U.S. Department of the Interior
Bureau of Reclamation

PROPOSAL

DESALINATION AND WATER PURIFICATION RESEARCH AND DEVELOPMENT (DWPR)

FISCAL YEAR 2016 PILOT PROJECTS:

Building-Scale Treatment for Direct Potable Water Reuse & Intelligent Control for Real Time Performance Monitoring

R16-FOA-DO-010

San Francisco Water Power Sewer

carollo
Engineers...Working Wonders With Water®

FEBRUARY 2016

OMB Number: 4040-0004
Expiration Date: 8/31/2016

Application for Federal Assistance SF-424

* 1. Type of Submission:	* 2. Type of Application:
☐ Preapplication	☒ New
☒ Application	☐ Continuation
☐ Changed/Corrected Application	☐ Revision

* If Revision, select appropriate letter(s):

* Other (Specify):

* 3. Date Received: 2/8/16

4. Applicant Identifier:

5a. Federal Entity Identifier:

5b. Federal Award Identifier:

State Use Only:

6. Date Received by State:

7. State Application Identifier:

8. APPLICANT INFORMATION:

* a. Legal Name: City and County of San Francisco

* b. Employer/Taxpayer Identification Number (EIN/TIN): 94-6000417

* c. Organizational DUNS: 0276590640000

d. Address:

* Street1: 525 Golden Gate Avenue, 10th Floor
Street2:
* City: San Francisco
County/Parish:
* State: CA: California
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 94102-3220

e. Organizational Unit:

Department Name: Public Utilities Commission

Division Name: Water Treatment

f. Name and contact information of person to be contacted on matters involving this application:

Prefix: Ms.
* First Name: Manisha
Middle Name:
* Last Name: Kothari
Suffix: P.E.

Title: Project Manager

Organizational Affiliation: San Francisco Public Utilities Commission

* Telephone Number: 415-554-3256

Fax Number:

* Email: mkothari@sfwater.org

Application for Federal Assistance SF-424

*** 9. Type of Applicant 1: Select Applicant Type:**

C: City or Township Government

Type of Applicant 2: Select Applicant Type:

Type of Applicant 3: Select Applicant Type:

* Other (specify):

*** 10. Name of Federal Agency:**

Bureau of Reclamation

11. Catalog of Federal Domestic Assistance Number:

CFDA Title:

*** 12. Funding Opportunity Number:**

No. R16-FOA-DO-010

* Title:

Desalination and Water Purification Research And Development (DWPR) - Fiscal Year 2016 - Pilot Projects

13. Competition Identification Number:

Title:

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Building-Scale Treatment for Direct Potable Water Reuse & Intelligent Control for Real Time Performance Monitoring

Attach supporting documents as specified in agency instructions.

Add Attachments | Delete Attachments | View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant: CA-012

* b. Program/Project: CA-012

Attach an additional list of Program/Project Congressional Districts if needed.

Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date: 07/15/2016

* b. End Date: 07/17/2017

18. Estimated Funding ($):

* a. Federal	200,000.00
* b. Applicant	262,000.00
* c. State	0.00
* d. Local	0.00
* e. Other	20,530.00
* f. Program Income	0.00
* g. TOTAL	482,530.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

☒ a. This application was made available to the State under the Executive Order 12372 Process for review on 02/08/2016.

☐ b. Program is subject to E.O. 12372 but has not been selected by the State for review.

☐ c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

☐ Yes ☒ No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

☒ ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

Prefix: Mr.

* First Name: Steven

Middle Name: R.

* Last Name: Ritchie

Suffix:

* Title: Assistant General Manager, Water

* Telephone Number: 415-934-5736

Fax Number:

* Email: sritchie@sfwater.org

* Signature of Authorized Representative:

* Date Signed: 2/4/16

OMB Number: 4040-0007
Expiration Date: 01/31/2019

ASSURANCES - NON-CONSTRUCTION PROGRAMS

Public reporting burden for this collection of information is estimated to average 15 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Management and Budget, Paperwork Reduction Project (0348-0040), Washington, DC 20503.

PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET. SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.

NOTE: Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant, I certify that the applicant:

1. Has the legal authority to apply for Federal assistance and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project cost) to ensure proper planning, management and completion of the project described in this application.

2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.

3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.

4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.

5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards for merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).

6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C.§§1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U. S.C. §§6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee- 3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.), as amended, relating to nondiscrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and, (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.

7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.

8. Will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§276a to 276a-7), the Copeland Act (40 U.S.C. §276c and 18 U.S.C. §874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§327-333), regarding labor standards for federally-assisted construction subagreements.

10. Will comply, if applicable, with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is $10,000 or more.

11. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§1451 et seq.); (f) conformity of Federal actions to State (Clean Air) Implementation Plans under Section 176(c) of the Clean Air Act of 1955, as amended (42 U.S.C. §§7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended (P.L. 93-523); and, (h) protection of endangered species under the Endangered Species Act of 1973, as amended (P.L. 93-205).

12. Will comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.

13. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470), EO 11593 (identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. §§469a-1 et seq.).

14. Will comply with P.L. 93-348 regarding the protection of human subjects involved in research, development, and related activities supported by this award of assistance.

15. Will comply with the Laboratory Animal Welfare Act of 1966 (P.L. 89-544, as amended, 7 U.S.C. §§2131 et seq.) pertaining to the care, handling, and treatment of warm blooded animals held for research, teaching, or other activities supported by this award of assistance.

16. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§4801 et seq.) which prohibits the use of lead-based paint in construction or rehabilitation of residence structures.

17. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act Amendments of 1996 and OMB Circular No. A-133, "Audits of States, Local Governments, and Non-Profit Organizations."

18. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations, and policies governing this program.

19. Will comply with the requirements of Section 106(g) of the Trafficking Victims Protection Act (TVPA) of 2000, as amended (22 U.S.C. 7104) which prohibits grant award recipients or a sub-recipient from (1) Engaging in severe forms of trafficking in persons during the period of time that the award is in effect (2) Procuring a commercial sex act during the period of time that the award is in effect or (3) Using forced labor in the performance of the award or subawards under the award.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL	TITLE
	Assistant General Manager, Water
APPLICANT ORGANIZATION	DATE SUBMITTED
San Francisco Public Utilities Commission	02/05/2016

U.S. Bureau of Reclamation

Desalination and Water Purification Research and Development Program (DWPR)

Funding Opportunity Announcement No. R16-FOA-DO-010

San Francisco Public Utilities Commission

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CONTENTS

BUILDING-SCALE TREATMENT FOR DIRECT POTABLE WATER REUSE & INTELLIGENT CONTROL FOR REAL TIME PERFORMANCE MONITORING

EXECUTIVE SUMMARY

Direct potable water reuse (DPR) starts with raw wastewater and ends with purified water that is protective of public health. This project will use innovative building-scale treatment, proven purification processes, real time online monitoring, and advanced analytical tools to demonstrate the first operational and safe facility in the country. This project examines two innovative concepts: DPR at the building-scale coupled with advanced analytical monitoring and a "smart" control system that verifies the performance of each process and the collective water quality online in real time, which would be a first for potable reuse systems anywhere. The advanced purification system for DPR will be sited at the San Francisco Public Utilities Commission Headquarters Building, where an existing Living Machine® System (a constructed wetlands with tertiary treatment) treats the building's wastewater to non-potable reuse standards.

The treatment train will use the existing tertiary treatment system, followed by ultrafiltration (UF), reverse osmosis (RO), and ultra violet light with an advanced oxidation process (UV AOP) to produce purified water. A final engineered storage buffer (ESB) is included to provide a time barrier to safely monitor all processes before distribution. State-of-the-art advanced analytics, including bioassays and non-target analyses, will be used during the DPR demonstration to prove the safety of the purification facility. These analytics allow researchers to understand the impact of the "unknown unknowns," chemicals of unknown type at trace levels that may have some degree of toxicity.

This project brings together international experts in treatment, analytical chemistry, and biological monitoring. This project also brings substantial financial support; including $262,000 from the San Francisco Public Utilities Commission and $20,530 from Carollo Engineers. This outside funding will be used to best leverage funding from the Bureau of Reclamation - $200,000 for one year.

BACKGROUND AND INTRODUCTION

Advanced treatment of wastewater for direct potable reuse (DPR) is operational at one facility in the United States, the Colorado River Municipal Water District's Raw Water Production Facility in Big Spring Texas. Ongoing research of that facility is demonstrating the production of a high quality water that is protective of public health (Steinle-Darling *et al.,* 2015). These results demonstrated the effective use of multiple barriers for reduction of trace pollutants and pathogens. While providing high quality water, the "Big Spring" facility relies upon monitoring systems designed for indirect potable reuse (IPR) applications. Nationally, the National Water Research Institute (NWRI) recently published a 173-page "how to" document on DPR, titled *Framework for Direct Potable Reuse* (NWRI, 2015). ***Central to this document was the use of precise and accurate monitoring technologies for public health protection in DPR applications***. Within California, an extensive research program (>$6M), the California DPR Initiative, has been undertaken to define the necessary level of treatment for a DPR project in California, and inform the discussion of DPR nationally. The Division of Drinking Water (DDW) is part of this Initiative, providing third party review of all research as they consider the possibility of regulating DPR in California. Even with the success of "Big Spring," with the development of clear guidelines for safe DPR implementation, and with extensive funding for research, the public and regulatory concern over "unknown unknowns" remains. What is that next pollutant? How do we find it? Are trace levels of pollutants harmful? The State Water Resources Control Board recently conducted an expert workshop to lay the groundwork for tracking down these questions (SWRCB, 2015). ***The expert workshop team recommended the use of non-target analysis (NTA) and bioassays to better grasp the significance of the "unknown unknowns."***

These key research needs, the ability to document real time precise and accurate monitoring technologies and the use of advanced analytics to understand the impact of the "unknown unknowns," are the primary objectives of this proposed research project. There is a secondary value of this project, which is the integration of DPR methodologies into building-scale treatment. The proposed project would use the existing constructed wetlands with tertiary treatment that harvests wastewater from the building and treats it to non-potable water reuse standards, and then purify the water to potable standards.

In total, the goals of the demonstration are:

- Demonstrate innovative building-scale treatment of wastewater for DPR.
- Procure purification processes that produce potable water in accordance with health criteria established in National documents (NWRI, 2015).
- Use leading edge online analytical techniques to demonstrate the performance of each treatment process.
- Use advanced analytical monitoring to understand the potential impact of unknown trace level pollutants.
- Clearly document the costs of a potential future DPR system for utilities in California.
- Educate regulators and community members about the safety of properly engineered potable water reuse treatment systems.

This ambitious project will span one year, and includes a substantial work effort which is supported by funding from the San Francisco Public Utilities Commission (SFPUC) and Carollo Engineers.

TECHNICAL APPROACH

1.0 Building-Scale Treatment for Non-Potable Water Reuse

This project starts with raw wastewater, harvested from the 13-story, 900 employee SFPUC headquarters building. The advanced, ecologically based Tertiary treatment system currently collects and treats wastewater for non-potable reuse inside the structure. The Tertiary treatment system consists of a two-stage, recirculating, engineered wetland system with subsequent filtration and disinfection units (collectively called a tertiary treatment system henceforth in this proposal) and is housed in landscaped planters on the interior and exterior of the structure.

The tertiary treatment system can treat a maximum flow of 5,000 gallons per day and consists of primary treatment and flow equalization followed by (2) the Recirculating Tidal Wetland System, (3) the Recirculating Vertical Flow Polishing Wetland System (4) denitrification and (5) polishing and disinfection and (6) a reclaimed water reservoir. The system has proven capable of treating raw wastewater with a small physical footprint, appropriate to an urban setting.

The value of de-centralized wastewater treatment cannot be overstated. Water can be treated and used within one watershed, eliminating the need for sewers, pump stations, and wasted conveyance energy. Demonstrating advanced purification of the reclaimed water to potable water standards is possible and safe may lead to a radical revolution in the water industry.

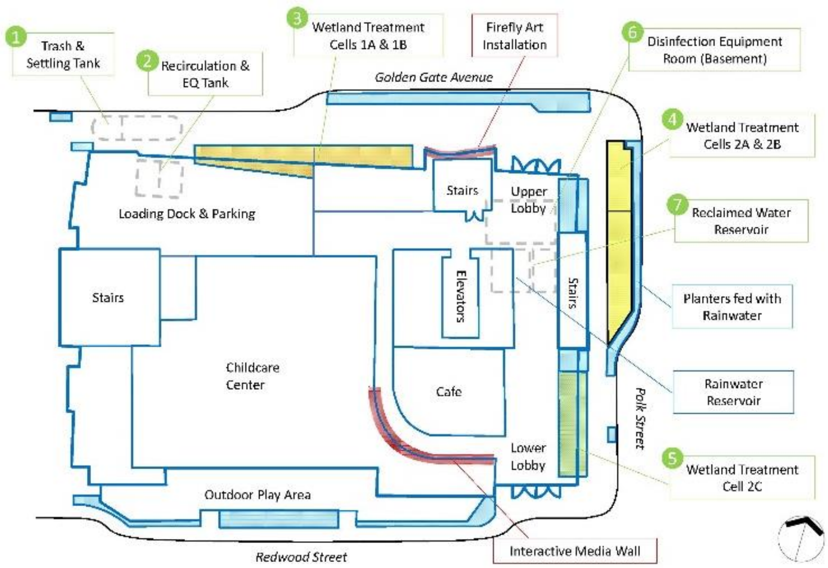


Figure 1. Wetland Treatment Schematic and Photo of Disinfection Room at SFPUC

2.0 Purification Processes for Potable Water Reuse

There are numerous treatment trains that could be used for potable water reuse. Within California, the particular processes that could be employed for this type of project are more limited (CDPH, 2014). In particular, IPR projects in California that include 100 percent purified water (no dilution) and do not benefit from surface spreading (soil aquifer treatment), must have reverse osmosis (RO) and advanced oxidation processes (AOP) within the treatment train. Using these two processes as a starting point, and relying upon the NWRI Framework for Direct Potable Reuse (NWRI, 2015), the purification process proposed for this treatment train are ultrafiltration (UF), RO, ultraviolet light (UV) AOP, and an engineered storage buffer (ESB) with free chlorine during storage (Figure 2, shown on the next page). These processes will provide multiple barriers to both pollutants and pathogens, as shown in Table 1 on the next page. When coupled together, the proposed processes meet all pathogen and pollutant requirements for potable water reuse as defined by CDPH (2014).

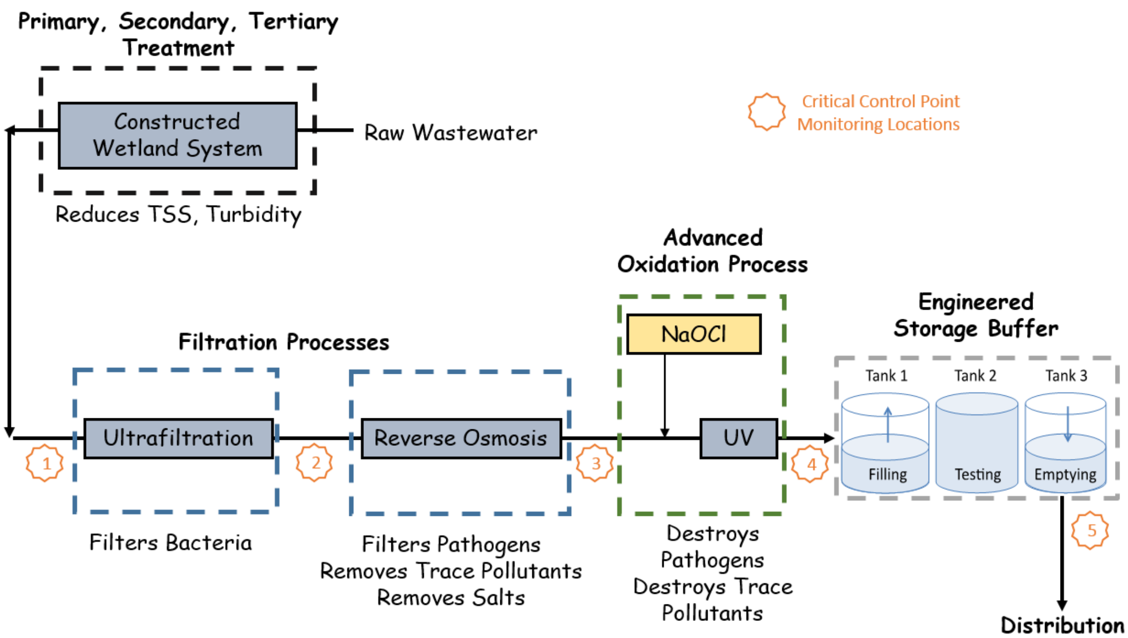


Figure 2. Proposed Advanced Treatment Train for Direct Potable Reuse

Table 1. Use of Multiple Barriers for Purification

	Bulk Organic Removal	Trace Organic Removal	Virus Removal	Protozoa Removal	Bacteria Removal
Primary, Secondary, and Tertiary Treatment	●	●	●	●	●
UF	●	–	–	●	●
RO	–	●	●	●	●
UV AOP	–	●	●	●	●
ESB with free chlorine	–	Partial	●	Partial	●

This proposed treatment train will have online monitoring at critical control points (CCPs), as detailed further on below.

Ultrafiltration

Recent work with Clean Water Services (CWS) (Oregon), as part of DPR demonstration testing, indicates that a well-functioning UF (0.01 μm nominal pore size) can attain 4.7-log reduction of seeded virus (CWS, 2014) without chemical use (such as alum or polymer) ahead of the membrane. Equivalent or greater reduction of protozoa can be assumed based upon this data, and is directly supported by NSF (2012). Furthermore, MF or UF membrane integrity testing (MIT), confirms system performance and demonstrates how MIT data can be used to track and ensure continued membrane performance (CWS, 2014). Therefore, both MF and UF membranes can be relied upon for 4+ log reduction of protozoa.

Reverse Osmosis

The RO is the primary treatment process that addresses the removal of total dissolved solids (TDS), hardness, and trace levels of organic and inorganic contaminants. The RO trains also help to remove trace organic compounds, total organic carbon (TOC), and pathogens from the tertiary effluent.

Studies have found virus removal by RO to be from 3 to >6-log (Reardon *et al.*, 2005, NRMMC/EPHC/NHMRC 2008, CWS 2014). Equal or greater removal is expected for protozoa. Unfortunately, RO process performance for pathogen rejection is not governed by the ability of an intact membrane to reject pathogens; it is governed by the ability to monitor process integrity (Reardon et al., 2005 and Schäfer et al., 2005). The monitors currently used, electrical conductivity (EC) meters and total organic carbon (TOC) meters, can measure 99 percent or less removal of both parameters through the RO process. Recently, the DDW granted 1.5 log reduction credit for all pathogens for RO (WRD, 2013), based upon a requirement to continuously monitor TOC reduction across RO. Alternative technologies, such as online fluorescent dye monitoring, have been shown to have higher accuracy in assessing membrane efficiency (3+ log based upon new research as part of Water Research Foundation project 4536), with other research showing similar results (Kitis et al., 2003; Henderson et al., 2009; Pype et al., 2013). Using traditional monitoring technology, we recommend using the 1.5-log reduction value for all pathogens for RO at this time.

UV AOP

In the event of pathogens passing through RO, the UV process provides for a high level of disinfection. NDMA, with a DDW notification level (NL) of 10 ng/L, can pass through RO at low concentrations (typically 20 to 100 ng/L), requiring destruction by UV photolysis (Sharpless and Linden, 2003). Therefore, it is common to set the UV dose at 800+ millijoule per square centimeter (mJ/cm^2). This high UV dose photolyzes NDMA as well as many other smaller chemicals that may have passed through the RO train. Adding H_2O_2 before the high dose UV, typically in the range of 3 to 5 mg/L, results in the generation of hydroxyl radicals throughout the UV process. This turns the treatment into an AOP. Hydroxyl radicals are nonselective and break down most chemicals with which they come in contact, destroying a range of trace level pollutants.

At a dose of 800+ mJ/cm^2, as would be applied for this project, the high UV dose will result in 6+ log reductions of all target pathogens (USEPA, 2006; Hijnen et al., 2006; Rochelle et al., 2005), including *Cryptosporidium, Giardia*, and adenovirus. Higher reductions are theoretically possible, but the DDW allows only a maximum of 6-log reduction credits per any one treatment technology (CDPH, 2014).

ESB with Free Chlorine

DPR forgoes the environmental buffer in lieu of an Engineered Storage Buffer (ESB, Tchobanoglous *et al.*, 2011). The ESB would be applied for any DPR application in California.

Eliminating the environmental buffer leads to the loss of several benefits, including contaminant reduction, dilution, and, perhaps most importantly, time to detect and respond to a treatment failure. Recent potable reuse reports suggest that these are limitations that can be overcome. These studies include the WateReuse Research Foundation's 2011 report entitled "Direct Potable Reuse: A Path Forward" (Tchobanoglous et al., 2011), the National Research Council's 2012 report entitled "Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater" (NRC, 2012), the Australian Academy of Technological Sciences and Engineering's 2013 report entitled "Drinking Water through Recycling: The benefits and costs of supplying direct to the distribution system" (ATSE, 2013), and the WateReuse Research Foundation Project 11-

10, Application of Risk Reduction Principles to Direct Potable Reuse (Salveson et al., 2014). They suggest that a higher level of treatment at the Advanced Water Treatment (AWT) facility can compensate for the treatment and dilution provided by the groundwater aquifer or surface water reservoir. The ESB can be designed to provide time to hold and test the treated water to ensure its safety before distribution. No further treatment is added in the ESB (except, perhaps further contact time), and therefore no log-removal credits for pathogens should be expected from this treatment process.

The ESB provides several key benefits over the environmental buffer. For communities without available environmental buffers such as rivers or aquifers (which are often in the most dire need), water reuse is still a possibility with ESBs. Second, ESBs eliminate the need for costly pumps and pipes to and from environmental buffers. Much of the treated water is also lost in the environmental buffer, either washed downstream or dispersed through an aquifer. Finally, advanced treated water is typically higher in quality than groundwater or surface water. Environmental sources can be easily contaminated with runoff and other influences. Keeping the treated water separate from these sources can lower contamination and decrease further treatment costs.

For this project, the ESB would follow the recommendations in Salveson et al. (*in press*) for ESB application. The ESB would be designed to hold at least 4 hours of water, allowing for all key processes to be monitored for quality prior to release of water. The time value becomes critical, as the subsequent processes must perform at a high level during such upstream process upsets. For each unit process and its associated monitoring method, a failure and response time (FRT) is defined. The process FRT is the maximum possible time between when a failure occurs and when the system has reacted such that the final product water quality is no longer affected. The FRT is a sum of the sampling interval, the sample turnaround time (TAT), and the system reaction time, as shown in Figure 3 below. For a unit process monitored by a traditional sampling technique, the sampling interval may range from continuous online monitoring to periodic sampling. In this pilot project, key process monitoring will be done online to minimize the FRT of the system.

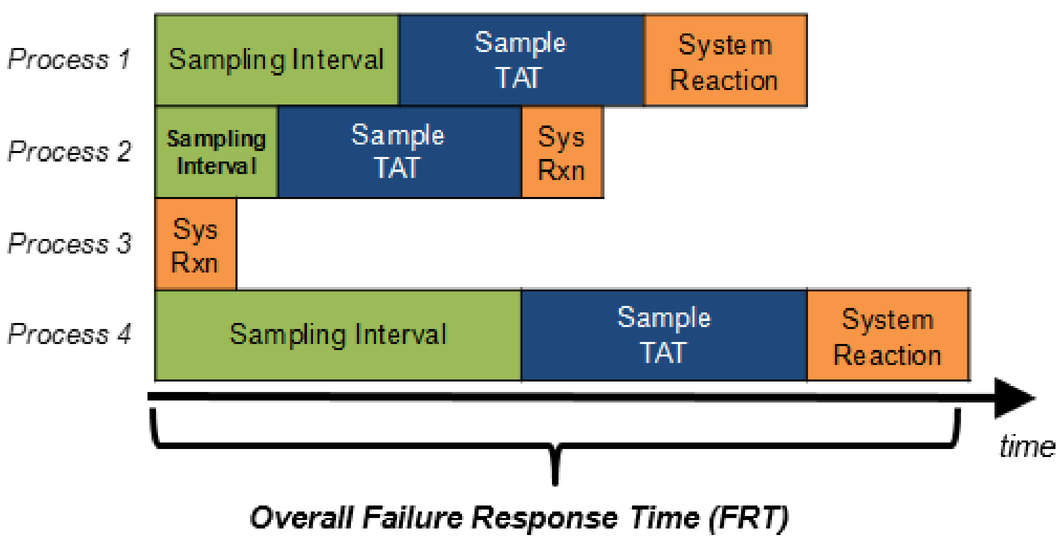


Figure 3. Determination of Failure and Response Time for ESB

In addition to the FRT value of the ESB, the ESB provides for substantial disinfection treatment by free chlorine. The ESB would have free chlorine dosing and be controlled to maintain a target free chlorine *Ct* sufficient to attain 3-log for *Giardia* and 4-log for viruses, based upon a 4 hour contact time with a 1 mg/L free chlorine residual, with an RO permeate pH of 6. The pathogen credits are based upon the 1990 SWTR Guidance Manual (USEPA, 1990).

3.0 Monitoring Technologies

Conventional potable reuse trains have repeatedly met EPA drinking water standards, as documented by long term compliance with California regulations by the Orange County Water District, among many others. Demonstration testing of similar advanced treatment trains has shown similar performance (CWS, 2015; Trussell, 2013). Emerging pollutants will be evaluated for this project, focusing on the following trace level pollutants:

- A suite of pharmaceuticals and personal care products (PPCPs)
- A suite of perfluorinated compounds (PFCs)
- NDMA
- NDMA formation potential
- THM and HAA formation potential
- Fluorescence

Pathogens will also be evaluated for this project, documenting with grab sampling the pathogen levels after secondary treatment and thus allowing an analysis of sufficient reduction of such pathogens through the purification processes. Pathogens (and surrogate organisms) to be evaluated include: male specific and somatic coliphage, *enterococci, E. coli,* total coliform, *Giardia*, *Cryptosporidium*, enterovirus, and norovirus.

The ability for these processes to produce high quality water in accordance with regulations is not in question. What this project looks to define is the ability to continuously monitor the performance of the advanced treatment systems in real time. This will be done through the use of precise and accurate metering of the critical control points in the purification process. To that end, we have secured the use of two ZAPs LiquID stations to perform such monitoring, as shown in Table 2, on the next page. These parameters will be used to demonstrate process by process performance; as follows:

- **UF -** UF filtrate turbidity and *E. coli* concentrations will closely track UF performance. These continuous measurements will be paired with daily pressure decay test (PDT) results to provide real-time confidence in protozoa and bacteria removal performance.
- **RO -** TOC values collected pre and post RO allow for clear determination of a conservative surrogate for pathogen removal by RO as well as consistent reduction in TOC. TOC values will be paired with online electrical conductivity (EC) to verify TOC performance values.
- **UV AOP -** Destruction of total chlorine across UV systems has now been shown to correlate directly with UV dose, which then correlates directly to pathogen removal and destruction of pollutants such as NDMA (work in press). Free chlorine measurements and UV absorbance (UVA) can be used to develop a "chlorine weighted UV dose," which has recently been shown to correlate directly with destruction of trace pollutants by UV AOP (work in press).
- **ESB -** Free chlorine residual after the ESB will be used to calculate a Ct and show disinfection credit in accordance with EPA standards.

Table 2. Online Real Time Monitoring for Demonstration Project

Measurement	Post UF	Post RO	Pre UV	Post UV
Chloramines	●		●	●
Free Chlorine	●		●	●
E. coli	●			
TOC	●	●		
UVA			●	●
Turbidity	●			

The information from the ZAPs systems will be logged for the duration of the 6-month demonstration and used to evaluate overall reliability in system performance. These values will also be used to monitor system performance remotely, available 24/7/365.

The research will take one further step, the investigation of the "unknown unknowns." While hundreds of chemicals have been detected in water, thousands more likely occur at very low concentrations but have not yet been detected. Chemical surrogates and indicators are often used to gauge the efficacy and efficiency of a particular treatment process and/or multibarrier train (Yu et al., 2015; Merel et al., 2015; Anumol et al., 2015; Gerrity et al., 2012). However, these measures do not provide any reference to biological effects and thus do not account for the potential additive or synergistic effects of chemical mixtures. Bioassay-based monitoring complements chemical analysis by providing a comprehensive assessment of the mixture of substances present in a particular water sample (Escher et al., 2014). A limitation of bioassays is the ability to determine what substance, or substances, were responsible for the bioactivity observed. Therefore, non-targeted analysis (NTA) will also be performed using high-resolution mass spectrometry (HRMS) with both gas chromatography (GC) and liquid chromatography (LC) interfaces for volatile and non-volatile organic compounds, respectively. National experts convened in California recently to examine two promising techniques for such investigation (SWRCB, 2015). In that two-day workshop, the expert group concluded that these two methods, non-target analysis (NTA) and bioassays, should be paired.

In order to accomplish both the bioassays and NTA methods proposed below, we will use 4L of water (approximately one gallon) for each sample. Technically, two liters of water is required; however, we recommend providing additional water for replicates (3) to improve statistical accuracy of the NTA work, and allows for repeat analyses if necessary. Two one-liter samples will be extracted using a comprehensive two-SPE system previously shown to capture the majority of organic contaminants occurring in water systems (Escher et al. 2014; Jia et al., 2015). Positive controls for bioassays will be used for matrix spikes to ensure acceptable recovery (greater than 70 percent) of bioactive substances.

Assays selected were those recently demonstrated to address relevant endpoints, displayed significant activity using water samples, and were reliable in multiple laboratories (Escher et al., 2015).

1) Non-specific Toxicity: Cytotoxicity. Cytotoxicity will be assessed using the MTS assay. The MTS reagent will be purchased from Promega (CellTiter 96® AQueous One Solution Cell Proliferation Assay, #G3580). MTS (tetrazolium) is bioreduced by cells in culture into a colored formazan product that is soluble in tissue culture medium, and this conversion is presumably accomplished by NADPH or NADH produced by dehydrogenase enzymes in metabolically active cells. Assays are performed by adding a small amount of the MTS Reagent directly into culture wells, incubating for 2 hours, and then recording the absorbance at 490 nm with a 96-well plate reader.

2) Specific (Receptor-mediated) Toxicity: Glucocorticoid Receptor (GR) and Estrogen Receptor (ER). Estrogens and glucocorticoids have been reported to occur widely in WWTP effluents (Escher et al., 2014; Snyder et al. 2001; Stavreva et al., 2012). Based on previous testing of multiple ER and GR assays, our team has elected to use the Invitrogen platform as it also was selected by the State of California funded project on which Snyder is a Co-PI. The ER/GR assay uses GeneBLAzer® HEK 293T cells which contain an estrogen receptor/glucocorticoid receptor (ER/GR) ligand-binding domain/Gal4 DNA binding domain chimera stably integrated into the GeneBLAzer® UAS-*bla* HEK 293T cell line. GeneBLAzer® UAS-*bla* HEK 293T contains a beta-lactamase reporter gene under control of a UAS response element stably integrated into HEK 293T cells. Fluorescence Resonance Energy Transfer (FRET) substrate that generates a ratiometric reporter response and dual-color (blue/green) reading is used to minimize experimental noise. The ER and GR assay will help to identify potential for endocrine disruption effects caused by estrogenic and glucocorticoid hormones, respectively, as well as contaminants that mimic these hormones.

3) Xenobiotic Metabolism: Aryl Hydrocarbon Receptor (AhR). A well-known example of a xenobiotic receptor is the arylhydrocarbon receptor (AhR), which responds to exposure to dioxin-like chemicals. The AhR assay has been used to gauge remediation of PCB and dioxin in environmental spill scenarios (Giesy et al., 2002). For the proposed research, rat hepato-carcinoma cells (H4IIE-luc) which have been stably transfected with the luciferase gene under control of the AhR will be used (Giesy et al., 2002; Sanderson et al., 1996; Jarosov et al., 2012).

4) p53 reporter gene. The p53 protein is known for its major role in the prevention of cancer. It acts as a tumor suppressant, recognizing damaged DNA and triggering DNA repair. This pathway also plays a role in cell cycle arrest and apoptosis. Our team has chosen to use the CellSensor *p53RE-bla HCT-116* cell line, which operates very similarly to GeneBLAzer® HEK 293T cells, to represent stress response. The CellSensor *p53RE-bla HCT-116* cell line contains a p53 receptor ligand-binding domain/Gal4 binding domain, as well as a beta-lactamase reporter gene under control of a UAS response element. CCF4-AM substrate will be used to measure fluorescence, as it emits a green in the absence of betalactamase and blue in the presence. The primary difference between the CellSensor *p53RE-bla HCT-116* cell line and to GeneBLAzer® HEK 293T cells is that the p53 cell line uses human colorectal carcinomacells, where the ER/GR cell lines use human embryonic kidney cells. The p53 assay will help determine the quality of the water since the ability of a cell to repair itself may be more sensitive than actual damage done.

NTA of unknown compounds will be performed using the latest generation quadrupole-time-of-flight (QTOF) mass spectrometers. The LC-QTOF will use an aliquot of methanol extracts prepared for bioassay and analyzed using both positive and negative electrospray ionization (ESI). These extracts will also be analyzed by GC-QTOF by injection of the methanol extracts and analyzed with electron impact ionization. Samples will be analyzed in auto-MS/MS mode in both instruments, where instruments record all the mass to charge ratios (m/z). Between acquisitions of MS spectra, the instrument is programmed to isolate the most abundant ions and fragment them to acquire their corresponding MS/MS spectra. These analyses generate large amounts of data, which will be processed using software specifically designed for this purpose.

Using the QTOF data, our team is able to statistically “fingerprint” different water qualities based on their mass profile. In previous preliminary studies, our team has demonstrated that HRMS could discriminate water exposed to different treatments or different doses of the same oxidant. Resulting HRMS data is evaluated initially through heatmaps, revealing multiple classes of compounds such as recalcitrant, those removed, and transformation products (including intermediates). Each sample profile will be paired both with water treatment variable and with bioassay results. Therefore, while bioassays indicate if a treatment leads to an increase or decrease in toxicity, QTOF data will provide information on which compounds or group of compounds correlate statistically to the biological observation.

The second value of this approach consists in being able to identify compounds of interest among the list of molecular features. For example, if sample toxicity increases after a specific treatment, the transformation products formed by such treatment will be isolated from the molecular features enclosed in the sample profile for further identification. Based on their high resolution mass spectra, transformation products will be searched against libraries of compounds available in Dr. Snyder's laboratory. While some of these products may not be registered in the library, a first identification of chemical formula can be proposed based on the accurate mass. Such molecular formula would then be further evaluated based on MS/MS spectra. In addition, these data produce a lasting electronic record of what substances were present, thus if a new contaminant is identified, these spectra can be retroactively mined to determine if the substance was present and its relative abundance.

For this initial research, the NTA and bioassay analysis will be taken across the treatment train as detailed in the Scope of Work. These two tools, when used in combination, will present a powerful picture of water quality through different levels of treatment over the duration of the study. These tools will supplement the previously detailed analysis for regulated and unregulated pollutants and pathogens and begin to answer the questions about the "unknown unknowns" frequently raised by opponents to water reuse projects.

4.0 Data Analysis

Three distinct sets of data will be collected. What those data are, and how they will be utilized, is defined below:

- **Online Data -** online data will be logged and performance probability distribution functions (PDFs) will be created, which document the statistical reliability of each process to provide the desired results (for pathogen and pollutant reduction)
- **Grab Sample Data** - trace pollutant data will be collected and compared against industry standards, and then used to compare pollutant levels with the results from the advanced analytics. Pathogen data will be used to set a baseline of pathogen levels in the purification feed water, and then document the levels of reduction of those pathogens to the new potable water supply, clearly documenting compliance (or lack thereof) with published health standards (CDPH, 2014; NWRI, 2015).
- **Advanced Analytics** - NTAs and bioassays will be paired together and compared/contrasted with the trace pollutant data.

SCOPE OF WORK

Project Management

As Principal Investigator (PI) for this project, Manisha Kothari, will serve as the contact PI on this project and work closely with PI Paula Kehoe. As such, Ms. Kothari and Ms. Kehoe will be responsible for overall project management, including oversight of Carollo as the contractor, communication with USBR, and review of the technical progress of the research and ensure that results are applicable to the water community. Ms. Kothari and Ms. Kehoe, in conjunction with Carollo, will monitor the progress of the research through review of semi-annual reports, participation in project calls and face-to-face meetings, and review of all project final deliverables.

The Co-PI for this project, Andrew Salveson, will manage the day-to-day and long-term objectives of this project. That includes the review and guidance of Carollo staff in the performance of their duties and the coordination of subconsultant team members. The project management responsibilities extend to the management of the project budget and the billings. Additionally, Andrew Salveson will meet with the funding parties and the project team during the project. Finally, project management includes quality assurance/quality control, which is a period review of project progress from outside the core project team by experts in the relevant field(s).

Schedule: N/A.

Deliverables: The management team will be available for weekly check-in calls for the duration of the project. Any issues that arise during the management of this project will be documented in quarterly reports.

Purification Facility Design and Construction

For potable water reuse, the project team will select and install a series of advanced processes to purify the Tertiary treatment system effluent and to monitor the water quality online. The proposed technologies to be applied are ultrafiltration (UF), reverse osmosis (RO), ultraviolet light disinfection (UV) with sodium hypochlorite addition to result in an advanced oxidation process (AOP), with a final treatment/storage step using an engineered storage buffer (ESB). Online monitoring includes turbidity, *E. coli*, total organic carbon (TOC), electrical conductivity (EC), total and free chlorine, and ultraviolet transmittance (UVT). These online monitoring parameters will be done by the ZAPs LiquiD, as shown in Table 3 below.

Table 3. Online Monitoring Parameters

Measurement	Post UF	Post RO	Pre UV	Post UV
Chloramines	●		●	●
Free Chlorine	●		●	●
E. coli	●			
TOC	●	●		
UVA			●	●
Turbidity	●			

For this Task, the project team will do the following:

- Select and rent (or purchase) small-scale advanced treatment processes (as listed above), with capacities in the range of 1 to 3 gpm[1].
- Select and purchase online monitoring processes (as listed above).
- Start up the purification and monitoring systems
- Collect and store all online data in a centralized control system, allowing for later analysis.
- Summarize all process, monitoring, and startup procedures in a TM.

Schedule: Selection of equipment, installation of equipment, and startup of equipment would be expected to start within 30 days of the receipt of grant funding and will be completed within 4 months of the notice to proceed.

Deliverables: A TM will be completed in draft form that details the treatment and monitoring processes as well as any details related to operation and startup.

[1] The current plan is to rent UF and RO systems and purchase small UV and ESB treatment systems. For monitoring systems, the project team will need to purchase online monitoring equipment.

Direct Potable Water Reuse Performance Demonstration

To date, no potable water reuse system (indirect or direct), provides a comprehensive real-time monitoring of overall performance. For potable water reuse, the treatment targets include virus, protozoa, bacteria, total organic carbon, salts, and trace level pollutants. This project will build a treatment system that tracks and records performance of each system, and most importantly of the entire system for the removal of pathogens and pollutants. This will be the first real-time "smart" potable water reuse treatment system, operating for 6 consecutive months, which will be used to demonstrate the long term reliability of advanced water purification processes.

To that end, we have broken up the 6-month demonstration into the following work efforts.

Operation. The facility will be run continuously for 6 months. The system will be run automatically, with twice-weekly inspections and calibration of online devices.

Conventional Parameters, PPCPs, Pathogens, and Advanced Analytics. Over the 6-month timeframe, the system will be continuously monitored using the online technologies discussed previously. This online monitoring will be supplemented by three different analytical chemistry approaches, as shown in the bullets and Table 4 below.

- **Conventional Parameters:** TOC (twice monthly), ATP (weekly), turbidity, UVA, total and free chlorine (twice weekly).
- **CECs[2]:** pharmaceuticals and personal care products (PPCPs), perfluorinated compounds (PFCs), NDMA, NDMA FP, THM/HAA FP, and fluorescence EEM, all monthly. This work will be done by (monthly) work will be done by the Dr. Eric Dickenson at the Southern Nevada Water Authority.
- **Pathogens:** male specific and somatic coliphage, enterococci, *E. coli*, total coliform, *Giardia*, *Cryptosporidium*, enterovirus and norovirus. Biological analysis will be done (monthly) by Dr. Rick Danielson at BioVir.
- **Advanced Analytics:** non-target analysis and bioassays. Advanced analytics will be done (monthly) by Dr. Shane Snyder at the University of Arizona.

Table 4. Online Monitoring - Analytical Chemistry Approaches

Measurement	Secondary Effluent	Post UF	Post RO	Post UV	Post ESB
Conventional Parameters		●	●	●	●
CECs	●	●	●	●	●
Pathogens	●				
Advanced Analytics	●	●	●	●	●

Schedule: Testing will be done periodically over a 6 month time period.

Deliverables: Prior to the start of testing, a test protocol will be developed which includes detailed sampling methods, lab testing methods, and quality control. Test results will compiled in the draft report as detailed below.

[2] The CEC list and pathogen list are identical to WaterRF 4536 and WateReuse Research Foundation 14-16, which are both run by this current project team.

Public Communication and Outreach

Outreach efforts will be provided by SFPUC and as an in-kind contribution. SFPUC outreach materials will include web-site information, educational banners at the demonstration facility, handouts, and tour materials. SFPUC will schedule guided tours with the community on a regular basis. In addition, the utility may prepare a web-based education and survey campaign in accordance with the Ways of Water analysis in WateReuse Research Foundation Project 12-06. Project results will be submitted for peer-review publications and conference proceedings.

Schedule: The outreach work would begin prior to the start of testing and run through the completion of the project.

Deliverables: Webcast and final report, survey results, and any other outreach materials will be shared with the funding agencies.

Project Communication and Reporting

The project team will prepare quarterly reports for the duration of this project (one year), one draft report, and one final report. The project team will meet with the funding agencies in person twice and can meet by phone on a monthly basis as needed.

Schedule: Reporting will be done throughout the duration of the project, with quarterly reports done after the first three months of work and done every three months thereafter. An on-site project meeting will occur at the start of the 6 month DPR testing period. One draft report and one final report will be completed after the end of the 6 month demonstration period. Near the completion of the project, one member of the project team will travel to Denver to present the results to Reclamation staff.

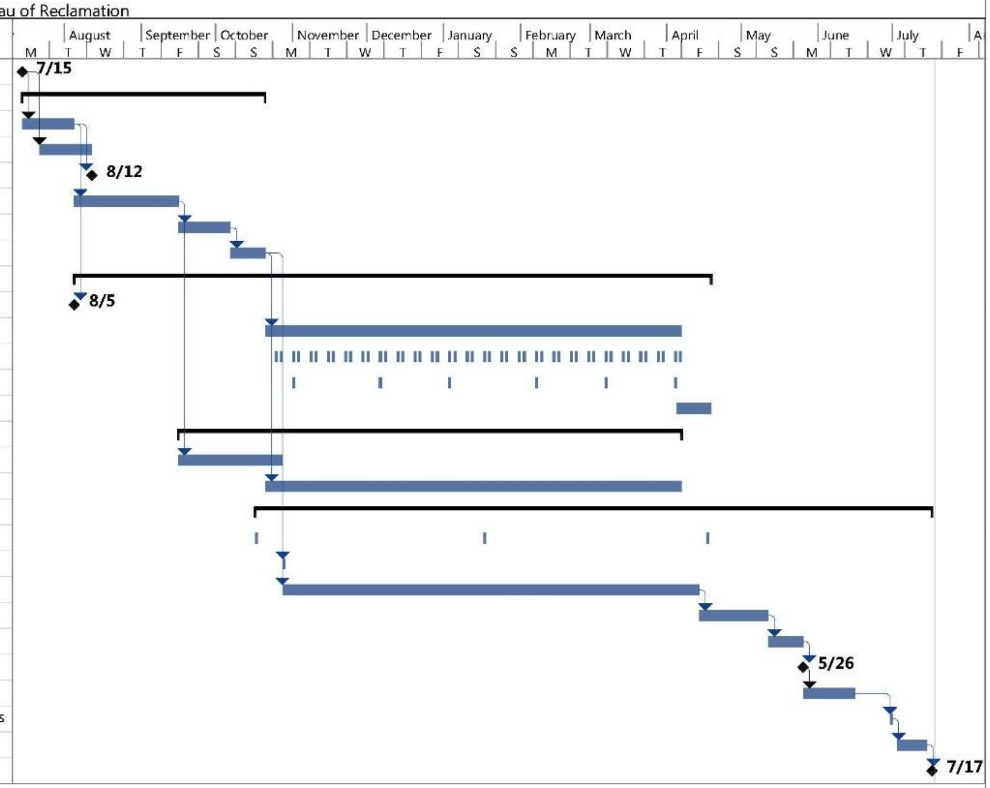
Deliverables: 3 quarterly reports, one draft report, and one final report, one on-site project meeting, and one USBR presentation delivered in Denver.

RESEARCH WORK PLAN AND SCHEDULE

The work to be carried out in the demonstration study is described in task descriptions of the Scope of Work Section. The project schedule, including all major tasks and subtasks, is shown below. The schedule details the elapsed time for the entire pilot testing project. Estimates of equipment delivery dates, pilot construction and commissioning, and dates of all deliverables are included.

US Bureau of Reclamation

ID	Task Name	Duration	Start	Finish	Predecessors
1	USBR Award	0 days	Fri 7/15/16	Fri 7/15/16	
2	**Task 1: Pilot Facility Design and Construction**	**70 days**	**Fri 7/15/16**	**Thu 10/20/16**	
3	Purchase/Rent UF/RO/UVAOP Units	15 days	Fri 7/15/16	Thu 8/4/16	1
4	Site Preparation	15 days	Fri 7/22/16	Thu 8/11/16	1FS+5 days
5	Submit Treatment and Monitoring TM	0 days	Fri 8/12/16	Fri 8/12/16	3
6	Deliver UF/RO/UVAOP to site	30 days	Fri 8/5/16	Thu 9/15/16	3
7	Pilot Installation, Testing, and Commissioning	15 days	Fri 9/16/16	Thu 10/6/16	6
8	Pilot Monitoring/Control Installation, Testing, Commissioning	10 days	Fri 10/7/16	Thu 10/20/16	7
9	**Task 2: Direct Potable Water Reuse Demonstration**	**183 days**	**Fri 8/5/16**	**Tue 4/18/17**	
10	Submit DPR Test Protocol	0 days	Fri 8/5/16	Fri 8/5/16	3
11	DPR Pilot Operation	6 mons	Fri 10/21/16	Thu 4/6/17	8
12	**Pilot Inspection and Calibration**	**118 days**	**Tue 10/25/16**	**Thu 4/6/17**	
61	**Advanced Analytics**	**111 days**	**Tue 11/1/16**	**Tue 4/4/17**	
68	Pilot Decomissioning and Site Clean-up	10 days	Wed 4/5/17	Tue 4/18/17	61
69	**Task 3: Public Outreach**	**145 days**	**Fri 9/16/16**	**Thu 4/6/17**	
70	Install Banners/Distribute Educational Material	30 days	Fri 9/16/16	Thu 10/27/16	6
71	Provide Educational Tours	6 mons	Fri 10/21/16	Thu 4/6/17	8
72	**Task 4: Project Communication and Reporting**	**195 days**	**Mon 10/17/16**	**Mon 7/17/17**	
73	**Prepare and Submit Quarterly Progress Reports**	**131 days**	**Mon 10/17/16**	**Mon 4/17/17**	
77	Onsite Project Meeting	1 day	Fri 10/28/16	Fri 10/28/16	8FS+5 days
78	Compile Pilot Data	6 mons	Fri 10/28/16	Thu 4/13/17	8FS+5 days
79	Prepare Draft Report	20 days	Fri 4/14/17	Thu 5/11/17	78
80	Internal Review of Draft Report	10 days	Fri 5/12/17	Thu 5/25/17	79
81	Submit Draft Report to USBR for Review	0 days	Fri 5/26/17	Fri 5/26/17	80
82	USBR Review of Report	15 days	Fri 5/26/17	Thu 6/15/17	81
83	Presentation to USBR Staff	1 day	Fri 6/30/17	Fri 6/30/17	82FS+10 days
84	Prepare Final Report to USBR	10 days	Mon 7/3/17	Fri 7/14/17	83
85	Submit Final Report to USBR	0 days	Mon 7/17/17	Mon 7/17/17	84



Project: USBR
Date: Tue 2/2/16

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

PROJECT MANAGEMENT

SFPUC will be responsible for overall project management, coordination, and communications with USBR, and facilitation with the research team. Carollo will be the technical leader for this project and will manage it as it manages all of its research projects. Hourly expenditures will be monitored and compared to the percent completion of the tasks.

Quarterly Technical Progress Reports

In accordance with Reclamation requirements, quarterly technical progress reports will be prepared and submitted. It is estimated that up to seven progress reports will be required during the duration of the pilot testing. The reports will be letter-style and will include a summary of the completed activities, activities in progress, and a calculation of the estimated percent of completed work. The quarterly reports will also identify areas where delays have occurred and the reason for the delay, planned activities during the next reporting period, and recommendations to get the project back on schedule and/or budget, if necessary.

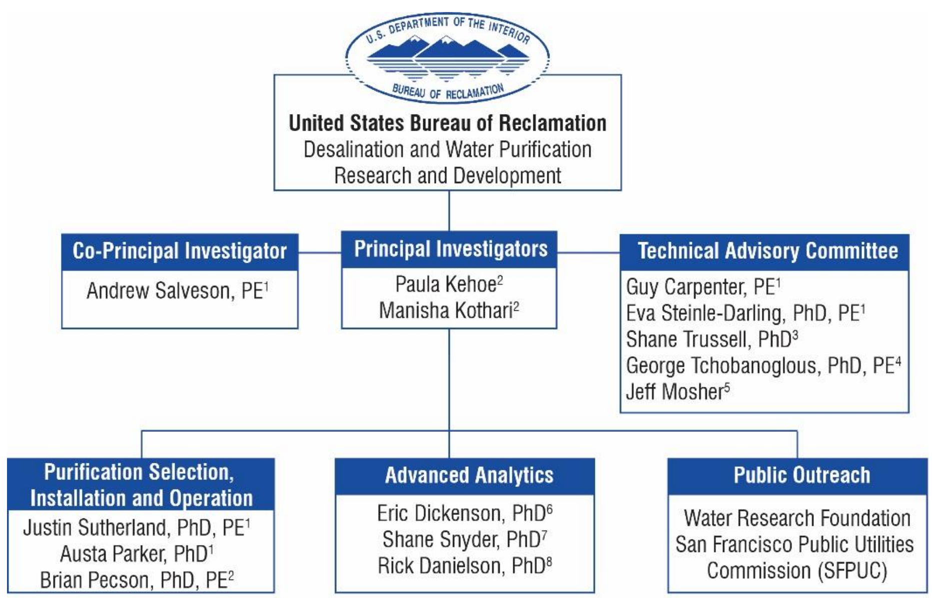
Project Meetings

In accordance with Reclamation requirements, Carollo will participate in one intermediate project meeting. Other team members will attend via webinar. This meeting is anticipated in October 2016 and will be held in Carollo's Walnut Creek, California, office and include a visit to the pilot plant site.

PERSONNEL QUALIFICATIONS

We have assembled a team of professionals experienced in municipal reuse and leading-edge water technology. They offer strength in their core technical specialties and have a proven track-record of delivering projects on time and within budget. Your project will benefit from the diversity of experience and perspective that our team members bring to this effort.

The core project team and its lines of communication are depicted in the organizational chart below. Biographies of key personnel are provided on the next page. Customized resumes are included at the end of this section.



1. Carollo Engineers, Inc.
2. San Francisco Public Utilities Commission
3. Trussell Technologies
4. University of California Davis
5. National Water Research Institute
6. Southern Nevada Water Authority
7. University of Arizona
8. IEH-BioVir Laboratories

Key Team Members

Paula Kehoe – Principal Investigator

Paula Kehoe is the Director of Water Resources for the San Francisco Public Utilities Commission (SFPUC). She is responsible for diversifying San Francisco's local water supply portfolio through the development and implementation of conservation, groundwater, and recycled water programs. Paula spearheaded the landmark legislation allowing for the collection, treatment, and use of alternate water sources for non-potable end uses in buildings and districts within San Francisco.

Manisha Kothari – Principal Investigator

Manisha Kothari is a Project Manager with the Water Resources Division of the San Francisco Public Utilities Commission. Manisha represents the SFPUC in the planning of water reuse projects that the SFPUC is developing through regional partnerships in order to diversify its water supply portfolio and meet future demands. She works with water agencies throughout the Bay Area to evaluate and develop recycled water and desalination opportunities for San Francisco's customers. Manisha has over 10 years of experience managing infrastructure projects from concept to implementation. Manisha has a BA in Political Science and Economics from the University of California, Berkeley and an M.S. from Georgetown University.

Andrew Salveson, PE – Co-Principal Investigator

Andy Salveson has 22 years of environmental consulting experience serving public and private-sector clients in the research and design of water and wastewater treatment systems. He is a nationally recognized expert in water reuse, including IPR and DPR. Mr. Salveson provides guidance and expertise on state-of-the-art technologies on the latest industry issues regarding reuse, as has led numerous planning, design, and research projects, including extensive projects for the WateReuse Research Foundation and Water Research Foundation related to Potable Reuse. Andy was named to a national panel of 7 experts to develop national guidance on Direct Potable Reuse (NWRI Framework for Direct Potable Reuse) and was named to a panel of experts to develop potable water reuse for the World Health Organization. In recognition of his contributions to the industry, Mr. Salveson was honored with the 2007 WateReuse Person of the Year Award for bringing innovative technologies to market.

Justin Sutherland, PhD, PE – Purification Selection, Installation, and Operation

Dr. Justin Sutherland is a member of Carollo's Research Group with 16 years of experience in applied research, bench- and pilot-scale process design and testing. He has extensive experience in water reuse. He served as project manager for Water Research Foundation Project #4536, titled "Blending Requirements for Water from Direct Potable Reuse Treatment Facilities." He also served as Project engineer for the Texas Water Development Board-funded project, "Testing Water Quality in a Municipal Wastewater Effluent Treated to Drinking Water Standards." He was responsible for the review of historical RO performance data and sampling water quality (EDC, pharmaceuticals, etc.) around the MF, RO, and AOP processes at the Direct Potable Reuse Plant and led a pilot scale evaluation of a direct integrity monitor (Nalco's Trasar technology) for potable reuse RO systems.

Austa Parker – Purification Selection, Installation, and Operation

Ms. Parker joined Carollo in early 2014, gaining experience in potable reuse permitting and planning studies, and also providing expertise in advanced oxidation processes. She serves as the Northern California Lead for the Carollo Research Group. Austa is currently serving as staff engineer for WRRF Project #14-16, Operational, Monitoring & Response Data from Unit Processes in Full-Scale Water Treatment, IPR, and DPR.

Eric Dickenson, PhD – Advanced Analytics

Dr. Dickenson serves as R&D project manager for the Southern Nevada Water Authority. His experience includes the fate of emerging contaminants (e.g., EDCs and pharmaceuticals) in natural systems (e.g., aquifer recharge, riverbank filtration) and conventional and advanced engineered systems (e.g., RO, nanofiltration, GAC, ozone, AOP, MBR). Additionally he is experienced in the utilization of state-of-the-art characterization methods for natural and effluent organic matter for water quality characterization and optimization of disinfection processes.

Shane Snyder, PhD – Advanced Analytics

Dr. Snyder is a Professor of Chemical and Environmental Engineering at the University of Arizona. He holds a PhD in Environmental Toxicology and Zoology and a BA in Chemistry. Dr. Snyder is a microconstituents expert who participated in the "Blue Ribbon Panel" for the California Water Resources Control Board to consider Constituents/Contaminants of Emerging Concern in Recycled Water. He is also Co-director of the Arizona Laboratory for Emerging Contaminants, a state-of-the-art analytical facility that identifies and quantifies emerging contaminants, such as pharmaceutical compounds, endocrine disrupting compounds, and nanoparticles.

Rick Danielson, PhD – Advanced Analytics

Dr. Danielson has a broad background in environmental health microbiology including: the development and application of bio-technology (PCR, ELISA, monoclonal antibodies, plasmid analysis, etc.); microbiological risk assessment; environmental virology and parasitology (certified USEPA Principal Analyst for protozoans and viruses); providing information and consultation on agents of bioterrorism; expert testimony in environmental microbial contamination cases; and, the establishment of certified environmental microbiological testing laboratories. He is a lecturer of microbiology at the U.C. Berkeley School of Public Health (1993 to present) and has served on several national public health (US FDA & NMFS, ASTM) and research review committees (WERF, AWWA, Sea Grant, USDA).

Resumes

Resumes of key personnel are shown starting on the next page.

Paula A. Kehoe

525 Golden Gate Ave, 10th Floor San Francisco, CA 94102
(415) 554-0792/pkehoe@sfwater.org

EMPLOYMENT

City and County of San Francisco, Public Utilities Commission ***San Francisco, CA***
Director of Water Resources **May 2004- Present**

- Manage the development of new local water supplies, including groundwater, recycled water, desalinated water and alternate water sources.
- Develop and implement water shortage allocation plans, drought polices, and water shortage measures.
- Prepare ordinances to streamline regulatory pathways to develop new non-potable water supplies to offset potable supplies.
- Lead innovative water strategies, including installing composting toilets in urban areas and treating blackwater to flush toilets in new commercial and multi-family buildings.
- Identify water conservation measures, prepare ordinances and implement tools to reduce and track consumption among residential, commercial and industrial sectors.
- Identify partnerships and negotiate agreements with external governmental and non-governmental agencies to develop and implement new water supply projects.
- Direct long-range water demand studies, integrated water resource plans, groundwater management plans, recycled water plans, desalinated water plans and water efficiency plans.
- Conduct research on public perceptions and acceptance of new water supplies, such as groundwater, recycled water and desalinated water.
- Prepare operations plans to document water system facilities, operating strategies, water quality and permitting requirements.
- Participate in U.S. Department of State, Bureau of International Information Programs, to share technical assistance on Water Management in Brazil, including Sao Paulo, Brasilia, and Rio de Janeiro.
- Prepare water resources management Memorandum of Understanding between San Francisco and Bangalore, India.
- Develop and track performance measures for SFPUC Sustainability Plan.
- Manage staff, produce publications and technical reports, administer contracts and manage $9 million annual budget.

City and County of San Francisco, Public Utilities Commission ***San Francisco, CA***
Chief of Staff and Public Affairs Manager **Oct 1999- May 2004**

- Developed educational programs and served as a liaison with commissioners, elected officials, media and stakeholders to increase awareness of the SFPUC's water system improvements and water resource issues.
- Assisted with the development and public outreach for the SFPUC $3.6 billion capital improvement program designed to rebuild and repair the third largest water delivery system in California.
- Managed the bottling and distribution of Hetch Hetchy Mountain Water™ to promote high quality municipal drinking water.
- Coordinated a strategic management system (Balanced Scorecard) to identify organization goals, objectives, and performance measures specific to water, wastewater, and power operations.
- Directed multifaceted communications and government affairs programs and staff, created coalitions and resolved disputes.
- Produced publications, administered contracts, prepared annual work plans and managed a $400,000 annual budget.

City and County of San Francisco, Public Utilities Commission ***San Francisco, CA***
Pollution Prevention Public Education Director **Dec 1991-Oct 1999**

- Developed and managed water resource programs for the Water Pollution Prevention Program to reduce pollutant loadings to the San Francisco Bay and Pacific Ocean from point and non-point sources.
- Prepared technical reports, including source identification studies, waste minimization plans and influent and effluent mass loading studies.
- Conducted market research, developed marketing strategies and implemented innovative public education campaigns for targeted audiences.
- Developed publications and programs shown to change behaviors among targeted populations.
- Designed and implemented educational outreach programs through public-private partnerships.
- Awarded six state and national awards for excellence in water pollution prevention public education.
- Received grant funding to develop an integrated pest management and green gardening program.
- Obtained significant media coverage on pollution prevention and water conservation issues.
- Assisted with the development of an *Effluent Management Training Course* for the Water Environment Federation and U.S. AID in Cairo and Alexandria, Egypt, March-April 1998

EDUCATION

University of San Francisco, San Francisco, CA
Master of Science, Environmental Management
September 1990-December 1993

University of Colorado, Boulder, CO
Bachelor of Arts Degree, Geography
September 1983-May 1987

PUBLICATIONS

Kehoe, P. *Drought, San Francisco, and Innovation Though Local Water and Alternative Water Projects*, Green Technology Magazine, August 2015.
Kehoe, P., Rhodes, S., Scarpulla, J. *Blueprint for Onsite Water Systems Shifts Traditional Views on Water Use*. Trim Tab The Magazine for Transformative People + Design. February 2015.
Kehoe, P., Rhodes, S., Scarpulla, J. *Moving from Building-scale to District-scale – San Francisco's Non-potable Water Program.* Alternative Water Supply Systems. London. IWA Publishing. 2015.
Elmer, V., Kehoe, P. *The Tricky Business of Onsite Water Treatment and Reuse.* Planning Magazine. American Planning Association. December 2014.
Kehoe, P., Rhodes, S., Scarpulla, J. *San Francisco Takes the Lead in Setting Standards for Onsite Reuse*. Source Magazine. AWWA. Vol 28, No 4. Fall 2014.
Kehoe, P., Rhodes, S. *Innovations for Water in Urban Areas Require Rethinking and Reuse*. ECOHOME Magazine. Winter 2013.
Beck, S., Goel, N., Kehoe, P., Linden, K., Rhodes, S., Rodriguez, R., Salveson, A. *Disinfection Methods for Treating Low TOC, Light Graywater to California Title 22 Water Reuse Standard*. Journal of Environmental Engineering. Volume 139, Issue 9. September 2013.
Kehoe, P., Rhodes, S. *Pushing the Conservation Envelope Through the Use of Alternate Water Sources*. Journal of the American Water Works Association. Vol. 105:2. February 2013.
Kehoe, P., Rhodes, S. *Regulatory Pathway Streamlined for Onsite Non-potable Reuse in San Francisco.* Water Reuse and Desalination. Vol. 3:3. Autumn 2012.
Kehoe, P., O'Rorke, M. *An Educated Approach to Educating the Public.* Wastewater Technology Showcase, Water Environment Federation. 2000.
Kehoe, P., O'Rorke, M. *Targeted Research and Marketing Put Muscle into Pollution Prevention Education Campaigns.* Utility Executive, Water Environment Federation. 2000.
Kehoe, P., O'Rorke, M. *Targeted Research and Marketing Put Muscle into Pollution Prevention Education Campaigns.* Watershed & Wet Weather, Water Environment Federation. 2000.
Mass Loadings of Used Motor Oil and Latex Paints to the Sewerage System. City and County of San Francisco, Department of Public Works, Bureau of Environmental Regulation and Management, Water Pollution Prevention Program, San Francisco, California. 1993.
A Community of Land. Gildea Review. 1988.

PROFESSIONAL ORGANIZATIONS

Alliance for Water Efficiency, Project Advisory Committee Member: *Net Blue Development*, 2015-Present
WaterReuse Research Foundation, Project Subcommittee Member: *A Framework for the Successful Implementation of Onsite Industrial Water Reuse*, 2014- Present
Water Research Foundation, Project Subcommittee Member: *Blending Requirements for Water from Direct Potable Reuse Treatment Facilities*, 2014-Present
One Water Council, U.S. Water Alliance, Committee Member, 2013-Present **California Urban Water Agencies**, Water Reuse Committee Member, 2013-Present **Vision 2020, ECOHOME, Hanley Wood,** Water Efficiency Chair, 2013
Water Research Foundation, Project Subcommittee Member: *Institutional Issues for Green-Grey Infrastructure based on integrated "OneWater" Management and Resource Recovery*, 2013- 2015
WateReuse Foundation, Project Advisory Committee Member: *Evaluating Long and Short Term Planning Under Climate Change Scenarios to Better Assess the Role of Water Reuse*, 2009-2012
Water Environment Federation, member, Public Education Committee 2006- 2012
WateReuse Foundation, Project Advisory Committee Member: *Talking About Water: Vocabulary and Images that Support Informed Decisions about Water Recycling and Desalination*, 2008-2011
WateReuse Foundation, Project Advisory Committee Member: *Feasibility Study of Offshore Desalination Plants*, 2007-2010
Bay Area Clean Water Agencies, Chair**,** Water Recycling Committee, 2005-2009
American Water Works Association, Vice Chair, Water Resources Planning & Management Committee, 2006-2007
Water Environment Research Foundation, Member, Peer Review Committee for WERF Project: *Communicating Risks with Your Local Government and Community,* 2004-2006

MANISHA KOTHARI

525 Golden Gate Avenue, 10th Floor, San Francisco, CA, 94102
Tel: (415) 554-3256 (direct); E-mail: mkothari@sfwater.org

PROFESSIONAL EXPERIENCE

Project Manager
San Francisco, CA

5602 Utility Specialist
2007-Present

5620 Regulatory Specialist
2006-2007

San Francisco Public Utilities Commission (www.sfwater.org), *a department of the City and County of San Francisco that provides water and wastewater services in San Francisco; wholesale water to three Bay Area counties; and green hydroelectric and solar power to San Francisco's municipal departments*

Key responsibilities and achievements include:

- Manage project planning, environmental review, design and implementation activities for complex capital improvement projects in the areas of recycled water, desalination and potable reuse
- Manage water supply planning effort for the evaluation of key decisions affecting the SFPUC's post-2018 supply obligations (WaterMAP)
- Deliver project milestones on-time and within budget, including the successful implementation of the SFPUC's first two recycled water projects
- Initiate, build and manage long-term regional partnerships with other water and wastewater service providers in the Bay Area to develop strategic, collaborative, cost-effective water supplies
- Lead public outreach efforts working with environmental groups, schools, local communities and regulatory agencies on behalf of multiple agencies to evaluate the potential for regional desalination and recycled water projects
- Prepare and manage project reporting of the alternative local water supply portfolio
- Secured over $6 million in grant funds to support water supply projects
- Successfully advanced projects that faced significant challenges from various groups through effective education and public outreach campaigns

Sr Environmental Planner
2002-2006

URS Corporation (now part of AECOM **www.aecom.com),** *a global environmental and engineering consulting firm with expertise in the planning, assessment, design, and implementation of projects in over 65 countries worldwide*

Key responsibilities and achievements include:

- Managed the environmental review, including stakeholder engagement and public outreach activities, for California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) compliance for various public and private capital projects in water, wetland restoration, natural resource development and transportation
- Assisted with the development of corporate policies and initiatives for U.S. companies working in developing countries to address environmental justice and labor concerns

- Prepared and won several competitive project and grant proposals
- Contributed to the development of strategic business plans, identifying key growth areas and opportunities with the U.S. federal government and in Asia

Program Manager, Asia **U.S. Trade and Development Agency (USTDA) (www.ustda.gov),**
a foreign assistance agency of the U.S. federal government that grants seed capital for priority infrastructure projects in low and middle-income countries, while promoting job creation in the United States

Key responsibilities and achievements included:

- Managed grant program for South and Southeast Asian countries, supporting the development of infrastructure in sectors including, banking, technology, transportation, environment, telecommunications, energy, and security
- Worked with the U.S. Departments of State and Commerce to re-engage political discourse on the subjects of human rights and nuclear non-proliferation through new trade initiatives in China, India and Pakistan
- Reviewed, assessed, and successfully recommended over 100 projects for federal grant assistance
- Worked with U.S. companies to ensure compliance with U.S. laws and policies, and the promotion of U.S. goods and services while working overseas
- Partnered with U.S. government agencies (including the Department of Commerce, OPIC, Ex-Im Bank, the FAA, DOE, and USAID), multilateral development banks (Asian Development Bank and World Bank) and other regional players to structure and implement projects
- Monitored performance of past investments and the associated impact on U.S. jobs and exports for annual Congressional and agency reports and to develop regional strategic priorities for the future
- Planned and executed roundtable discussions, conferences and study tours for Asian project sponsors
- Drafted marketing materials, public information briefs, presidential and congressional briefs, and press releases

EDUCATION

Georgetown University *Washington, DC*
Master of Science in Foreign Service (International/Public Policy) **1998**
Landeggar Program in International Business-Government Relations

University of California, Berkeley *Berkeley, CA*
Bachelor of Arts, *cum laude*, in Political Science **1996**
Bachelor of Arts in Mass Communications **1996**
Semester-long internship with the ***United Nations High Commissioner for Refugees (UNHCR)***
(Political Communications position at headquarters in Geneva, Switzerland) 1995

LANGUAGE SKILLS

Languages: Native speaker of ***English***, ***Hindi***; fluent in ***Thai***; working knowledge of ***French***

Andrew T. Salveson

Education

MS Water and Wastewater Engineering, University of California, Davis, 1994

BS Civil Engineering, San Jose State University, San Jose, California, 1993

Licenses

Civil Engineer, California

Professional Engineer, Texas

Professional Affiliations

International UV Association

Water Environment Foundation

Expert Services

Contributing Author, MOP 8, Design of Municipal Wastewater Treatment Plants

Editor of Reuse Treatment, EPA's 2012 Guidelines for Water Reuse

Contributing Author, National Water Research Institute, 2012 UV Guidelines

Contributing Author, National Water Research Institute DPR Framework

Contributing Author, World Health Institute Potable Water Reuse Guidelines

Mr. Salveson has 21 years of environmental consulting experience serving public and private-sector clients in the research and design of water and wastewater treatment systems. He is a nationally recognized expert in water reuse and disinfection. Mr. Salveson provides guidance and expertise on state-of-the-art technologies on the latest industry issues regarding reuse, as has led numerous planning, design, and research projects for various organizations, utilities, and corporations. In recognition of his contributions to the industry, Mr. Salveson was honored with the 2007 WateReuse Person of the Year Award for bringing innovative technologies to market.

Predesign/Design/Planning/ Permitting

- Project manager for the analysis of indirect and direct potable reuse feasibility for the Encina Wastewater Authority.

- Project manager for the analysis of indirect potable reuse treatment technologies for the Water Replenishment District, with Carollo as a subconsultant to CH2M HILL.

- Process engineer for the 30% design of MBR, UF, Ozone, UV, and chlorination membrane and UV disinfection for water reuse for the Barwon Water of Victoria Australia (Carollo teamed with SKM).

- Project manager for the potable reuse feasibility analysis for the Santa Clara Valley Water District, San Jose, California. Work includes expert services related to regulations, treatment, and the creation of a feasibility report for potable reuse.

- Project manager for the preliminary design of a microfiltration (MF)/reverse osmosis (RO)/advanced oxidization process (AOP) for streamflow augmentation with reclaimed water for the Southwest Florida Water Management District, Florida.

- Process advisor for the research and design of advanced membrane and carbon treatment technologies for the Synderville Basin Water Reclamation District, Utah.

- Technical assistance for the Santa Clara Valley Water District, California, Potable Reuse Grant Funding Program.

- Project manager for the City of Los Angeles Bureau of Sanitation for the analysis of alternative advanced oxidation technologies for potable reuse and subsequent permitting with the DDW for those technologies.

- Project engineer for the permitting of IPR for the City of Oxnard, California.

- Technical specialist for the IPR Design/Build for the City of Los Angeles Terminal Island Water Purification Facility.

Testing and Research

- Co-principal Investigator for the 2013 Texas Water Development Board Priority Research Topic Study, "Testing Water Quality in a Municipal Wastewater Effluent Treated to Drinking Water Standards." This study will develop and implement a detailed testing protocol at the Colorado River Municipal Water District's Raw Water Production Facility (RWPF) at Big Spring. This advanced treatment facility constitutes the nation's first instance of direct potable reuse (DPR). The project will also develop monitoring guidelines, based on in-depth parallel study of pathogens, chemicals, and appropriate surrogates, for use at DPR facilities like RWPF and others across the nation. The WateReuse Research Foundation has increased the depth and breadth of this work through their tailored collaboration process.

- Principal investigator for Water Research Foundation Project 4536, Blending Requirements for Water from Direct Potable Reuse Treatment Facilities. This project examines the pathogens, pollutants, and subsequent water quality impacts to drinking water quality due to blending reclaimed water with other raw water supplies.

- Principal investigator for the WERF project CEC4R08, examining the most cost efficient method to reduce microconstituents. The project includes investigations of the secondary treatment process and comparisons with various tertiary methods to destroy microconstituents.

- Principal investigator for the WateReuse Research Foundation WERF Project 12-06, "Guidelines for Engineered Storage for Direct Potable Reuse" Work includes an evaluation of how to integrate Engineered Storage treatment and monitoring into Direct Potable Reuse Treatment trains.

- Principal investigator for the WateReuse Research Foundation Project 10-06, "Challenge Projects on Low Energy Treatment Schemes for Water Reuse" Work includes an evaluation of emerging treatment technologies for low energy treatment for water reuse.

- Co-principal investigator for the WERF project ENER4R12 – Low Energy Alternatives for Activated Sludge, Advancing AnMBR Research, Work includes the design and construction of three AnMBR treatment trains utilizing flat sheet, hollow fiber, and ceramic membranes.

- Co-principal investigator for the WateReuse Foundation's 11-02 "Equivalency of Advanced Treatment Trains for Potable Reuse). Work includes the search for lower energy and lower cost treatment technologies that meet the public health objectives for potable water reuse.

- Project manager for the treatment and analysis of Clean Water Services (Oregon) Direct Potable Reuse Demonstration Facility.

- Principal investigator for the WateReuse Foundation Project 10-10, "Filtration and Disinfection Compliance through Soil Aquifer Treatment." Work included detailed water quality monitoring pre and post SAT to prove treatment to Title 22 Standards.

- Principal investigator for the WateReuse Foundation Project 11-10, "Evaluation of Risk Reduction Principles for Direct Potable Reuse." This important project is examining the methods to modify our current approach to IPR design and operation for direct potable reuse systems.

- Project manager for the WateReuse Foundation's 06-019 "Monitoring for Microcontaminants in an Advanced Wastewater Treatment (AWT) Facility and Modeling Discharge of Reclaimed Water to Surface Canals for Indirect Potable Use " study. Work includes detailed trace organic (EDC, etc.) analysis and in-vivo and in-vitro bioassays to determine hormonal impact, as well as surface water modeling to track fate and transport of trace organics.

- Co-principle investigator for the Australian Water Quality Center of Excellence Pasteurization Demonstration in Melbourne, Australia.

- Co-principal investigator for the WateReuse Foundation's 02-009 "Innovative Treatments for Reclaimed Water" study. Work includes detailed pathogen and micropollutant analysis and the investigation of innovative, but market ready, advanced oxidation technologies.

- Lead investigator for the performance evaluation of pasteurization for reclaimed water disinfection, a sustainable approach to harnessing waste energy for reclaimed water disinfection. Work resulted in the approval of pasteurization by the State of California for wastewater reuse. Demonstration testing has been completed at Santa Rosa, Ventura, and Graton, California.

- Project manager for the research and analysis of a microfiltration, reverse osmosis, and UV disinfection use for the potable reuse of wastewater at Dublin San Ramon Services District, California. The analysis addressed NDMA, standard DBPs, and endocrine disrupting compounds. This project received the 1999 California Water Environment Association Research Achievement Award.

- Technical advisor for the SFWMD to evaluate secondary and tertiary processes for microcontaminant removal and disinfection for 100+ mgd of wastewater to be potentially supplied to the Biscayne Bay as part of the Comprehensive Everglades Restoration Project (CERP). The investigation addresses advanced oxidation for microcontaminant destruction and examines standard compounds with drinking water MCLs, as well as numerous research-level compounds.

- Co-principal investigator for the WateReuse Foundation's 03-001 "Pathogen Removal and Inactivation in Reclamation Plants" study, which investigated the ability of various disinfectants to reduce pathogens of concern.

Shane A. Snyder Ph.D.

Professor of Chemical and Environmental Engineering

snyders2@email.arizona.edu

(520) 621-2573

Education

1994-2000 | **Michigan State University, East Lansing, Michigan** – Ph.D. Environ. Toxicology/Zoology
1990-1994 | **Thiel College, Greenville, Pennsylvania** – B.A. Chemistry (*Magna Cum Laude*)

Employment

2010-Present | **University of Arizona – Professor of Chemical and Environmental Engineering.**
2010-Present | **Arizona Laboratory for Emerging Contaminants (ALEC) – Co-Director.**
2013-Present | **Water & Energy Sustainable Technology Center (WEST) – Co-Director.**
2000-2010 | **Research and Development – Project Manager.** Southern Nevada Water Authority, Las Vegas, Nevada. Develop an
1998–Present | **Owner/Consultant.** Total Environmental Solutions Inc., Boulder City, Nevada.

Relevant Research Projects

2015 | **CoPI - WateReuse Research Foundation:** "Advancing the Potential for Direct Potable Reuse through Novel Sensor Systems and Effective Decision Tools" Project 14-01
2014 | **CoPI - Water Research Foundation**: "Assessment of Techniques to Evaluate and Demonstrate the Safety of Water from Direct Potable Reuse Treatment Facilities"
2014 | **CoPI – WateReuse Research Foundation:** "Integrating Sensor Data for Real-Time Decision Management" (Project# 14-01)
2013 | **PI – CARD Technologies**: "Chemical Contaminant Attenuation with Catalytic Activated Carbon"
2012 | **PI – Suez Environment:** "Advanced Treatment Technologies for RO/NF Brine Streams"
2012 | **PI – PWN Technologies:** "Mutagenic Nitrogenous Compounds from UV and Nitrate Treatment"
2010 | **PI - WateReuse Research Foundation:** "Use of UV and Fluorescence Spectra as Surrogate Measures for Contaminant Oxidation and Disinfection in the Ozone/H2O2 Advanced Oxidation Process"
2010 | **Principal Investigator – Water Sustainability Program (University of Arizona):** "Parallel Evaluation of Ozone and UV Advanced Oxidation for Reducing Toxicity in Reclaimed Water"
2009 | **PI - WateReuse Research Foundation: "**Use of Ozone in Water Reclamation for Contaminant Oxidation"

Recent Synergistic Efforts

2011-2016 | **Visiting Professor.** National University of Singapore.
2014-Present | **World Health Organization.** Drinking water advisory panel.
2014-Present | **Co-Editor in Chief.** *Chemosphere* (Impact Factor 3.6)
2012-Present | **US EPA Science Advisory Board** Drinking Water Committee member.
2008-2011 | **National Research Council**: Member of Water Reuse expert panel
2008-2013 | **WateReuse Research Foundation:** Research Advisory Council (RAC) member

Recent Publications (from Google Scholar November 2014: h-index = 48; times cited = 9752)

2015 | Anumol T and **Snyder SA**. *Rapid Analysis of Trace Organic Compounds in Water by Automated Online Solid-Phase Extraction Coupled to Liquid Chromatography-Tandem Mass Spectrometry*. Talanta. **132**:77-86.

2014 | Sgroi M, Roccaro P, Oelker GL, **Snyder SA**. *N-Nitrosodimethylamine Formation upon Ozonation and Identification of Precursors Source in a Municipal Wastewater Treatment Plant.* Environmental Science & Technology 48(17):10308-10315.

2013 | Drewes JE, Anderson P, Denslow N, Olivieri A, Schlenk D, **Snyder SA**, and K.A. Maruya. *Designing monitoring programs for chemicals of emerging concern in potable reuse - what to include and what not to include?* Water Science and Technology. **67**(2): 433-439.

2014 | **Snyder SA**. *Emerging Chemical Contaminants: Looking for Better Harmony*. Journal of the American Water Works Association. **106**(8):38-52.

2014 | Escher BI, et al. *Benchmarking Organic Micropollutants in Wastewater, Recycled Water and Drinking Water with In Vitro Bioassays*. Environ. Sci. Technol. **48**(3):1940-1956.

2013 Merel S, Walker D, Chicana R, **Snyder SA**, Baurès E, Thomas O. *State of knowledge and concerns on cyanobacterial blooms and cyanotoxins*. Environment International **59**:303-327.

2012 Bull RJ, Kolisetty N, Zhang XL, Muralidhara S, Quinones, Lim KY, Guo ZX, Cotruvo JA, Fisher JW, Yang XX, Delker D, **Snyder SA**, Cummings BS. *Absorption and disposition of bromate in F344 rats*. Toxicology. **300** (1-2):83-91.

2012 Pisarenko AN, Stanford BD, Yan DX, Gerrity D, **Snyder SA**. *Effects of ozone and ozone/peroxide on trace organic contaminants and NDMA in drinking water and water reuse applications.* Water Research. **46**(2):316-326.

2012 Mawhinney DB, Vanderford BJ, **Snyder SA**. Transformation of 1H-Benzotriazole by Ozone in Aqueous Solution. Environmental Science & Technology. 46(13):7102-7111.

2012 Pisarenko AN, Stanford BD, Yan DX, Gerrity D, **Snyder SA**. Effects of ozone and ozone/peroxide on trace organic contaminants and NDMA in drinking water and water reuse applications. Water Research. 46(2):316-326.

2011 Stanford BD, Pisarenko AN, Holbrook RD, **Snyder SA**. Preozonation Effects on the Reduction of Reverse Osmosis Membrane Fouling in Water Reuse. Ozone: Science & Engineering. 33(5):379-388.

2011 Gerrity D and **Snyder SA**. Review of Ozone for Water Reuse Applications: Toxicity, Regulations, and Trace Organic Contaminant Oxidation. Ozone Science and Engineering. 33:253-266.

2011 Sarp S, Stanford B, **Snyder SA**, Cho J. Ozone oxidation of desalinated seawater, with respect to optimized control of boron and bromate. Desalination and Water Treatment. 27:308-312.

2011 Dickenson ERV, **Snyder SA**, Sedlak DL, Drewes JE. Indicator Compounds for Assessment of Wastewater Effluent Contributions to Flow and Water Quality. Water Research 45:1199-1212.

2009 Dickenson ERV, Drewes JE, Sedlak DL, Wert EC, **Snyder SA**. Applying Surrogates and Indicators to Assess Removal Efficiency of Trace Organic Chemicals during Chemical Oxidation of Wastewaters. Environmental Science & Technology 43(16):6242-6247.

2009 Wert EC, Rosario FL, **Snyder SA**. Effect of Ozone Exposure on the Oxidation of Trace Organic Contaminants in Water. Water Research. 43:1005-1014.

2009 Wert EC, Rosario FL, **Snyder SA**. Using UV Absorbance and Color to Assess Pharmaceutical Oxidation during Ozonation of Wastewater. Environmental Science & Technology. 43(13):4858-4863.

2008 Ikehata K, El-Din MG, **Snyder SA**. Ozonation and Advanced Oxidation Treatment of Emerging Organic Pollutants in Water and Wastewater. Ozone Science & Engineering. 30(1):21-26.

2008 Rosario-Ortiz FL, Mezyk SP, Doud DFR, Wert EC, **Snyder SA**. Effect of Ozone Oxidation on the Molecular and Kinetic Properties of Effluent Organic Matter. Journal of Applied Oxidation Technologies. 11(3):529-535

2007 Lei H and **Snyder SA**. 3D QSPR models for the removal of trace organic contaminants by ozone and free chlorine. Water Research 41:3271-3280

2007 Wert EC, Rosario-Ortiz FL, Drury DD**, Snyder SA**. Formation of Oxidation Byproducts from Ozonation of Wastewater. Water Research. 41:1481-1490

2006 **Snyder SA**, Wert EC, Rexing DJ, Zegers RE, Drury DD. Ozone Oxidation of Endocrine Disruptors and Pharmaceuticals in Surface Water and Wastewater. Ozone Science & Engineering. 28:445-460

FACILITIES AND EQUIPMENT INFORMATION

The treatment equipment, monitoring equipment, and facility information are documented throughout this proposal. The exact site of the advanced purification facilities within the SFPUC Headquarters Building has yet to be determined.

APPLICANT EXPERIENCE AND PAST PERFORMANCE

Clean Water Services, Oregon – 2550 SW Hillsboro Highway, Hillsboro, OR 97123

High Purity Water Project – Direct Potable Reuse Demonstration Facility

Client Reference

Mr. Rick Shanley, PE
Engineering Division Manager
Ph: 503-547-8178

Completion Date: April 2015

Clean Water Services (CWS) produces a high quality wastewater effluent that can be recycled. Advanced water treatment technologies make it feasible to treat water to any level. To demonstrate this potential, CWS conducted a demonstration project to purify municipal secondary effluent to various levels sufficient for use in a variety of purposes, including semiconductor processing, agriculture and food crops, product manufacturing, and human consumption. CWS is interested in demonstrating to the public that advanced treatment of wastewater can be a viable source of water supply. Regulatory challenges had to be overcome, as the Oregon regulations (from the Oregon Department of Environmental Quality (ODEQ) specifically did not allow potable water reuse.

Carollo worked closely with CWS staff in the process design, installing ultrafiltration, reverse osmosis, ultraviolet light advanced oxidation process, and granular activated carbon as the purification steps. These technologies provided robust pathogen and pollutant treatment through multiple barriers. These processes were used in series to purify disinfected secondary effluent from CWS's Forest Grove Facility (FGF). The testing demonstrated that the FGF effluent, when treated with UF, RO, and UV AOP, provides a very high quality water that is absent of trace pollutants and pathogens. As a result, a purified water suitable for potable use and public consumption was confirmed, and a single use DPR permit was obtained from ODEQ.

City of Ventura, California – 501 Poli Street, Ventura, CA 93001

Direct Potable Reuse Demonstration Study

Client Reference

Ms. Shana Epstein
General Manager
Ph: 805-652-4518

Completion Date: April 2016

The primary purpose of the demonstration facility is to document the high quality of purified reclaimed water through extensive water quality testing and to understand the impact of blending this purified water with the conventional finished potable water. A secondary purpose of the demonstration facility is to provide an educational opportunity for the community, including Ventura Water and City of Ventura staff, the general public, and for local regulators.

The VenturaWaterPure demonstration facility was designed to have multiple barriers for both pathogens and trace pollutants in excess of the treatment required for indirect potable reuse (IPR) via groundwater injection. The ~20 gallon-gpm process train takes undisinfected filtered secondary effluent from the Ventura Water Reclamation Facility and provides treatment through pasteurization, ultrafiltration, reverse osmosis, and an ultraviolet light advanced oxidation process. For a future DPR facility, granular activated carbon (GAC) may be added after RO for an additional barrier to trace pollutants and an engineered storage buffer (ESB) would be added to the treatment train after the UV AOP to allow for appropriate system monitoring and water quality assurance.

The VenturaWaterPure direct potable reuse (DPR) demonstration facility represents the combined efforts of Ventura Water, the City of Ventura, Carollo Engineers, and members of the Water Research Foundation Project 4536 team.

Colorado River Municipal Water District in Big Spring, Texas – PO Box 13231, Austin, TX 78711 - High Purity Water Project – Direct Potable Reuse Demonstration Facility Evaluation

Client Reference

Ms. Erika Mancha, Team Lead
Innovative Water Technologies
Texas Water Development Board
Ph: 512-463-7932

Completion Date: May 2016

A team led by Carollo was selected by the Texas Water Development Board to perform a comprehensive evaluation and monitoring study of the Raw Water Production Facility in Big Spring, TX, the country's first direct potable reuse facility

A team led by Carollo was selected by the Texas Water Development Board to perform a comprehensive evaluation and monitoring study of the Raw Water Production Facility in Big Spring, TX, the country's first direct potable reuse facility. An overarching goal of the study was to determine the efficacy and reliability of DPR treatment for implementation across the State of Texas, and ultimately support the development of DPR projects across the nation. Our study includes:

- A comprehensive and independent evaluation of the Big Spring DPR process (MF, RO, UV AOP), including analysis of each treatment barrier, determination of pathogen and pollutant removal and the use of surrogate parameters for performance demonstration.
- Development and implementation of a detailed testing protocol that included direct measurement of pathogens (virus, protozoa, and bacteria) and trace chemicals (pharmaceuticals and personal care products, hormones, flame retardants, and others) as well as a number of indicator and surrogate measurements that could be used to monitor treatment performance.
- A guidance document that recommends monitoring approaches for DPR.

Additional research was funded by the WateReuse Research Foundation to extend the depth and breadth of the analysis. Leading edge research was completed, including the use of fluorescent dyes to provide greater accuracy and precision for pathogen removal by RO.

To support development of a robust monitoring approach that is practicable for utilities of various sizes and financial means, our testing protocol included measurement of less costly surrogates wherever possible to complement the testing for primary parameters, and defined correlations between primary parameters and surrogates.

The results shown an extremely high quality water produced from this facility and serves to support broad acceptance of DPR in Texas.

WORK CURRENTLY SPONSORED BY OTHERS

This work has not been presented for funding elsewhere.

ENVIRONMENTAL IMPACT

The demonstration facility will be sited within the SFPUC Headquarters building, and therefore will not require an environmental impact documentation. The pilot system will be aesthetically contained and secured within the building. Public outreach banners and educational material will be posted around the system. Raw wastewater will be pumped from an existing sewer, treated, and returned to the same sewer along with all other waste streams generated from the pilot.

DISMANTLING PLANS

Upon completion of the pilot study, the dismantling of the pilot equipment will be undertaken by Carollo and SFPUC staff. The advanced purification process units will be decommissioned by the manufacturer's representative and removed from the site. All other miscellaneous equipment such as pumps, electrical equipment, etc. will be donated to Reclamation or other participating agencies. If these latter items are not desired by participating agencies, then Carollo may reuse or scrap the equipment.

OTHER INFORMATION

Technical References

Technical references will be provided upon request.

BUDGET NARRATIVE

The project team is proposing to complete this project in 1 year. We estimate that $200,000 of the Bureau share of the project will be expended in the first few months to rent and install the advanced purification facilities. Cash funds of **$200,000** from SFPUC will be distribution to the project team. Substantial in-kind funding totaling **$82,530** for this project is detailed in the Funding Plan and Letters of Commitment Section.

PRIMARY CONTRACTOR BUDGET JUSTIFICATION – CAROLLO ENGINEERS

Salaries and Wages (Total: $74,385)

Salary rates for the Carollo employees (Andrew Salveson and with support staff [word processing/graphics]) are established in conjunction with their employer, Carollo Engineers, Inc. (Carollo). Indirect costs of 126% are included in the hourly rates budget for each of Carollo employees. A 0% wage increase has been incorporated for each staff person for each year of the project.

Fringe Benefits (Total $37,193)

Fringe benefits at Carollo are provisional rates used for billing purposes, and include the following categories: Employer Taxes, Unemployment Insurance, Workers Compensation, Paid Time Off, Sick Time, Holiday Pay, Group Insurance, 401K Matching, incentive, and Allocated Group Insurance. For Carollo personnel, fringe benefits are 50% of direct labor.

Equipment Rental and Sample Shipping ($125,250)

SFPUC requires the rental of advanced treatment equipment, totaling $125,250. The funds for this equipment will be covered by USBR and SFPUC. The itemized list of pilot equipment costs are as follows:

Component	Vendor	Description	Rental/ Purchase	Unit	Unit Cost	Duration/ #Units	Subtotal
MF/UF	GE	3 gpm skid with membranes	R	$/ Month	$2,500.00	5	$26,000.00
		First Month, includes shipping and startup	P	$	$6,250.00	1	
		Last Month, includes de-mob and shipping	P	$/day	$6,250.00	1	
		Replacement Membranes	P	$	$1,000.00	1	
RO	GE	3 gpm skid with membranes	R	$/ Month	$2,500.00	5	$26,000.00
		First Month, includes shipping and startup	P	$	$6,250.00	1	
		Last Month, includes de-mob and shipping	P	$/day	$6,250.00	1	
		Replacement Membranes	P	$	$1,000.00	1	
ESB	TBD	Tankage and Valving	P	$	$750.00	3	$2,750.00
		Shipping	P	$	$500.00	1	

Component	Vendor	Description	Rental/ Purchase	Unit	Unit Cost	Duration/ #Units	Subtotal
UV	Trojan	1 gpm unit	P	$	$1,500.00	2	$7,500.00
		Shipping	P	$	$500.00	1	
		Oxidant Tankage and Pumping	P	$	$2,000.00	1	
		Sensors	P	$	$1,000.00	2	
Flow Meter	TBD		P	$	$3,000.00	2	$6,000.00
Piping	TBD		P	$	$ 2,000.00	1	$2,000.00
Analyzers	ZAPs	(turbidity, TOC, e. coli, UVA, total and free chlorine)	R-6 month	$			$51,000.00
EC	TBD		P	$	$ 2,000.00	2	$4,000.00
						Total	**$125,250.00**

Materials and Supplies ($62,000)

No materials, other than listed above, are expected as part of this proposal for Carollo portion of work. However, site preparation and dismantling, public outreach, miscellaneous supplies, and project management, is estimated to cost approximately $62,000. These funds, documented in their Letter of Commitment, will be contributed by SFPUC.

Travels ($0)

Travel for the proposed project will be limited to local vehicular travel to and from the test site, as well as one trip to Reclamation in Denver by the Project Manager to make a presentation of the final report. Travel will be covered as an in-kind contribution from Carollo.

Subcontract ($88,860)

Carollo will enter into a subcontract with three entities. The subcontracts include Southern Nevada Water Authority (SNWA) for $39,420, BioVir for $13,440, and University of Arizona for $36,000.

See below (Subcontractor Budget Justification) for a detailed description of these costs.

Other Direct Costs ($1,000)

Other direct costs include sample shipping during the demonstration. These costs are estimated at $1,000.

Indirect Costs ($93,725)

As noted earlier, 126% indirect costs for non-federal researcher salaries have been included in the Salaries and Wages budget estimate, as these costs are more accurately described for this project as Direct Costs incurred by Carollo.

CONTRACTUAL BUDGET JUSTIFICATION

Contractual work will include all advanced analytics. Southern Nevada Water Authority (SNWA) will perform all CEC analysis. BioVir will perform all pathogen analysis. The University of Arizona will perform all bioassays and non-target analysis testing. The itemized costs of each test and the contract subtotals are presented in the table below.

	Total Samples	$/Sample	Total $
SNWA Scope			
PPCPs	24	500	12,000
PFCs	24	500	12,000
NDMA	18	250	4,500
NDMA FP	18	350	6,300
THM/HAA FP	18	200	3,600
TOC	18	30	540
Fluorescence	24	20	480
		SNWA Subtotal	***39,420***
BioVir - Pathogen Analysis			
Male Specific Phage & Somatic Phage	6	125	750
Enterococci	6	60	360
E. coli	6	55	330
Total Coliform	6	Inc.	
Giardia/Cryptosporidium	6	350	2,100
Enterovirus and Norovirus	6	1,650	9,900
		BioVir Subtotal	***13,440***
University of Arizona Scope			
Bioassay Suite	24	500	12,000
GC-NTA	24	400	9,600
LC-NTA	24	600	14,400
		University of Arizona Subtotal	36,000
		Total Cost	**88,860**

TOTAL COSTS

The Total Project Cost is shown in the Table on the following page. Total Costs are **$482,413**.

FUNDING PLAN AND LETTERS OF COMMITMENT

This funding plan includes all anticipated project costs as $482,413. The Reclamation share of the cost will be $200,000 and the remaining funds ($282,413) will be provided by the project team members, in the form of both in-kind and monetary contributions. As shown, recipient funding accounts for 59 percent of the project total. Letters of commitment from SFPUC, and Carollo are provided on the following pages.

Funding Sources	Funding Amount	Cost Share (%)
Non-Federal Entities		
SFPUC, cash	$200,000	41
SFPUC, in-kind	$62,000	13
Carollo, in-kind	$20,530	4
Non-Federal Subtotal:	**$282,530**	**59**
Other Federal Entities - None		
Requested Reclamation Funding:	$200,000	41
Total Project Funding:	**$482,530**	**100**

San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission

525 Golden Gate Avenue, 13th Floor
San Francisco, CA 94102
T 415.554.3155
F 415.554.3161
TTY 415.554.3488

February 5, 2016

Attn: Ms. Janeen Koza
Bureau of Reclamation
Mail Code: 84-27852
Denver Federal Center, Bldg. 67, Rm. 152
6th Avenue and Kipling Street
Denver, CO 80225

Electronic Submittal via www.grants.gov

Building-Scale Treatment for Direct Potable Water Reuse & Intelligent Control for Real Time Performance Monitoring

Dear Ms. Koza:

The San Francisco Public Utilities Commission (SFPUC) is pleased to submit this application for a pilot demonstration for water purification research in response to the Bureau of Reclamation's Funding Opportunity Announcement No. R16-FOA-DO-010. As a wholesale and retail water provider serving over 2.6 million people, the SFPUC is committed to the responsible and sustainable use of water. We recognize that the development and application of technologies that improve the efficiency and quality of water reuse play a key role in meeting this commitment.

In an effort to continue to advance our water sustainability goals, we have put together a team of water treatment and public health experts to develop a building-scale direct potable water reuse (DPR) treatment facility. This new purification facility will take tertiary recycled water from an existing non-potable water system at our headquarters in San Francisco and treat it to potable water standards. This demonstration project will fulfill three critical values to the industry:

1. **Cost Effective Building-Scale Treatment -** The work will demonstrate the economic viability of building-scale treatment for potable water reuse using innovative technologies. The non-potable water system (Living Machine®), in place at the SFPUC Headquarters Building since 2012, treats the 13-story, 900+ employee building's wastewater to non-potable reuse standards. The tertiary effluent from the non-potable water system will then go through advanced membrane treatment and advanced oxidation treatment, producing a high quality potable water.

2. **Intelligent Control for DPR -** To date, no potable water reuse system (indirect or direct), provides a comprehensive real-time monitoring of overall performance. For potable water reuse, the treatment targets

include virus, protozoa, bacteria, total organic carbon, salts, and trace level pollutants. This project will build a treatment system that tracks and records performance of each system, and most importantly of the entire system for the removal of pathogens and pollutants. This will be the first real-time "smart" potable water reuse treatment system, operating for 6 consecutive months, which will be used to demonstrate the long term reliability of advanced water purification processes.

3. **Advanced Analytics -** No water is 100% pure, even after an RO system. Trace level chemicals can be found. This novel project will use emerging analytical tools such as a suite of bioassays and non-target analysis (NTA) to better understand the relevance of such trace level pollutants.

To that end, SFPUC is willing to support this effort by providing the following in-kind and direct funding support:

- a site for the advanced purification treatment at the SFPUC Headquarters Building that allows for public engagement;

- site work, which includes: purchase and installation of plumbing and electrical connections to the treatment facilities, as well as decomissioning (estimated at 120 hours over one year, at $150/hr, and $1,000 of materials and equipment, resulting in a cost of $19,000);

- educational and outreach materials for the treatment facilities (website, brochures, banners, tour materials, estimated at $25,000); and

- review and support of the work effort (estimated at 120 hours over one year, at $150/hr, resulting in a cost of $18,000).

In addition to the direct funding of the items above, SFPUC understands the high cost of analytical testing for this demonstration, which will span significant periods of the 1-year demonstration project. To that end, SFPUC is willing to provide $200,000 in cash in support of analytical testing.

The total costs for these contributions are estimated at **$262,000**. Please contact Manisha Kothari at (415) 554-3256 if you have any questions or comments. We look forward to working with your team on this important research topic.

Sincerely,

Steven R. Ritchie

Assistant General Manager, Water

carollo
Engineers...Working Wonders With Water®

WATER
OUR FOCUS
OUR BUSINESS
OUR PASSION

February 4, 2016

Ms. Paula Kehoe
San Francisco Public Utilities Commission
525 Golden Gate Avenue, 13th Floor
San Francisco, CA 94102

Subject: Building-Scale Treatment for Direct Potable Water Reuse & Intelligent Control for Real Time Performance Monitoring

Dear Ms. Kehoe:

Carollo Engineers, Inc. is pleased to provide this Letter of Commitment to confirm our support to the City of San Francisco, acting through the Public Utilities Commission, for our services (both paid and in-kind) related to the proposed project to pilot test building scale direct potable reuse with intelligent control systems and advanced performance monitoring. Carollo is committed to providing the following services for this project:

- Provide 10 percent of contractual hours as an in-kind service (an in-kind contribution of $20,530).
- Vehicular travel to and from the pilot site and to one trip to Denver to present findings to the USBR as an in-kind service, not quantified here.

Carollo commits to providing identified staff and resources for the duration of the project. The value of the services is $420,412. The services include approximately 1,300 hours of time, equipment, chemicals and consumable supplies, and analytical services. Carollo commits to providing $20,530 as in-kind contributions and, should the proposal be successful, will contract with SFPUC for $399,882 to perform other services.
If you have any questions regarding our participation, please contact me at 925-788-9857.

Sincerely,

CAROLLO ENGINEERS, INC.

Andrew Salveson

Andrew Salveson, P.E.
Vice-President

AS:MS

Project No Carollo Letter of Committment.docx

2700 Ygnacio Valley Road, Suite 300, Walnut Creek, California 94598
P. 925.932.1710 F. 925.930.0208
carollo.com

LABOR AND BUDGET ESTIMATE 1/29/16

Task	Task Description	SP $95	AP $60	AP $50	WP $25	Carollo Hours	Carollo Labor Cost	Fringe 50%	Indirect 126%	Carollo In Kind Contribution 10%	Other Direct Costs (ODC) Equipment	Lab Analysis	ODC Total	Total Cost
1.0	Project Management													
1.1	Prepare Project Work Plan	1	2		0	3	$215	$108	$271	$59	$0		$0	$534
1.2	Attend Meetings (2)	16	8	8	0	32	$2,400	$1,200	$3,024	$662	$0		$0	$5,962
1.3	Project Coordination, Tracking and Status	26	26	8	0	60	$4,430	$2,215	$5,582	$1,223	$0		$0	$11,004
1.4	QA/QC	16	0	_	0	16	$1,520	$760	$1,915	$420	$0		$0	$3,776
	Task 1.0 Totals =	**59**	**36**	**16**	**0**	**111**	**$8,565**	**$4,283**	**$10,792**	**$2,364**	**$0**		**$0**	**$21,275**
2.0	Building-Scale Treatment for Non-Potable Water Reuse													
	Living Machine® treatment facility currently in operation, performance data donated to the project	0	0			0	$0				$0		$0	$0
	Task 2.0 Totals =	**0**	**0**	**0**	**0**	**0**	**$0**				**$0**		**$0**	**$0**
3.0	Purification Facility Design and Construction													
3.1	Selection and Purchase/Rental of Treatment Processes	4	8	16		28	$1,660	$830	$2,092	$458	$70,250		$70,250	$74,373
3.2	Selection and Purchase/Rental of Online Monitoring Systems	4	8	16		28	$1,660	$830	$2,092	$458	$55,000		$55,000	$59,123
3.3	Installation and Startup of Treatment and Monitoring Systems	16	36	48		100	$6,080	$3,040	$7,661	$1,678	$0		$0	$15,103
3.4	Installation and Preliminary Collection of Online Monitoring System	16	36	48		100	$6,080	$3,040	$7,661	$1,678	$0		$0	$15,103
3.5	Summary TM	4	12	20	8	44	$2,300	$1,150	$2,898	$635	$0		$0	$5,713
	Task 3.0 Totals =	**44**	**100**	**148**	**8**	**300**	**$17,780**	**$8,890**	**$22,403**	**$4,907**	**$125,250**		**$125,250**	**$169,416**
4.0	Direct Potable Reuse Performance Demonstration													
4.1	6 months of O&M	40	104	312		456	$25,640	$12,820	$32,306	$7,077	$1,000		$1,000	$64,690
4.2	Conventional Parameters, PPCPs, Pathogens, and Advanced Analytics (additional hours for sampling only)	0	26	52	_	78	4160	$2,080	$5,242	$1,148	_	$88,860	$88,860	$99,193
	Task 4.0 Totals =	**40**	**130**	**364**	**0**	**534**	**$29,800**	**$14,900**	**$37,548**	**$8,224.80**	**$1,000**	**$88,860**	**$89,860**	**$163,883**
5.0	Public Communication and Outreach													
	Costs for public communication and outreach will be funded entirely by SFPUC	0	0			0	$0				$0		$0	$0
	Task 5.0 Totals =	**0**	**0**	**0**	**0**	**0**	**$0**				**$0**		**$0**	**$0**

LABOR AND BUDGET ESTIMATE 1/29/16 (CONT.)

Task	Task Description	SP $95	AP $60	AP $50	WP $25	Carollo Hours	Carollo Labor Cost	Fringe 50%	Indirect 126%	Carollo In Kind Contribution 10%	Other Direct Costs (ODC)			Total Cost
											Equipment	Lab Analysis	ODC Total	
6.0	Project Communication and Reporting													
	6.1 Quarterly Reporting	8	8	32	8	56	$3,040	$1,520	$3,830	$839	$0		$0	$7,551
	6.2 Final Report	40	40	160	40	280	$15,200	$7,600	$19,152	$4,195	$0		$0	$37,757
	Task 6.0 Totals =	**48**	**48**	**192**	**48**	**336**	**$18,240**	**$9,120**	**$22,982**	**$5,034.24**	**$0**		**$0**	**$45,308**
	Totals (Tasks 1-6)=	**191**	**314**	**720**	**56**	**1,281**	**$74,385**	**37,193**	**$93,725**	**$20,530**	**$126,250**	**$88,860**		**$399,882**

Legend:

SP	Senior Professional	AP	Assistant Professional
LPP	Lead Project Professional	CAD	CAD Technician/Graphics
PP	Project Professional	WP	Word Processor
P	Professional		

BUDGET INFORMATION - Non-Construction Programs

OMB Number: 4040-0006
Expiration Date: 01/31/2019

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds: Federal (c)	Estimated Unobligated Funds: Non-Federal (d)	New or Revised Budget: Federal (e)	New or Revised Budget: Non-Federal (f)	New or Revised Budget: Total (g)
1. Desalination and Water Purification Research & Development	15.506	$	$	$ 200,000.00	$ 282,530.00	$ 482,530.00
2.						
3.						
4.						
5. **Totals**		$	$	$ 200,000.00	$ 282,530.00	$ 482,530.00

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total
	(1)	(2)	(3)	(4)	(5)
	Desalination and Water Purification Research & Development				
a. Personnel	$ 74,385.00	$	$	$	$ 74,385.00
b. Fringe Benefits	37,193.00				37,193.00
c. Travel					
d. Equipment	125,250.00				125,250.00
e. Supplies	62,000.00				62,000.00
f. Contractual	88,860.00				88,860.00
g. Construction					
h. Other	1,000.00				1,000.00
i. Total Direct Charges (sum of 6a-6h)	388,688.00				$ 388,688.00
j. Indirect Charges	93,725.00				$ 93,725.00
k. TOTALS (sum of 6i and 6j)	$ 482,413.00	$	$	$	$ 482,413.00
7. Program Income	$ 0.00	$	$	$	$

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SECTION C - NON-FEDERAL RESOURCES

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e)TOTALS
8. Desalination and Water Purification Research &	$ 262,000.00	$ 0.00	$ 20,530.00	$ 282,530.00
9.				
10.				
11.				
12. TOTAL (sum of lines 8-11)	$ 262,000.00	$	$ 20,530.00	$ 282,530.00

SECTION D - FORECASTED CASH NEEDS

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
13. Federal	$ 200,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00
14. Non-Federal	$ 200,000.00	50,000.00	50,000.00	50,000.00	50,000.00
15. TOTAL (sum of lines 13 and 14)	$ 400,000.00	$ 100,000.00	$ 100,000.00	$ 100,000.00	$ 100,000.00

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT

(a) Grant Program	FUTURE FUNDING PERIODS (YEARS)			
	(b)First	(c) Second	(d) Third	(e) Fourth
16. Desalination and Water Purification Research &	$ 200,000.00	$ 0.00	$ 0.00	$ 0.00
17.				
18.				
19.				
20. TOTAL (sum of lines 16 - 19)	$ 200,000.00	$	$	$

SECTION F - OTHER BUDGET INFORMATION

21. Direct Charges:	22. Indirect Charges:
23. Remarks:	