processes and Styles	Localized authority; ready funding can be pulled from established accounts; involvement of plant maintenance and operations personnel who may be directly affected	Used to planning, negotiating, and decision making as extremely lengthy processes, due to numerous rounds of discussions and public input that are required by law; subject to remote decision making by nonparticipants
5. Regulatory Landscape	Understanding of regulatory issues/processes is greater in highly regulated industries (e.g., oil/gas, petrochemical, power); less so in relatively unregulated sectors (e.g., data centers, logistics)	High level of sophistication based on repeated engagement with multiple levels of government, sensitivity to dynamics of policy and legislation, and knowledge of interpersonal networks
6. Terminology	Don't speak "acre-feet"; likely to use volume and flow terms that reflect their industries (gallons, barrels, "gallons per chicken"); typically have a "plant operator" mindset that affords opportunity for alignment with providers' treatment plant and engineering personnel	Steeped in technical and engineering language of public water systems; some "bureau-speak" (e.g., vague generalities over specific examples); can find common ground via the "plant operator" mindset that exists within treatment facilities versus agency management or administration

VIEWS OF TIME AND MONEY

Among respondents, *time* was one of the most significant points of departure. Once a customer's organization was convinced recycled water was a good deal, they wanted it to be a "done deal." Most expected that the typical timelines they experienced with their own small-to-medium capital projects would apply to the proposed reuse implementation process. In one case study involving a pipeline extension to bring recycled water into a plant cooling system, the customer's expectation was 6 months. Ultimately, the project took 18 months to complete, which according to the company's project sponsor, was "6 months too long."

From a post-mortem perspective, 12 months was a reasonable duration for the project. The "learn from" here is two-fold: the need for providers to educate customers and better manage their expectations from the outset and providers having an opportunity to bring their response times more in line with private sector expectations and, as the saying goes, operate at the **speed of business**.

The organizational culture of government institutions and public service agencies has long traditions of moving cautiously, and many volumes have been written about reasons and remedies. For purposes of this document, that is all water under the bridge. The meaningful take-aways of this research are these:

> *If water providers truly want an exponential increase in recycled water use by industrial customers, they will have to revisit and revamp their existing project planning processes, approvals, and execution to bring a more timely response to businesses requests for delivery of recycled water. At the same time, business customers must come to understand that many regulatory reviews and approvals are outside the agencies' jurisdiction and sphere of influence. The result will be project delays that are, in many cases, unavoidable.*

The second half of this "point of departure" is money. To a large extent, "time *is* money" in the private sector. In analyzing the use of recycled water, customers will consider such time and value factors as potential lost revenue from plant shutdown or business interruption and more. If they will be bringing money to the table, they will consider borrowing costs, ROI, lost opportunity cost from delays, etc. And, if they are contributing to the budget, they want to see the same level of cost control applied to the budget as they use internally. For providers, this means managing the project to minimize "pass-throughs" to the customer.

Another difference is the dynamics of money. The larger the business, the faster and easier it is to find and access the financing when a project has been deemed desirable. Often, there are existing budgets to draw from; if not, the process for funding approval is typically a matter of weeks or months. Sometimes advantage can be taken of more long-term planning by including projects in the next budget cycle or even the following year's cycle, which can then be more aligned with water agency long-term planning strategies timelines.

IN ANALYZING THE USE OF RECYCLED WATER, CUSTOMERS WILL CONSIDER SUCH TIME AND VALUE FACTORS AS POTENTIAL LOST REVENUE FROM PLANT SHUTDOWN OR BUSINESS INTERRUPTION AND MORE.

This stands in stark contrast to public funding models that apply to the majority of water providers. Typically, agencies are constrained by annual operating budgets that have been cobbled together from property tax forecasts, revenue from permits and fees, and anticipated billings to the rate payer base. In order to respond to a customer request for recycled water, providers may need to draw from multiple sources of funding at the federal, state, and local levels. Each “pot of money” has its own application or administrative requirements, multiple approval loops, and sign-offs. This is, perhaps, a primary reason that projects in the public sector have longer timelines than equivalent projects in the private sector. This fact needs to be part of the shared understanding that project stakeholders create at the outset of an IWR project.

METRICS AND MEASURES OF SUCCESS

This point of departure is, in some ways, an extension of the previous one, Views of Time and Money. In the private sector, decision makers expect a relatively fast payback (6–12 months) from small capital projects. This can be from a combination of performance measures, e.g., lower costs for water, increased plant run time, reduced maintenance and better reliability, and other quantifiable benefits. There may be nonmonetary measures if one of the project drivers includes a “green,” or environmentally friendly, corporate social responsibility commitment.

Although providers focus on delivering the customer’s desired business results, there may be a separate set of success measures that providers can achieve at the same time. These include mission-driven objectives, such as fresh water conservation and other environmental benefits, or expanding infrastructure now in order to hook up future customers for recycled water.

All parties should have the opportunity to set forth their respective needs and measures of success upfront to ensure that any potential project they pursue together represents a win–win solution.

ALL PARTIES SHOULD HAVE THE OPPORTUNITY TO SET FORTH THEIR RESPECTIVE NEEDS AND MEASURES OF SUCCESS UPFRONT TO ENSURE THAT ANY POTENTIAL PROJECT THEY PURSUE TOGETHER REPRESENTS A WIN–WIN SOLUTION.

DECISION-MAKING PROCESSES AND STYLES

Many barriers and failures to communicate originate from differences in the ways organizations make decisions. The length of time it takes, the number of people involved, the chain of command – these and more factors impact the speed of decision making. As a rule of thumb, industrial operating plants have a degree of autonomy when it comes to doing what’s best for the asset. As long as they are hitting their revenue targets, plant management teams typically have the authority to approve projects and allocate funds for plant upgrades and expansions. They will rely on plant maintenance staff, technical experts, and operations personnel to validate the business case and make a recommendation.

There is a very different scenario, however, among water providers. The professional community is required to maintain an open and transparent process as it pertains to planning, negotiating, and finalizing projects and decisions. This is a consequence of the numerous rounds of discussions and public input that are required by law. The larger and more bureaucratic the organization, the more detailed and involved the decision making tends to be. In cases that include multiple public agency stakeholders (e.g., provider/wholesaler, municipality/retailer, conservation districts, EPA, etc.), consensus building, turf battles, conflicting agendas and other factors may come into play. At best, they will delay the process and test customers' patience; at worst, they could stop a viable project from getting off the drawing board.

REGULATORY LANDSCAPE

The most critical legislative barrier to industrial water reuse (in fact, all types of reuse) is the level of treatment required in various states for the effluent to be reused. Beyond cooling applications, the use of reclaimed or recycled water as an input to industrial production requires secondary and tertiary treatment at minimum. Many companies prefer to keep using freshwater instead of investing in the treatment infrastructure and technology. Around the country, water reuse proponents have undertaken an increasing number of efforts to reshape policy legislation and remove barriers at the state level. In California, for example, planning of new developments must include designated percentages of water from renewable and/or recycled sources before freshwater sources can be accessed.

IWR projects that fall within acceptable reuse criteria will still face regulatory hurdles. Some customers will be better prepared than others to understand the regulatory process, depending largely on the type of industry they are in. The more highly regulated the industry (e.g., oil and gas, petrochemical, food processing, power production), the more the customer's team can provide support and manage internal expectations around permitting and compliance issues. Customers in relatively unregulated sectors (e.g., data centers, logistics) are at a disadvantage.

This is where providers have the opportunity to add significant value to the project. Technical professionals and even managers generally have a high level of sophistication in dealing with multiple levels of government. More important, they have connections such as informal personal networks that they can use to move projects off of one desk and onto the next, making slow but steady progress toward meeting all applicable requirements. They also have the means to tap into legal channels (i.e., internal legal representation, or through professional associations) that can assist in providing regulatory review and recourse on regulatory matters. It is also worth

AROUND THE COUNTRY, WATER REUSE PROPONENTS HAVE UNDERTAKEN AN INCREASING NUMBER OF EFFORTS TO RESHAPE POLICY LEGISLATION AND REMOVE BARRIERS AT THE STATE LEVEL.

noting that providers and customers can sometimes find common cause in their frustration with a third-party regulator (e.g., a health department). This actually may present an opportunity for them to work together if they each provide their best effort to resolve the regulatory issues.

TERMINOLOGY

Somewhat surprisingly, this point of departure is the least divergent of the group. Project contributors from the customer side and from the provider side often share an “operations mentality” that comes from working in a plant and keeping it running. Whether their experience is in an industrial facility or a water treatment plant, they still value the same things, e.g., efficiency, reliability, productivity, cost management.

That said, few people outside the water community understand the term “acre-feet.” Typically, customers will use the terms for volume and flow rates that reflect their industries (e.g., gallons/min, barrels/day). The best approach is for all participants to define terms early and apply them consistently throughout a project. Beyond that, the same caveats apply as they would to any group steeped in technical and engineering jargon: keep it simple.

GLOSSARY OF TERMS

https://www.watereuse.org/information-resources/about-water-reuse/glossary-1

MESSAGING PLATFORM

Being accurately heard and clearly understood is the bottom-line goal of every effort to communicate. One tool used toward that goal is a messaging platform. It serves as a reference or repository for how the members of an organization can consistently address key audiences on the issues that most concern those audiences. Although core messages can be used verbatim, they typically are reworded as appropriate to better suit the specific communication channel being used, e.g., print, correspondence, meetings or group presentations, Web site, or others.

Following is an initial messaging platform to address key issues that have been surfaced as points of departure between water customers and water providers regarding industrial water reuse. Typically, the platform will evolve over time as the audiences become more familiar with one another and develop a shared understanding of one another's perspectives.

TOPIC	MESSAGING *FROM* **WATER PROVIDERS** *TO* **WATER CUSTOMERS**
Industrial Water Reuse	Use of recycled water is a globally proven solution with documented benefits to industrial facilities that need to improve supply security, cost reduction, regulatory compliance, and social responsibility impacts.
Water Quality Concerns	Industrial use of recycled water is a technically mature field in which guaranteed water quality is no longer a significant barrier to implementation. Treatment technology and application expertise are widely available to support successful integration of recycled water into a growing number of industrial processes.
Cost / ROI Considerations	Nationwide experience indicates payback of industrial reuse projects to be in the range of 6–12 months, based on median scope and complexity. This range factors in the combination of upfront costs, cost savings versus freshwater, operational benefits, incentives, reliability, and other project objectives and, naturally, will vary with each case.
What to Expect	As water providers, we have a wealth of knowledge and experience we can bring to the table to help our industrial customers benefit from water reuse. As public entities, however, we operate within an environment that has some marked differences and constraints compared with the private sector. Although we will we make every effort to bring transparency and urgency to the task of supplying your facility with recycled water, the process is likely to be less straightforward and more involved than some are used to. We commit to managing your expectations and the process itself to make it as efficient and cost effective as possible.
Regulatory Issues	Water projects are subject to a level of regulatory scrutiny that may differ from that applied to your industry. If yours is a highly regulated industry (e.g., oil and gas, petrochemical, power, food processing), we will rely on your assistance; if your industry is relatively unregulated, we have the expertise to navigate the water-related issues on your behalf.

TOPIC	MESSAGING *FROM* **WATER CUSTOMERS** *TO* **WATER PROVIDERS**
Industrial Water Reuse	(Interested) We want to know more about the potential for using recycled water in our production facilities. We need you, as our water provider, to help us make the right recommendation to our management and decision makers, as well as plant personnel. (Committed) We have been charged by our company to start capturing the advantages and benefits of recycled water in our industrial facility and need the prompt response from our water provider. How soon can we get this done?
Water Quality Concerns	We are concerned that recycled water is not high enough quality for use in our facility/process, or that it will compromise our systems and equipment over time. How do we make that determination? What technology options are there to consider?
Cost / ROI Considerations	Every project we propose to our management must have a reasonable ROI in order to be approved. What are the parameters of other or typical projects that we can use when putting together our business case?
What to Expect	We have a wealth of knowledge and experience about our plant and process facilities to contribute to the planning and executing the right recycled water solution for our business. In the private sector, we typically have a "get 'er done" mindset when it comes to small projects. This translates to making decisions locally and fairly quickly once the business case or project request has been approved. We will need our provider's help managing not only our expectations but also those of our senior management team if time frames or response times differ significantly from what we are used to in our industry.
Regulatory Issues	(Low-level regulation) Our facilities are subject to very little regulation, so we are not familiar with the issues and agencies that are involved in water reuse. We need the assistance of water providers knowledgeable with the mechanics of that process. (High-level regulation) We are in an industry that is subject to a wide range of regulation and, therefore, have a sophisticated understanding of the processes and players. That experience and expertise will be important to integrating a water reuse project with our existing operations.

Case Study

PHARMACEUTICAL AND MUNICIPAL RECYCLED WATER

Amylin Pharmaceuticals

INTRODUCTION

Amylin Pharmaceuticals Inc. (Amylin), located in the "Golden Triangle" area of the City of San Diego, had previously undertaken a separate retrofit project to connect another property to recycled water for nonpotable irrigation use and cooling tower use. Based on Amylin's previous experience with recycled water use and the savings realized over the use of potable water, Amylin desired to retrofit two additional facilities located nearby. This case study describes the recent recycled water retrofit and alternative cooling tower treatment project at Amylin's facilities at 9360 and 9390 Towne Centre Drive in San Diego, CA. The case study focuses on the alternative cooling tower treatment technology employed at the 9390 location. This alternative treatment technology significantly reduces recycled water make-up demand and chemical use, and decreases the operational issues that typically affect cooling towers utilizing traditional chemical treatment program with recycled water.

PROJECT DESCRIPTION

Amylin implemented recycled water retrofit projects at 9360 and 9390 Towne Centre Drive in San Diego, CA, in January 2011. Recycled water retrofit engineering plans were prepared by Amylin's engineer, RBF Consulting, pursuant to City of San Diego (city), San Diego County Department of Environmental Health (DEH), and California Department of Public Health (CDPH) requirements. The retrofits at 9360 included conversion of the irrigation system and a large, decorative reflecting pond to recycled water use. The retrofits at 9390 included

PROJECT GENERAL INFORMATION

Location City: **San Diego**

Location County: **San Diego**

Location State: **California**

Recycled Water Supplier: **City of San Diego**

NAICS Codes: **541711**

SIC Codes: **873108**

PRIMARY PROJECT GOALS

- Reduce water costs
- Implement an alternative pretreatment technology
- Support ISO 14000 recertification

KEY PROJECT BENEFITS

- Conversion to recycled water from potable water
- Reduced overall potable water use to the site
- Pretreatment technology reduced make-up water consumption and reduced chemical consumption and cost
- Eliminated scale formation and reduced corrosion resulting in extended time between chiller inspections (from annual to every 3 years)

WateReuse

conversion of the irrigation system and cooling tower system make-up water to recycled water. Because of the cooling tower conversion at 9390, RBF Consulting prepared a separate Title 22 Engineering Report for review and approval by DEH and CDPH. Construction permitting and approvals were received by early July 2011, and construction of the project commenced immediately thereafter. Project construction was completed by mid-August and cross-connection tests performed by late-August/early September of 2011. Approval for release of the recycled water meters was received in late October 2011. Recycled water meter installation and start-up occurred on November 3, 2011.

RECYCLED WATER QUALITY

The recycled water feed to the Amylin facility is provided from the City of San Diego's North City Water Reclamation Plant (NCWRP) in accordance with California Title 22 Disinfected Tertiary requirements. The city of San Diego regularly uploads its recycled water quality results to the Internet monthly for use by its customers. Most recent water quality data for the NCWRP show the following important constituents of concern to Amylin: TDS–781 mg/L, calcium–57 mg/L, magnesium–28.3 mg/L, sulfate–145 mg/L, chloride–239 mg/L, nitrate–59.9 mg/L (as NO3), phosphorus–0.63 mg/L (as P).

Amylin uses recycled water for irrigation and for make-up water feed to its cooling towers. Cooling tower water chemistry and treatment must be selected to minimize or control sparingly soluble salts to prevent scale formation, control aggressive water that may lead to corrosion, and control nutrients to prevent and inhibit microbial activity.

AMYLIN USES RECYCLED WATER FOR IRRIGATION AND FOR MAKE-UP WATER FEED TO ITS COOLING TOWERS.

PROCESS DESCRIPTION (RECYCLED WATER USE AND PROCESS MODIFICATIONS)

The cooling tower at Amylin Pharmaceuticals is of the counter-current induced draft type, two cells, variable speed fans, and having a design cooling capacity of 600 tons. The tower construction is galvanized steel upper with stainless steel basin. Make-up water feed is controlled by pilot-activated float valves. Two make-up water feed sources are provided to each tower cell: recycled water (primary) and potable water (emergency only). The recycled water feed utilizes a newer alternative treatment technology patented by Water Conservation Technologies International (WCTI). The WCTI process employs a high-efficiency, strong-acid cation exchange system to remove scale-forming cations, such as calcium and magnesium, from the make-up water. The remaining natural chemistry in the softened source water (silica, alkalinity, and total dissolved solids) is then used beneficially by increasing their concentrations within the cooling tower. This was accomplished at Amylin by increasing the cycles of concentration (COC) within the cooling tower from 3.5 (typical of recycled water with chemical treatment) to greater than 50 COC. The tower has been operating between 50 to 75 COC since August 2012, following ramp-up of the process. The increase in cycles of concentration resulted in an instantaneous make-up water reduction of approximately 30%. The increased silica concentration in the tower forms natural corrosion inhibition of metal surfaces. Because of the removal of calcium and magnesium hardness in the softening process, low-solubility salts, such as calcium carbonate, magnesium sulfate, and calcium silicate can no longer form, which significantly reduces scaling potential. Furthermore, operation at high cycles of concentration increases TDS, alkalinity and pH. The high TDS and pH create a naturally biostatic environment that eliminates biological activity. The results of this alternative treatment system are reduced water use (owing to decreased tower blow-down) and significantly decreased chemical use. Because of specific California Title 22 requirements, a disinfectant feed system is maintained but is only used during the ramp-up period until the tower control chemistry is established. In case of interruption of the recycled water feed because of planned utility maintenance, scale inhibitor and corrosion control feed systems are maintained for temporary use with the emergency potable water make-up system.

BY CONVERTING FROM POTABLE TO RECLAIMED WATER, THE SAVINGS IN POTABLE WATER IS ESTIMATED TO BE 10 MILLION GALLONS PER YEAR.

WATER SAVINGS RESULTS AND OTHER PROJECT BENEFITS

The conversion to recycled water replaced almost 39 acre-ft of annual potable water use (10.5 acre-ft from landscape and irrigation, plus 28.1 acre-ft from cooling tower use), saving approximately $65,000 per year. In addition, because of efficiencies gained by the use of an alternative treatment technology for the make-up water feed to the cooling towers, the overall use of make-up water is reduced by about 30%.

PROJECT IMPLEMENTATION ISSUES

Primary issues encountered during the project implementation process included the following:

1. Somewhat lengthy plan review periods for permitting through the City and County Health Departments. Amylin's engineering consultant worked to mitigate lengthy reviews by maintaining regular and consistent communication with reviewing agencies, including facilitating plan deliveries between the review agencies.
2. Following receipt of plan approvals and construction permits, Amylin noted that field inspection tended to be inconsistent, sometimes deviating from the approved plans, which resulted in additional costs to Amylin. This issue was somewhat mitigated by site meetings with Amylin, the consulting engineer, and city review and inspection personnel to address concerns. It must be noted that actual field conditions (i.e., existing utility infrastructure not located where shown on record drawings, differing subsurface conditions, etc.) may require augmentation during construction and should be anticipated.

3. Coordination of cross-connection testing and facility shut-downs must be planned well in advance. Cross-connection testing to verify that no connections exist between the onsite potable and recycled water systems is a key component to finalizing approvals for recycled water meter installation and supply of recycled water to the facility. Coordinating a suitable schedule for all required parties requires advanced planning and sufficient float in the implementation schedule in case testing must be rescheduled.

4. Amylin's cooling towers and recirculation piping were highly scaled from the prior operation, and faulty isolation valves were discovered during start-up of the alternative treatment system. Normally, the leaking system valves are masked by low-cycle operation; however, high-cycle operation quickly exposed their location. Amylin operations staff replaced leaking and malfunction system valves. The alternative treatment process will also dissolve and remove scale buildup; however, the extent of the scale extended the ramp-up period and limited COC to less than 20 for a period of several months. Once the majority of scale and hardness were removed from the system, the alternative treatment system then ramped up quickly to between 50 to 75 COC. Total ramp-up time was about 8 months, as precleaning of the cooling towers prior to treatment implementation did not occur.

AMYLIN REPORTED THAT THIS YEAR'S INSPECTION REPORT WAS THE BEST EXPERIENCED AT ANY OF ITS FACILITIES AND IS ELATED WITH BOTH RECYCLED WATER USE AND ITS NEW TREATMENT PROGRAM.

PROJECT SUCCESSES

+ Significant water savings owing to conversion from potable water to recycled water. The City of San Diego recycled water purchase cost is currently approximately 20% of the potable water cost. In addition, implementation of the alternative treatment technology for this project reduced overall cooling tower make-up water use by about 25%, resulting in additional savings. Once the system ramp-up was complete, chemical use was significantly reduced. Total annual savings of up to $65,000 are expected. Owing to overall savings, payback for the entire project (engineering, construction, and treatment procurement) is expected to be less than 1 ½ years.
+ Amylin performed its annual teardown and chiller inspection in early 2013. The new treatment process on recycled water resulted in no scale or corrosion being found. The inspection report recommended extending periods between teardown and inspections from annual to once every 3 years. Amylin reported that this year's inspection report was the best experienced at any of its facilities and is elated with both recycled water use and its new treatment program.
+ Increased communication among Amylin, the city, and the county following initial inspection issues noted earlier resulted in successful project implementation.

LESSONS LEARNED

+ Unforeseen field conditions can and will occur and should be expected. Plan for these events by allocating additional project budget and allowing sufficient float in the schedule.
+ Maintain regular and consistent communication with review and regulating agencies during all aspects of the project from design through construction, testing, start-up, and follow-up inspections.
+ When implementing new treatment technologies, include budget for precleaning of systems that are moderately to heavily scaled. Ensure that all system valves, make-up water floats, and blow-down valves are in proper working order. High-cycle operation will quickly expose these issues and lengthen ramp-up time if not taken care of in advance.

PROJECT CONTACT

Joel E. Bowdan III, P.E., Senior Associate/Project Manager, RBF Consulting – A Baker Company.

(858) 614-5000

jbowdan@rbf.com

PUBLICATIONS/ AWARDS

Bowdan, Joel E., III, PE, and Ali Rahimian-Pour. *"Going "Green" Utilizing a Pretreatment Process for Recycled Use in Cooling Towers."* 2012 CA WateReuse Annual Conference, WateReuse Association March 2012

Case Study

INDUSTRIAL RECLAIMED WATER

BAE Systems | Austin, Texas

INTRODUCTION

BAE Systems is a global defense, aerospace, and security company that employs more than 88,000 people worldwide. BAE Systems, Austin site, operates two chilled water plants with two open recirculating cooling towers at each plant. Because of a multiyear, record setting drought, BAE Systems was faced with a need to reduce potable water consumption at the plants. The chilled water plants have historically used approximately 70–75% of the total campus potable water consumption. During this time period, the City of Austin's Water Department (Austin Water) contacted BAE Systems to request permission to install a new reclaimed water pipeline through the campus as part of Austin Water's reclaimed water system expansion. Upon learning of the potential benefits of using reclaimed water to reduce potable water consumption, BAE Systems contacted Austin Water to request a hook up to the new pipeline. During the retrofit process, BAE Systems discovered that a significant change in its cooling tower chemical water treatment approach would be necessary and would potentially result in unacceptable treatment costs. Partnering with Austin Water, an alternative cooling tower water treatment program was identified to reduce treatment costs by reducing make-up water consumption, blow-down, and chemical use. This case study focuses on using reclaimed water in open recirculating cooling towers and the use of an alternative treatment program that reduces make-up demand, significantly reduces blow-down, significantly reduces chemical usage, and as a result reduces operating costs of the plants.

PROJECT GENERAL INFORMATION

Location City: **Austin**

Location County: **Travis**

Location State: **Texas**

Recycled Water Supplier: **City of Austin**

NAICS Codes: **334511, 336411, 81121**

SIC Codes: **3721, 3769, 3812**

PRIMARY PROJECT GOALS

- Reduce potable water consumption
- Implement an alternative pretreatment technology
- Reduce operating costs

KEY PROJECT BENEFITS

- Converting to reclaimed water from potable water
- Reduced overall potable water use to the site
- Pretreatment technology reduced make-up water consumption and reduced chemical consumption, blowdown, and cost

PROJECT DESCRIPTION

In summer 2010, Austin Water and BAE Systems mutually agreed to the construction of a new 8-in. reclaimed water line through the BAE campus. This new reclaimed water pipeline was part of Austin Water's master plan for reclaimed water extension to the area. The new 8-in. pipeline was a lateral connection to a new 36-in. transmission main extension from Austin Water's nearby Walnut Creek Water Reclamation Plant. During preliminary design of the reclaimed water extension project, BAE Systems approached Austin Water to become the first new customer along the pipeline extension project. Austin Water revised its design to include two taps for use by BAE Systems. Parallel with the design effort, Austin Water and BAE Systems began the easement acquisition process. Following several planning and negotiation discussions, Austin Water agreed to provide additional taps as part of the design of the 8-in. pipeline for future irrigation use by BAE Systems. Pipeline design and easement acquisition work continued through 2010. The project was issued for bid in spring 2011. Follow bid evaluation, reviews and approvals, Austin Water began construction of the reclaimed water system expansion in early 2012. Concurrently, BAE Systems received authorization to proceed with its portion of the retrofit project, which included tapping of the new main and installation of new reclaimed water feed lines to each of the two chiller plants. During this time, a review of the water treatment program took place, and it was discovered that changing from potable water to reclaimed water would greatly increase the chemical treatment cost because of differences in the quality of the reclaimed water. Austin Water assisted BAE Systems in finding a suitable alternative treatment program that would work well with reclaimed water and keep operating costs close to existing potable water treatment costs. After exhaustive research, an alternative treatment program was adopted and equipment ordered and installed. Installation of the Austin Water reclaimed water pipeline, the BAE Systems feed pipelines, and the water treatment equipment was substantially complete about December 2012. Reclaimed water use began in January 2013.

THE INCREASE IN CYCLES OF CONCENTRATION RESULTED IN AN INSTANTANEOUS MAKE-UP WATER REDUCTION OF APPROXIMATELY 30%.

PROCESS DESCRIPTION (RECLAIMED WATER USE AND PROCESS MODIFICATIONS)

The cooling towers included as part of this reclaimed water retrofit are two 700 ton stainless steel Evapco, counter-flow, single cell units with variable speed fans, and two 500 ton fiberglass Marley, counter-flow, single cell units with variable speed fans.

The reclaimed water feed uses an alternative treatment technology patented by Water Conservation Technologies International (WCTI). The WCTI treatment process employs a filtration system (used only to remove any excess suspended solids from reclaimed water), followed by a high-efficiency, strong-acid cation exchange system to remove scale-forming cations, such as calcium and magnesium, from the make-up water. The concentration of the remaining chemicals already present in the cooling water has a beneficial effect on reducing corrosion and biofouling in the cooling tower. This was accomplished at BAE Systems by increasing the cycles of concentration (COC) within the cooling towers from approximately 5 COC to 42 COC at one plant and 50 COC at the other. As of the date of this case study, the process continues to ramp up. The COC target is 80 and is expected to be achieved at the end of the ramp-up period. The increase in cycles of concentration resulted in an instantaneous make-up water reduction of approximately 30%. The increased silica concentration in the tower forms natural corrosion inhibition of metal surfaces. Scaling is eliminated by the removal and elimination of low-solubility salts that normally would result from calcium and magnesium. Furthermore, the high cycles of concentration increase TDS, alkalinity, and pH. The high TDS and pH create a naturally biostatic environment that minimizes biological activity. The results of this alternative treatment system are reduced water use, whether using potable or reclaimed water (owing to decreased tower blow-down) and significantly decreased chemical use.

BY CONVERTING FROM POTABLE TO RECLAIMED WATER, THE SAVINGS IN POTABLE WATER IS ESTIMATED TO BE 10 MILLION GALLONS PER YEAR.

WATER SAVINGS RESULTS AND OTHER PROJECT BENEFITS

The drought conditions in central Texas make water conservation extremely important. By converting from potable to reclaimed water, the savings in potable water is estimated to be 10 million gallons per year. At the 6-month point since startup, the estimate is holding. In addition, the difference in cost between potable and reclaimed water, the reduced make-up demand, the very significant reduction in blow-down volume, and the savings in chemicals should total to approximately $65,000 per year in savings.

PROJECT IMPLEMENTATION ISSUES

The BAE Systems cooling tower retrofit was the first application within the Austin Water system to use reclaimed water in cooling towers. As a result, the appropriate procedures for processing and permitting this type of installation and operation were not yet established. Therefore, this project represented a test case for both BAE Systems and Austin Water. To ensure the success of the project, BAE Systems and Austin Water worked together as partners and collaborated to develop the necessary procedures and work through them with excellent results.

The drastic change in water quality and the necessary change in water treatment requirements was somewhat of a surprise; however, the outcome proved to be outstanding as BAE Systems achieved its goals and reduced its operating costs by using the noted alternative treatment program.

The transition to the new alternative treatment process also presented an issue that BAE Systems had not considered. Its existing cooling towers contained large amounts of scale and debris that were not removed prior to adopting the treatment process. The alternative WCTI treatment process requires low hardness in the cooling tower to ramp up the process to the required control ranges. The WCTI process cannot be ramped up if large amounts of scale-forming deposits are present in the system and the soft water produced from the cationic exchange units continue to dissolve existing scale over time. However, the volume of existing scale present in the towers would have necessitated a long period to mitigate fully. Therefore, BAE Systems replaced the scaled fill. In addition to aiding the WCTI ramp-up process, the removal of the excess scale and new fill has resulted in increased delta T across the tower, increasing overall cooling tower efficiency.

PROJECT SUCCESSES

+ Saved 10 MG of potable water per year
+ Reduced chemical use and storage on campus
+ Saved approximately $65,000 per year

LESSONS LEARNED

+ Project success required collaboration and teaming between BAE Systems and Austin Water to achieve the desired results for both parties.
+ Reclaimed water can be applied to various industry uses but may require a learning curve to establish appropriate procedures for implementation and permitting.
+ Adopting reclaimed water as source of make-up water to a cooling tower requires an understanding of the water quality and modification of the existing water or adoption of a new treatment technology to address the water chemistry.
+ Any treatment technology requires that highly scaled systems be cleaned to restore operational efficiency. Treatment control ranges should be monitored regularly to verify proper treatment and to prevent scale formation.

PROJECT CONTACTS

Walt Black,
Facility Manager,
BAE Systems, Austin Texas

512.929.2028

walt.black@
baesystems.com

Dan Pedersen PE,
Reclaimed Program
Manager, Austin
Water Utility

512.972.0074

Dan.Pedersen@
austintexas.gov

WATEREUSE

Case Study

POWER PLANT – LARGE INDUSTRIAL RECYCLED WATER USER

Inland Empire Energy Center

INTRODUCTION


Photo provided courtesy of GE

Inland Empire Energy Center, L.L.C. (IEEC) is a state-of-the-art, natural gas-fired, 800 MW combined cycle gas-turbine power plant financed, owned, and operated by GE Energy. Calpine Power Services managed plant construction and currently markets the plant's output and fuel management under an agreement with GE. California regulatory requirements dictate the use of recycled water for nonpotable uses where it is available and reasonably priced. Specifically, the California Energy Commission (CEC) adoption order required the use of recycled water for the IEEC project. Construction of IEEC was completed in 2008, and the facility was brought online using recycled water supplied by the Eastern Municipal Water District (EMWD). This case study discusses the challenges and success of implementing a large scale industrial reuse project among an agency and end-user both new to using recycled water for industrial purposes.

PROJECT DESCRIPTION

Inland Empire Energy Center project owners petitioned the California Energy Commission (CEC) for a new natural gas-fired power generating facility proposed for the Perris/Menifee area of Riverside County, CA. Use of recycled water for the proposed facility became a part of the CEC's certification of the project, which was issued on December 22, 2003. Because of GE's desire to implement use of its latest, most advanced high-efficiency gas turbine technology, the project owners requested and received project certification amendment from the CEC in 2005.

PROJECT GENERAL INFORMATION

Location City: **Menifee**

Location County: **Riverside**

Location State: **California**

Recycled Water Supplier: **Eastern Municipal Water District**

NAICS Codes: **221112**

SIC Codes: **4911**

PRIMARY PROJECT GOALS

- Comply with California Energy Commission regulations to use recycled water for cooling towers and boiler make-up.
- Obtain cost benefit of using lower cost–recycled water supply.
- Conserve potable water resources in California by using recycled water supply.

WATEREUSE

During the project certification process, the project owners began high-level negotiations with EMWD upper management for the supply of approximately 7.0 mgd of recycled water to IEEC. Until this time, EMWD primarily supplied recycled water only for irrigation purposes and was in the midst of facility modernization and expansion of its treatment and distribution facilities. Furthermore, EMWD was inexperienced with commercial, industrial and institutional (CII) reuse; therefore, no design standards or guidelines were in place that could assist EMWD staff and the project proponents with technical pre-planning for the proposed IEEC project. The resulting agreement between IEEC and EMWD established the volume and supply requirements, but did not include detailed technical and regulatory requirements generally necessary for non-irrigation CII use of recycled water.

In 2006 the IEEC project was in full design development by the project owners when EMWD recycled water program technical staff were alerted of the project by upper management. EMWD technical staff engaged the services of a knowledgeable recycled water industry consultant to assist in the process of coordination, technical information dissemination, and training of project personnel for both the agency and end user. Communication among IEEC and EMWD technical staff members became critical during the design phase to ensure technical and regulatory compliance requirements were being met. EMWD began facility improvements to address potential water quality concerns and ensure adequacy of the distribution system necessary to supply up to 7.0 mgd of California Title 22 disinfected tertiary quality recycled water to IEEC.

Power plants typically require distribution of nonpotable or “industrial water” throughout portions of the plant facility. The source of industrial water is generally derived from backflow-protected potable water. Use of recycled water requires strict compliance to cross-connection control regulations and verification that no cross connections exist within the facility between potable and recycled water sources. The regional state and local regulatory staff were generally unfamiliar with an industrial reuse project of this size and scale; therefore, plan approvals for the recycled water connection to IEEC required coordination, extended plan reviews, site visits, and meetings among all project technical participants. Ultimately, the level of communication and desire among all project participants to engage in problem solving resulted in successful implementation of recycled water use and critical supply of electrical energy from IEEC.

RECYCLED WATER QUALITY

The recycled water feed to the IEEC facility is provided from EMWD via the Moreno Valley Regional Recycled Water Facility (MVRWRF), Perris Valley Regional Recycled Water Facility (PVRWRF), and Temecula Valley Regional Recycled Water Facility (TVRWRF). The majority of the recycled water provided to IEEC is supplied from the PVRWF, which is located closest to the power plant site. Recent water quality data for the PVRWF show

KEY PROJECT BENEFITS

- Resource conservation by implementing recycled water use
- Reduced overall potable water use to the site
- Implementation of newer high-efficiency combined cycle gas-turbine technology (first implementation in the United States
- Provide additional power source to Southern California region

IEEC USES RECYCLED WATER FOR MAKE-UP WATER FEED TO ITS COOLING TOWERS AND BOILER SYSTEMS.

the following important constituents of concern to IEEC: TDS–660 mg/L, malcium–65 mg/L, magnesium–15 mg/L, sulfate–90 mg/L, chloride–215 mg/L, nitrate–45 mg/L (as NO3), and phosphorus–0.93 mg/L (as P).

In addition, EMWD notes that it uses large, open reservoirs for storage of recycled water prior to distribution. The open reservoirs periodically cause an increase in suspended solids because of wind-blown debris and algae. To assist IEEC in managing suspended solids spikes, EMWD furnished a new automatic backwashing filter battery system to IEEC.

IEEC uses recycled water for make-up water feed to its cooling towers and boiler systems. Although the EMWD recycled water is in full compliance with California Title 22 water quality requirements, IEEC is required to provide additional pretreatment prior to its use.

Photo provided courtesy of GE

PROCESS DESCRIPTION (RECYCLED WATER USE AND PROCESS MODIFICATIONS)

IEEC is an 800 MW natural gas-fired power plant that employs the latest in advanced combined-cycle turbine technology. The plant uses two 400 MW GE S107H systems, each of which is comprised of a steam turbine and gas turbine configured on a common shaft that drives a single generator. Each steam turbine has a dedicated eight-cell cooling tower with common water basin, pump pits, circulating water pumps and circulating water piping. At 100% load, the two cooling towers evaporate water at a rate of 3588 gpm. The cooling towers currently operate at about 4.5 cycles of concentration, which results in a blow-down rate of 1025 gpm and a total make-up water requirement of 4613 gpm. Approximately 203 gpm of additional recycled water is sent through membrane-based treatment to provide demineralized water to the combustion turbines (CTs) and heat recovery steam generators (HRSGs). In addition, 26 gpm of recycled water is used for onsite landscape irrigation. Therefore, the total recycled water demand for the IEEC facility at 100% load is approximately 4842 gpm or 7.0 mgd.

AT 100% LOAD, THE TWO COOLING TOWERS EVAPORATE WATER AT A RATE OF 3588 GPM.

EWMD delivers recycled water from the MVRWRF, PVRWRF, and TVRWRF via the 48-in. diameter McLaughlin Road recycled water pipeline, which connects to 18-in. through 24-in. pipeline approximately 0.2 miles to the IEEC site. Upon entering the site, the recycled water is pretreated by an automatic backwashing filtration system supplied by EMWD to IEEC and then stored onsite. From storage, recycled water is provided to the cooling towers, demineralized water treatment system, and irrigation. Additional treatment is provided as follows:

+ Make-up water to the cooling towers is primarily filtered recycled water. Chemical treatment is provided to address issues of scale prevention, corrosion control, and biological activity mitigation.

+ Make-up water to the CTs and HRSGs receives additional treatment comprised of microfiltration (MF) followed by two-pass reverse osmosis (RO), electro-deionization (EDI), and ultraviolet (UV) disinfection. The MF/RO/EDI/UV process results in approximately 131 gpm to the CTs and HRSGs. The MF backwash (10 gpm) is discharged sewer, whereas the RO and EDI reject and HRSG blow-down streams (138 gpm) are reused to supplement make-up feed to the cooling towers.

WATER SAVINGS RESULTS AND OTHER PROJECT BENEFITS

Based on data supplied in the 2005 CEC Certification Amendment, annual potable water savings resulting from the industrial reuse of recycled water ranges from 4180 to 4842 acre-ft per year (1.36 to 1.58 billion gallons per year).

…ANNUAL POTABLE WATER SAVINGS RESULTING FROM THE INDUSTRIAL REUSE OF RECYCLED WATER RANGES FROM 4180 TO 4842 ACRE-FT PER YEAR (1.36 TO 1.58 BILLION GALLONS PER YEAR).

PROJECT IMPLEMENTATION ISSUES

Primary issues encountered during the project implementation process include the following:

1. The initial supply agreement between IEEC and EMWD did not include the necessary technical and regulatory language to address recycled water use. This led to gaps in the design requirements and IEEC's understanding of those initial requirements necessary to meet the strict technical and regulatory requirements for implementing recycled water use.

2. EMWD was primarily a supplier of recycled water for agricultural users. It had only recently begun the process of converting from a gravity-fed supply system to a pressurized supply system having greater capacity. The IEEC project came about during a time when EMWD had not yet established design criteria and standards for industrial recycled water retrofit projects. Therefore, the lack of this information coupled with the recycled water system conversion, which was in process, and the size and type of industrial customer all combined to produce a very difficult and challenging project for both the EMWD and IEEC technical staff.

3. EMWD and regional state and local recycled water regulatory agencies did not have prior experience with large-scale recycled water use in a power plant. Furthermore, IEEC did not have recycled water use regulatory knowledge. This led to steep learning curves for both the agency and end user in developing and implementing typical recycled water standards and cross-connection controls for this type of large industrial user.

PROJECT SUCCESSES:

- Communication efforts by both the agencies and end user (once technical staff became involved in the project) led to greater awareness and understanding of the project needs, as well as the technical and regulatory requirements. Both the agency and end user worked together to implement nonthreatening, proactive, solution-oriented communication.
- The agency notes that the end user's commitment to use recycled water helped with prompt addressing of schedule and funding necessary to implement the project.
- Use of lower cost, high-quality recycled water resulted in the saving of local potable water resources for the area's potable water needs.

LESSONS LEARNED

- High-level discussions between agencies and industrial end users must include technical and regulatory requirements in the supply agreements up front.
- Regular and consistent communication must be maintained at all times during project planning, design, implementation, and operation. Both agencies and end users must be committed to the implementation process.
- Agencies and end users must understand each other's needs and processes. Agencies need to learn the process requirements of the industrial end user and how recycled water will be used within the end user's facility. Industrial end users need to learn and understand the technical and regulatory requirements necessary for using recycled water within their facilities. Encourage the use of knowledgeable persons (engineers, consultants, technical staff, etc.) who are familiar with the requirements for recycled water use.

PROJECT CONTACT

Becky Rathbone,
Recycled Division Manager, Eastern Municipal Water District
rathboneb@emwd.org

Case Study

DATA CENTER COOLING – RECYCLED WATER FOR COOLING TOWER

INTERNAP, Data Center

INTRODUCTION

Internap, located in Santa Clara, CA, is a premium power-rich data center employing state-of–the-art technology to provide high-density power with high-efficiency cooling options for data storage solutions having redundancy for 100% data protection. To ensure maximum uptime and data storage reliability, the site is provided with dual substation power feeds, onsite N+1 emergency power generation (4.5 MW), and uninterrupted power system battery backup. In addition to being a premium data storage provider, Internap incorporates "green" design philosophy into its facilities to reduce greenhouse emissions and minimize its impact on the environment. Internap employed this philosophy when it undertook the operation of its new 27,000 sq ft Santa Clara Data Center with two 1100 ton cooling towers and employed the use of recycled water as its make-up water source. Furthermore, Internap installed a make-up water pretreatment technology (WCTI) to eliminate chemical use and cooling towers blow-down, which represented a 40% saving on cost of water from South Bay Water Recycling and average water saving of 5000 to 10,000 gpd. By using recycled water, Internap is able to free up an average of 76,300 gallons of drinking water per day and nearly 28 million gallons per year.

PROJECT GENERAL INFORMATION

Location City: **Santa Clara**

Location County: **Santa Clara**

Location State: **California**

Recycled Water Supplier: **South Bay Water Recycling**

NAICS Codes: **51821013**

SIC Codes: **7374**

PRIMARY PROJECT GOALS

- Reduce water and sewer costs
- Implement an alternative pretreatment technology
- Discontinue use of hazardous chemicals in cooling towers
- Increase green footprint

KEY PROJECT BENEFITS

- Increase the company's green footprint
- Use pretreatment technology to reduce potable water consumption and eliminate all chemical use to site
- Eliminate scale formation and control corrosion as well as reduce time between inspections

PROJECT DESCRIPTION

Internap implemented the use of recycled water for its cooling towers on the basis of the availability of recycled water from South Bay Water Recycling within the vicinity of its data center. (It should be noted that Internap moved into a facility previously connected to a recycled water system installed for landscape irrigation.) Internap proceeded with a recycled water retrofit project and provided connection to its cooling towers following certification of the facility to use recycled water. Internap selected the alternative cooling water treatment technology provided by WCTI based on a vetting process that tested the process on an existing tower. The vetting process included operation of the alternative technology for a period of 2 years. This cooling tower was equipped with a corrosion coupon rack, and the results showed good corrosion control on carbon steel and copper with no scaling and biological activity in the cooling water system. On the basis of these observations, Internap moved forward with the alternative treatment program. Implementation of the WCTI treatment system required replacing existing software equipment with a much larger system having much tighter controls and automatic e-mail notification to the operation office. The payback of the complete system was less than 6 months.

THE COOLING TOWERS AT INTERNAP ARE THE COUNTER-CURRENT INDUCED DRAFT TYPE, TWO CELLS, HAVING A DESIGN COOLING CAPACITY OF 1100 TONS EACH.

RECYCLED WATER QUALITY

The source of recycled water used at Internap is from South Bay Water Recycling, which meets Title 22 requirements for disinfected tertiary recycled water.

PROCESS DESCRIPTION (RECYCLED WATER USE AND PROCESS MODIFICATIONS)

The cooling towers at Internap are the counter-current induced draft type, two cells, having a design cooling capacity of 1100 tons each. The recycled water feed to the cooling towers utilizes a newer alternative treatment technology patented by Water Conservation Technologies International (WCTI). The WCTI process employs a high-efficiency, strong-acid cation exchange system to remove scale-forming cations, such as calcium and magnesium, from the make-up water. Concentration of the remaining chemicals already present in the cooling water has a beneficial effect on reducing corrosion and biofouling in the cooling tower. The increased silica concentration in the tower forms natural corrosion inhibition of metal surfaces. Scaling is eliminated by the removal and elimination of low-solubility salts that normally would result from calcium and magnesium. Furthermore, the high cycles of concentration increase TDS, alkalinity, and pH. The high TDS and pH create a naturally biostatic environment that eliminates biological activity. The results of this alternative treatment system are reduced water use (due to decreased tower blow-down) and eliminated chemical use.

WATER SAVINGS RESULTS AND OTHER PROJECT BENEFITS

The conversion of the Internap cooling towers to recycled water replaced an average of 8.4 acre-ft of annual potable water use, saving approximately 40% on water costs. In addition, because of efficiencies gained by the use of an alternative treatment technology for the make-up water feed to the cooling towers, the overall use of make-up water was reduced significantly.

PROJECT IMPLEMENTATION ISSUES

Regulatory permitting related to implementation of recycled water retrofits proved challenging. This was primarily relating to a need to understand the regulatory permitting requirements.

PROJECT SUCCESSES

+ Saving more than 8.4 acre-ft of potable water
+ Saving 40% on water cost
+ Implementing new green cooling water treatment technology
+ Eliminating hazardous chemicals use in the cooling towers and storage onsite

LESSONS LEARNED

End users need to take time to understand to processes and timelines necessary for implementing an industrial reuse project. Make contact with recycled water agency in advance, and engage a consultant familiar with local county and state recycled water permitting processes.

PROJECT CONTACTS

Cash Bryan,
Facility Supervisor, Internap
cbryan@internap.com

Sim Ong, PE
Associate Engineer,
South Bay Water Recycling
sim.ong@sanjoseca.gov

PUBLICATIONS/ AWARDS

US Green Building Council LEED Silver certified facility

First California Data Center to be awarded two “Green Globes” by the Green Building Initiative (GBI) Environmental Assessment program

Case Study

LARGE INDUSTRIAL REFINERY: HIGH-QUALITY RECYCLED WATER FOR COOLING TOWERS, LOW- AND HIGH-PRESSURE BOILERS

Tesoro Los Angeles Refinery–Carson Operations

INTRODUCTION

The Tesoro Los Angeles Refinery —Carson Operations located in Carson, CA is a premier supplier of clean transportation fuels for the Los Angeles basin. The refinery supplies approximately 25% of the Los Angeles gasoline supply and provides about 20% of the jet fuel used at Los Angeles International Airport.

PROJECT DESCRIPTION

Historically the refinery relied on onsite privately owned wells to supply water to the refining operation. Today, the majority of these wells are no longer in service because of salt-water intrusion. Rather than increase its dependence on potable water, the refinery staff made a strategic decision to use recycled water.

The refinery implemented its first recycled water project in 2000 by using recycled water in cooling towers. The primary driver was to insulate itself from potential potable water curtailments. The refinery expanded its recycled water use in 2006 by converting the refineries entire boiler feed water supply to recycled water.

That investment proved to be highly beneficial in 2010 when Southern California faced the first water supply allocation in the history of the Metropolitan Water District of Southern California. The allocation in Southern California was because of, in part, drought conditions but also what was called a “regulatory drought” in which

PROJECT GENERAL INFORMATION

Location City: **Carson**

Location County: **Los Angeles**

Location State: **California**

Recycled Water Supplier: West **Basin Municipal Water District**

NAICS Codes: **324110, 325199, 424710, 486910**

SIC Codes: **1311, 2911**

PRIMARY PROJECT GOALS

- Protect the business from potential shortages in potable water
- Reduce pumping of onsite wells
- Create a synergy opportunity that benefits both the business and the community

WATEREUSE

pumping restrictions from the Sacramento–San Joaquin delta made water in short supply for users up and down the state. Water-intensive industries, such as oil refining, were not required to cut back, but interest was piqued regarding what could turn out to be longer term supply variability.

Consistent water *quality* and reliable water *quantity* (i.e. uninterrupted service) are the two most critical components for oil refinery water-use operations. The refinery maintains a backup potable water supply system for this reason.

RECYCLED WATER QUALITY

The source of recycled water used at the refinery is from West Basin Municipal Water District, Title 22 disinfected tertiary recycled water, distributed from Edward C. Little Water Recycling Facility in El Segundo. The supplied Title 22 recycled water is nitrified at the Carson Water Reclamation Facility (CRWRF or Carson Facility). This water has a high concentration of iron and phosphate owing to upstream treatment processes, which may limit the cycle of concentration in the cooling water systems. This effect is reduced by blending treated reverse osmosis (RO) water with the nitrified recycled water supply.

PROCESS DESCRIPTION (RECYCLED WATER USE AND PROCESS MODIFICATIONS)

The recycled water used at the refinery is produced by West Basin Municipal Water District at the CRWRF. The CWRF takes Title 22 water as feed and uses microfiltration and reverse osmosis to produce 4.5 mgd of first-pass RO product. The microfilter backwash is sent to a Biofor nitrification process to produce 0.8 mgd of nitrified water. The RO and nitrified water are conveyed in separate pipes approximately 1 mi to the Tesoro Refinery.

At the refinery, Tesoro processes the first-pass RO from CRWRF in another RO plant to produce second-pass RO water. The second RO treatment is needed to achieve the necessary boiler feed water (BFW) purity and can also act as a backup system. The water treatment tank features a break tank upstream of the RO train. In the event of loss of first-pass RO water from West Basin, the refinery can feed potable water to the tank, and after making some operational changes, still produce BFW. All of the refinery boilers run on recycled water.

About half of the RO water is used for BFW production. The remaining RO water is combined with the nitrified water. This recycled water blend is used for cooling tower makeup. To run recycled water, a separate "purple pipe" piping system was built in the refinery. At each cooling tower a new control valve and air gap was installed. The air gap prevents backflow of recycled water into the potable supply.

KEY PROJECT BENEFITS

- Shifting about 30% of the refinery's water supply to recycled water
- Reducing risk of water-related production cuts, which protects the Los Angeles fuel supply
- Using RO technology to make boiler water treatment operations simpler and safer
- Providing more consistent quality of water supply, which benefits the cooling tower treatment systems

CONSISTENT WATER QUALITY AND RELIABLE WATER QUANTITY ARE THE TWO MOST CRITICAL COMPONENTS FOR OIL REFINERY WATER-USE OPERATIONS.

WATER SAVINGS RESULTS AND OTHER PROJECT BENEFITS

Currently 30% of the Tesoro refinery's water supply is met with the recycled water with plans to increase this percentage to 55% by 2017. The major economic benefit of using West Basin recycled water is reduced treatment costs at the refinery, especially for BFW.

PROJECT IMPLEMENTATION ISSUES

+ **Reliability** - Because the make-up water supply to refinery boilers cannot be interrupted at any time, Tesoro has built-in city water backup supplies to supplement recycled water if it is not available for any reason. If the feed water to the onsite RO system is changed from first-pass RO water to city water, the operational characteristics of the unit must be adjusted to maintain sufficient quality. There are redundancies built into this system at several points with potable or "city" water ready injection points to ensure 100% reliability.
+ **Regulation** – Because there is a mixture of potable and recycled water used at the facility, there must be air gaps present to prevent a backflow situation if the potable system goes down for any reason. The air gaps are required by the Los Angeles Department of Public Health; check valves or block valves are not deemed sufficient. The installation of multiple air gaps throughout the facility and the need to meet other mandatory regulations is costly though necessary to enable recycled water use.
+ **Water Quality** – Water that is treated with RO is corrosive by nature, so a separate noncarbon steel pipeline distribution system was built inside the refinery to accommodate the use of this water. In addition, the Title 22 stream coming from West Basin's Edward C. Little Water Recycling Facility in El Segundo is nitrified at the Carson facility. This water is high in iron and phosphates because of upstream treatment processes and may limit the number of cycles the water can be used in the cooling towers.
+ **Chemical Treatment Program** - Chemical treatment programs need to be adjusted when switching from the city water supply over to a predominantly recycled supply, especially in cooling towers. The water quality from the Carson Regional Facility generally is of very consistent quality especially compared to city water, which can change seasonally or when the blend of imported water sources change. However, sudden quality changes can occur with recycled water. Good communication between the recycled plant operator and the refinery operators is critical to minimize the impacts of these changes.

CURRENTLY 30% OF THE TESORO REFINERY'S WATER SUPPLY IS MET WITH THE RECYCLED WATER WITH PLANS TO INCREASE THIS PERCENTAGE TO 55% IN 2014.

PROJECT SUCCESSES

+ Saved 30% of the refinery water supply using recycled water with goal of achieving 55% by 2017.
+ Practiced good communication between the recycled water provider and refinery operation staff.
+ Regulatory permitting was acquired for the proper implementation of cross-connection controls, as well as other requirements that must be factored into the design of the project early on. Understood the specific regulatory requirements and factor in the cost to implement those requirements.

LESSONS LEARNED

+ Permitting and regulatory requirements.
+ Adjustment to water treatment program. When switching from potable water to recycled water, the changes in water chemistry will necessitate a change in the current treatment program or adoption of a new treatment program.
+ Water quality requirements and additional onsite treatment for each process application; the use of RO treatment systems results in a water that is corrosive to ferrous-based pipelines and equipment. Verify the constituents in the recycled water, provide appropriate treatment for the process, and use suitable materials. Understanding the water quality will be key to successful implementation of an industrial reuse project.

PROJECT CONTACT

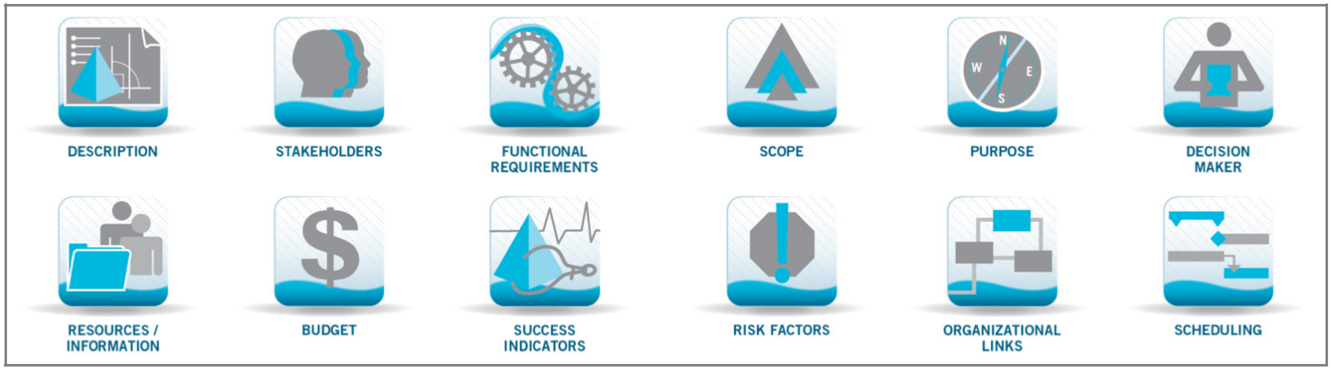
Ken Letwin, Sr.
Process Engineer, Tesoro Los Angeles Refinery – Carson Operations.

210.828.8484

Bruce.K.Letwin@tsocorp.com

IWR Project Charter

The IWR project charter is a combination game plan and play book designed to reflect a shared understanding among key stakeholders as to the project goals, objectives, and approach. It serves as a point of reference throughout the development, completion, and delivery of an industrial water reuse project. Topics include

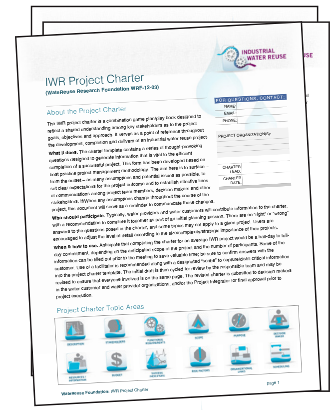


SUGGESTED GUIDELINES FOR COMPLETING THE PROJECT CHARTER

Why... The charter template contains a series of thought-provoking questions designed to generate information that is vital to the efficient completion of a successful project. This form has been developed as a guideline based on best practice project management methodology. The aim here is to bring to the surface – from the outset – as many assumptions and potential issues as possible, to set clear expectations for the project outcome, and to establish effective lines of communications among project team members, decision makers, and other stakeholders.

Who... Typically, water providers and water customers will contribute information to the charter, with the option to complete it together as part of an initial planning session. There are no “right” or “wrong” answers to the questions posed in the charter, and some topics may not apply to a given project. Users are encouraged to adjust the level of detail according to the size, complexity, and strategic importance of their projects.

When/How... Anticipate that completing the charter for an average IWR project would be a half-day to full-day commitment, depending on the anticipated scope of the project and the number of participants. Use of a facilitator is recommended along with a designated “scribe” to capture/distill critical information into the project charter template. The initial draft is then cycled for review by the responsible team and may be revised to ensure that everyone involved has the same understanding. The revised charter is submitted to decision makers in the water customer and water provider organizations and/or the project integrator for final approval prior to project execution.



A standalone **IWR project charter** template is provided to ensure thorough capture of information