Orange County Sanitation District

Research Report 2018

2017 - 2018
OCSD Research Report

Compiled by
Engineering Planning

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Acknowledgments

Oversight of the research program is provided by the Research Technical Advisory Group (RTAG), a staff technical committee charged with keeping current on OCSD's needs that could drive research activities, screening relevant technology developments, evaluating proposals for new research projects, monitoring the progress of existing projects, and disseminating the results of projects to interested parties inside and outside OCSD. The RTAG membership provides scientific and engineering expertise and reflects the wide-ranging occurrence of research activities throughout the agency.

The RTAG members in 2017-18 were:

- Jeff Brown (Engineering)
- Samuel Choi (Environmental Services)
- Lisa Frigo (Environmental Services)
- Margil Jimenez (Operations and Maintenance)
- Violet Renick (Environmental Services)
- Reza Sobhani (Operations and Maintenance)
- Christopher Stacklin (Environmental Services)

Abbreviations and Acronyms

ADG	Anaerobic digester gas
AQMD / SCAQMD	South Coast Air Quality Management District
AWWA	American Water Works Association
COD	Chemical oxygen demand
CVWD	Coachella Valley Water District
EBMUD	East Bay Municipal Utility District
EBRT	Empty bed residence time
EWA	Encina Wastewater Authority
FOG	Fat, oil, and grease
IEUA	Inland Empire Utilities Agency
iTAG / TAG	(International) Technology Approval Group
IRWD	Irvine Ranch Water District
LACSD	Sanitation Districts of Los Angeles County
MRL	Method reporting limit
MWD	Metropolitan Water District of Southern California
NG	Natural gas
NO_x	Nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NWRI	National Water Research Institute
OCSD	Orange County Sanitation District
SCCWRP	Southern California Coastal Water Research Project
SCWO	Supercritical water oxidation
SMWD	Santa Margarita Water District
SOCWA	South Orange County Wastewater Authority
SO_x	Sulfur oxides
TS / TSS	Total solids / total suspended solids
TWAS	Thickened waste activated sludge
VOC	Volatile organic compound
VS / VSR	Volatile solids / VS reduction
WERF	Water Environment Research Foundation

Part 1

Introduction and Overview

Part 1

Introduction and Overview

This document is a report of research activities at the Orange County Sanitation District (OCSD) during FY 2017-18. The project activities were carried out by various divisions in the Engineering, Operations & Maintenance, and Environmental Services departments. The projects addressed a range of topics, including odor control activities and treatment process improvements.

The funding sources for research projects include CIP research-specific allocations and departmental funds. A master operational research budget is included in OCSD's capital projects budget and is used for defined research projects. This continues a practice that has been in place for about nine years. In addition, individual departments may choose to fund research-type activities from their own annual budgets.

Projects can be suggested from a variety of sources, but establishing a project aligns with the general process used for capital projects. A proposed research project is reviewed and recommended by a technical committee (the Research Technical Advisory Group), reviewed by agency technical managers and the Project Clearinghouse, discussed before and after commencement at multiple project gate meetings, and approved by appropriate OCSD management according to the dollar limits set by OCSD's Delegation of Authority policy (including Board of Directors approval for contracts greater than $100,000). Throughout a project's duration, its budget and schedule performance are tracked in the Engineering Project Management Office's project controls activities.

OCSD is a member of Isle Utilities' Technology Approval Group (iTAG) program, an international consortium of wastewater agencies, to facilitate identifying and evaluating emerging technologies from around the world that could be beneficial for the agency. OCSD's membership is funded from the annual general budget allocation for research activities.

The US iTAG members are organized into seven regional groups, which operate autonomously. Each regional group meets three times per year. Prior to each meeting, the members receive a list of technologies that have been vetted by Isle's staff, and they vote on the technologies they want to have presented. Afterwards, if there is sufficient interest by one or more members, this can lead to technology demonstrations and collaborative trials. Isle also has relationships with the US EPA, the Water Research Foundation, and the Water Environment and Research Foundation to enhance the opportunities for utilities to participate in collaborative projects and to disseminate the results to wider audiences. Details of OCSD's iTAG program involvement are contained in Appendix A.

The members of the regional iTAG wastewater group with OCSD are:

- City of Escondido
- South Tahoe Public Utility District
- Inland Empire Utilities Agency (IEUA)
- Sanitation Districts of LA County (LACSD)
- City of Thousand Oaks
- Monterey One Water
- Metro Wastewater Reclamation District (Denver)
- Moulton Niguel Water District
- City of Roseville
- South Platte Water Renewal Partners (City of Englewood)
- City of Santa Barbara

OCSD also maintains agency memberships in several national organizations related to research. These are described in Appendix B.

In addition to the projects that are continuing, new projects will be undertaken in response to OCSD's current and future needs. The research program will continue to be proactive in bringing improvements to OCSD's activities to reduce costs, improve efficiency, and promote environmental protection.

Part 2

Active Research Projects

Part 2

Active Research Projects

This section provides details about research projects active during 2017-18. Of these, four used the CIP research budget (FY 2017-18 OCSD Budget, Section 8, p. 81) and five used other funding.

Funds for specific internal projects were drawn from a master budget line item (M-RESEARCH) that provides $8,500,000 for projects in 2017-18 through 2022-23 ($1.69M in 2017-18). The technical support project RE17-01 is for 2017-18 research staff time that is not associated with another open project; often, this will be time spent developing potential project topics until they become specifically-funded projects. The other 2017-18 projects involved various OCSD staff work as in-kind contributions or division-funded activities that were not tracked separately from other staff activities.

The completion status and current year budget expenditure for each project is summarized in the following table.

Project Number	Project Name	Status	2017-18 CIP Research Budget Expenditure
RE17-01	Research Technical Support	Continuing	$ 315,100
RE17-02	Biogas Scrubbing Process Improvement	Continuing	$ 800
RE17-03	Reliant Wet Well Wizard Evaluation	Continuing	$ 13,400
SP-125-15	Nutrient Cycling Sampling	Continuing	$ 0 [1]
WRF REUSE-13-12	Guidelines for Direct Potable Reuse	Complete	[2]
-	Evaluating Manhole Inserts	Complete	[2]
WERF1C15/ 4887	Occurrence & Persistence of Antibiotics	Complete	[2]
WERF2C15	Potential for Exposure to Ebola Virus Surrogates	Complete	[2]
WRF REUSE-14-13	Resilience of Treatment Processes for Direct Potable Reuse	Complete	[2]

[1] Funded in 2015-16; completed in 2017-18. [2] No specific OCSD funding was used.

Project Title:

Biogas Scrubbing Process Improvement (Project RE17-02)

Contact: Jeff Brown, Engineering

Purpose: Evaluate a chemical-free process for removing contaminants from digester gas

Lead: OCSD

Description:

Biogas from digesters contains chemicals, including odorous hydrogen sulfide and silicon compounds (siloxanes), that must be removed before the gas can be used in the Central Generation engines. Currently, this is done with liquid ferric chloride and columns of granular activated carbon. These processes are expensive and require a continuous chemical supply. In addition, since ferric chloride is used sequentially for both primary treatment and digester sulfide control, some potential primary treatment improvements using other additives are not possible as long as both process steps are tied to using this chemical.

Following Carollo Engineer's announcement of their own small-scale test results, OCSD started working with them to test, develop, and optimize their proprietary gas scrubbing process that uses only water to remove sulfides and siloxanes from biogas. OCSD obtained a royalty-free perpetual license to use the technology and will receive 20% of the royalties from any licensing of this process.

Background:

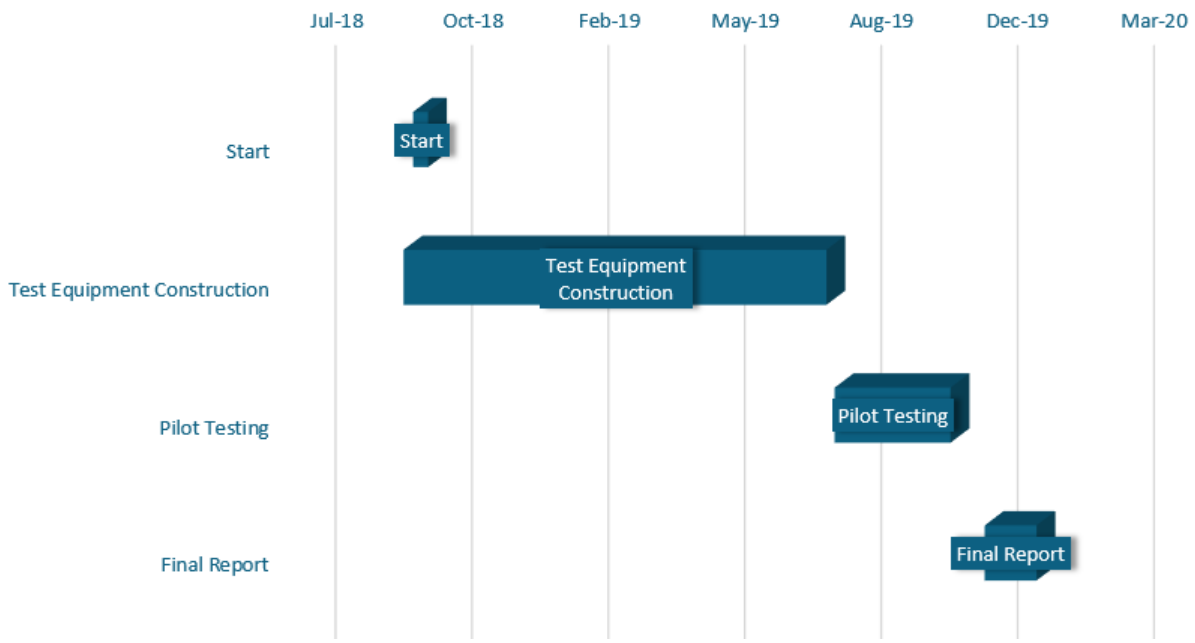
Proof-of-concept testing in 2013 showed that reduced sulfur compounds and a range of siloxanes were completely or almost completely removed by scrubbing. A feasibility study (7/2014: contract to Carollo for $106,000) then evaluated the impacts of using the system in a full-scale application. The cost analyses indicated that biogas scrubbing might be cost-effective compared to OCSD's current practices. However, important areas of uncertainty were identified that could not be resolved without having more extensive operating data.

Status:

As project RE17-02, extensive large-scale testing is planned for 2018-20 using a purpose-built pilot facility. This will be used to evaluate the effects of various scrubbing water recirculation cycle strategies, optimize the process performance, reduce methane losses, and investigate the control options for responding to changes in the incoming biogas flow.

Budget: $657,000 contract to Carollo (Board of Directors approval: 6/27/2018)

Schedule:



Project Title:

Reliant Wet Well Wizard Evaluation (Project RE17-03)

Contact: Margil Jimenez, Operations

Purpose: Evaluate an option for managing FOG buildup and odors in pump wet wells

Lead: OCSD

Description:

The wet wells in collection system pump stations are locations where FOG (fats, oils, and grease) masses coalesce and solidify on top of the water. These may require manual removal as often as monthly. Wet wells also are odor sources when H_2S is produced in septic conditions.

Reliant Water's Wet Well Wizard is an aeration product intended to solve the FOG and odor problems. The Wizard is a proprietary aeration device that is connected to a blower and is placed in a wet well to agitate and mix the water. The device contains disks inside a confined tube that are claimed to shape large air bubbles into high speed, spinning "FOG cutters." This is supposed to emulsify all FOG and prevent FOG masses from collecting in the wet well. The constant agitation with air also is supposed to promote the growth of aerobic microbes in the wastewater and eliminate H_2S formation.

Status:

The Crystal Cove pump station was selected for a Wizard test. Since the wet well is large, two Wizards were installed to ensure adequate agitation and aeration. The data to be collected included measurements of H_2S, dissolved oxygen (DO) in the wet well, and pH, as well as visual observations of the FOG mat to determine if it was broken up initially and whether it reformed later.

In the first four months of operation, odors, noise, and equipment reliability were not issues for the test, and the wet well typically had a positive DO content. The Wizard initially broke up the FOG mat that was present and may have reduced the rate of the subsequent FOG

mat accumulation, but it did not completely prevent the mat from forming. Reliant suggested this was due to the calcium nitrate that also was being used to control odors. In Q1/Q2 2018-19, the test will be continued without the calcium nitrate to determine if this affects the Wizard's performance. The project will conclude with the final report preparation in Q2 2018-19.

Budget: $74,000

Schedule:

Project Title:

Nutrient Cycling Sampling (SCCWRP Cooperative Project) (Project SP-125-15)

Contact: George Robertson, Environmental Services

Purpose: Understand the influence of effluent nitrogen on coastal waters and biologic communities.

Lead: SCCWRP

Description:

The goal of this project is to understand the influence of effluent nitrogen on coastal waters and how the nature of this nitrogen affects the response of the biological community. The study objectives are:

1. Conduct process studies to determine key rates of nitrogen and carbon cycling, including primary production, respiration, nitrogen uptake, and nitrification, in effluent-impacted (Orange County) and minimally-impacted (nearshore Oceanside and offshore) regions.

2. Characterize regional patterns in nutrient concentrations, stable isotope distributions, and measured rates in carbon and nitrogen cycling for application in focused validation of the coupled physical-biogeochemical model, which will be used for nutrient management scenario analysis.

Results:

1. *Impacts of wastewater effluent on nitrogen (N) cycling have both an immediate, local component and a longer-term, regional component.* Near outfalls, the presence of anthropogenic nitrogen from treated wastewater (as ammonia) influenced N cycling. Ammonia and nitrite concentrations and rates of nitrification (oxidation of ammonia to nitrite and ultimately nitrate) are elevated within the plume, suggesting a local and immediate influence of effluent on N cycling. However, nitrogen assimilation (incorporation of inorganic N into the biomass) was not significantly different in plume-affected areas versus non-plume areas, but had clear seasonal patterns, suggesting regional factors play a greater role in regulating these processes.

2. *Impacts of wastewater effluent on carbon and oxygen cycling have only a longer-term, regional component.* There were no significant differences in primary productivity and respiration in plume-affected areas compared to minimally-impacted areas. Furthermore, concentrations of chlorophyll and dissolved oxygen, as well as nitrate, phosphate, and nutrient and carbon ratios, were also not significantly different in the plume-affected areas compared to the minimally disturbed areas, suggesting the drivers for these processes are regional (e.g., mixing of water masses). However, inorganic nitrogen concentrations are one of the most predictive variables for primary production, indicating the importance of nutrient sources for chlorophyll biomass and suggesting that if wastewater nitrogen has an impact on this process, the effect is diluted region-wide.

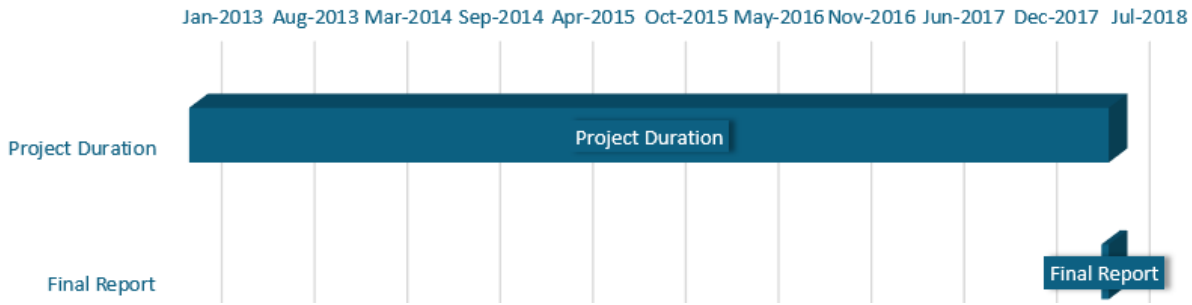
3. *The concept of "reference-area" for nutrient and carbon cycling as related to wastewater discharges in the Southern California Bight is flawed.* The study design was based upon the hypothesis that areas near outfalls would be more impacted from nutrient discharges than areas spatially distant from the outfalls. The results of this study proved that such a concept is only true for processes that occur at depth, where the plume is discharged (i.e., below the euphotic zone), such as nitrification. For processes that require the water mass to be mixed into the euphotic zone (e.g., primary production), an immediate, local effect was not observed. While a slight lag was expected in the timing (and thus distance) of elevated primary production and chlorophyll from introduced nutrients at depth, the reality of the mixing in the region indicates that the time lag of this mixing is sufficient to transport the anthropogenic nutrients to non-plume (reference) areas. Thus, the concept of "reference" for nutrient management is flawed for the region.

Conclusions:

The results illustrate the spatial scales of physical/biogeochemical models and ocean circulation patterns, including the treated wastewater effluent plume dispersion, are critically important factors in nutrient management scenarios. From this study, the main recommendation is that these data be used for focused validation of the ROMS-BEC model, currently under development. The model should reproduce the observed elevation of ammonia and nitrite concentrations and higher rates of nitrification within effluent plumes. Furthermore, the model should not indicate an increase in primary production, nor respiration, within effluent plume regions; rather, changes in rates of primary production and respiration should be region-wide and associated with seasonal changes in upwelling and mixing. These data have been communicated to the modeling team and modeling stakeholders.

Budget: $95,000 (paid in 2014-16)

Schedule: This is an ongoing SCCWRP project.



Executive Summary

Background

Biogeochemical cycling of nutrients in the Southern California Bight (SCB) is influenced by several interacting and synergistic factors; consequently, disentangling ecological effects of anthropogenic nutrient discharges is uniquely challenging. SCB coastal waters receive nutrient inputs from both wind-driven upwelling of cold, deep, nutrient-rich waters as well as via discharge of anthropogenic nitrogen (N) from treated wastewater through offshore outfalls. Previous studies have demonstrated that total N inputs from upwelling are greater than wastewater N inputs at a regional scale but are equivalent at local scales in urbanized coastal waters of the SCB. The relative influence of these nutrient sources are further complicated by Pacific Basin scale events, such as El Niño/La Niña as well as changes in carbon (C) and N cycling related to global CO_2 emissions and increasing global ocean temperature.

To understand the complex relationships between these factors and their influence on nutrient and carbon cycling, researchers are utilizing a coupled physical and biogeochemical ocean model to characterize the relative contribution of N sources to coastal eutrophication. These models must be comprehensively tested and validated for skill to predict scenario outcomes related to nutrient management; however, there is little biogeochemical data, particularly related to biogeochemical rates, on which to base such model skill-tests.

The objective of this study was to determine the effect of anthropogenic nutrient inputs on ecological processes related to primary productivity, concentrations of dissolved oxygen, and aragonite saturation state. These data will be used to validate and test model skill for management scenario analysis. The study aimed to characterize the difference in nutrient concentrations, form, and cycling in areas affected by N inputs from treated wastewater plumes compared to areas spatially distant from the plumes both along the coast and offshore.

Approach

This study used a nearfield versus farfield (outfall/reference) site study design for assessing influence of treated wastewater on the southern California coastal region. This design was based on the hypothesis that water chemistry and the rates of chemical and biological cycling and would differ between nearfield (i.e., treated wastewater plume) areas compared to farfield (i.e., non-plume) areas distant from outfalls. A combination of field observations and experimental studies were used to address the study objective. Water column and filtered particulate observational samples were collected at 11 sites in the spring and summer between 2014 and 2016. Experiments were conducted to determine the key rates of biogeochemical cycling needed for the models and to address the effects on eutrophication indicators.

Results and Conclusions

There were three major findings from this research:

Impacts of anthropogenic nutrient inputs on biogeochemical cycling of nitrogen has both an immediate, local component as well as a longer-term, regional component.

At local spatial scales, anthropogenic N inputs, in the form of ammonia, influenced N-cycling. Ammonia and nitrite concentrations and rates of nitrification (oxidation of ammonia to nitrite and ultimately nitrate) are elevated within the plume (both directly over the outfall and in "older" plume away from the outfall), suggesting a local and immediate influence of wastewater on N-cycling. However, concentrations of nitrate and isotopic tracers of assimilation (incorporation of inorganic N into the biomass) were not significantly different in plume-affected areas versus non-plume areas, but had clear seasonal patterns, suggesting regional factors play a greater role in assimilation.

Impacts of anthropogenic nutrient inputs on biogeochemical cycling of carbon and oxygen have only a longer-term, regional component.

There were no statistically significant differences in primary productivity and respiration in the wastewater plume versus locations spatially distant from outfalls. Furthermore, concentrations of chlorophyll and dissolved oxygen, as well as nitrate and phosphate concentrations, and ratios of nutrients and carbon in particulate matter, were also not significantly different in the nearfield versus far field. This suggests any potential impact from wastewater on these process is obscured by regional factors, such as mixing of water masses.

The concept of "reference-area" for nutrient and carbon cycling as related to anthropogenic nutrient discharges in the Southern California Bight is flawed.

The study design was based upon the hypothesis that areas near outfalls would be more impacted from nutrient discharges than areas distant from outfalls. The results indicate that such a concept is only true for processes that occur at depth, where the plume is discharged

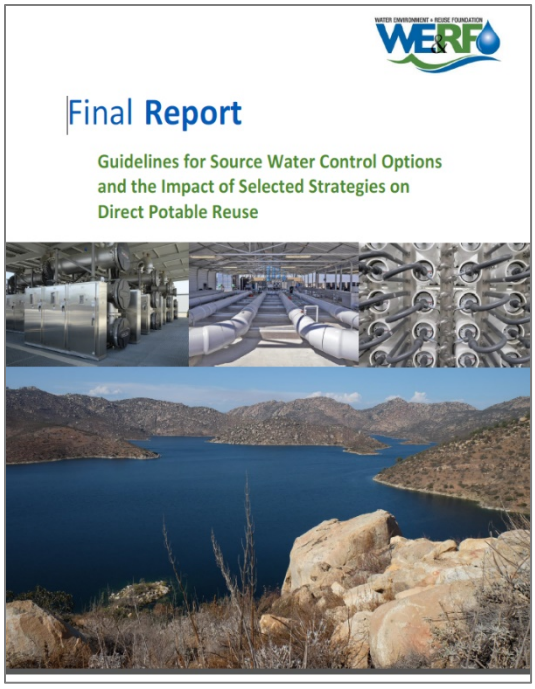
(i.e., below the euphotic zone), such as nitrification. For processes that require mixing into the euphotic zone (e.g., primary production), there was not an immediate, local effect. While a lag in timing (and thus distance) of elevated primary production and chlorophyll from discharged nutrients at depth was expected, regional water mass mixing may cause a time lag sufficient to transport anthropogenic N to non-plume (reference) areas. Thus, the concept of "reference" is likely flawed for the region. This hypothesis is supported by model output from the Regional Ocean Model (ROMs), run in particle tracking mode, which indicate wastewater is mixed outside of "plume" regions on timescales of days to weeks. In such cases, impacts of anthropogenic nutrients on primary production, related elevation in respiration, and impacts on acidification, are not easily deciphered with observational data alone.

Recommendations

Data from this study should be used to test the skill of the model at reproducing broad spatial and temporal patterns in N and C cycling along the southern California coast, within the expected uncertainty of these measurements. The model should reproduce observed elevation of ammonia and nitrite concentrations and higher rates of nitrification within effluent plumes. Furthermore, the model should not indicate an increase in primary production, nor respiration, within effluent impacted regions; rather, changes in rates of primary production and respiration should be region-wide and associated with seasonal changes in upwelling and mixing. The model should also be able to demonstrate assimilation of "new" nitrogen from deep water during upwelling events, versus the assimilation of nitrate from regenerated ammonia (via nitrification) during stratified periods.

Project Title:

Guidelines for Source Water Control Options and the Impact of Selected Strategies on Direct Potable Reuse (WRF REUSE-13-12)



Contact: Christopher Stacklin, Environmental Services [WRF Project Advisory Committee Member]

Purpose: Provide guidelines to enable wastewater treatment plants and advanced water purification (AWP) facilities to collaborate and complement each other to provide safe, reliable supplies of potable reuse water.

Lead: WERF

Description:

Utilities which own and operate existing wastewater treatment infrastructures (collection, treatment, and disposal) may consider expanding these to include advanced water purification facilities (AWPFs). Alternatively, they may consider collaborating with other entities who currently operate water treatment and distribution facilities. The governing paradigms, treatment objectives, operational objectives, and even the vernacular for wastewater treatment facilities and operators have historically been different from those of water treatment facilities and operators. However, in the development of a successful potable reuse program, it may be highly beneficial to overcome these inherent differences. This integration will enable the two programs (collection/wastewater treatment and water treatment/ distribution) to effectively collaborate and complement each other to provide safe, reliable supplies of potable reuse water.

Results:

One of the key elements that differentiates a pretreatment program from source control is a shift in focus from meeting discharge limits (pretreatment programs) and becoming part of an integrated water supply program (source control). Some of the principal objectives for a

source water treatment facility expanding to integrate AWP include:

- Production of a consistently high-quality supply water suitable for further treatment in the AWP facility;
- Ability to detect poor-quality supply water and divert flow away from the AWP process;
- Production of a steady and consistent flow.

Poor source water quality or wide flow variations can have significant impacts on the AWP process design and operations. Such impacts could translate to increased capital and O&M costs for the AWP process.

Management and Policy Implications:

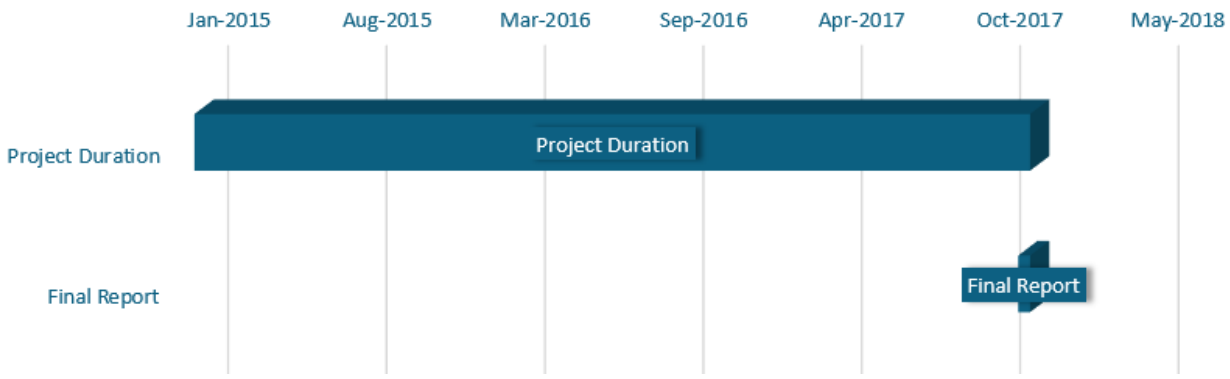
These guidelines provide objectives for the development of source control programs, design considerations related to AWP and source water treatment facilities, and operational issues that impact potable reuse systems. Facilities can use this information to implement their own source control programs, especially in cases where a move to potable reuse is in progress or is in their future. These considerations may allow for savings in capital and O&M costs when implementing the integration.

Status:

The project was completed in December 2017. OCSD provided guidance based on its enhanced source control program for the Groundwater Replenishment System and the impact of the Steve Anderson Lift Station and secondary effluent flow equalization storage tanks on the diurnal flow pattern.

Budget: $3,000 (OCSD in-kind work)

Schedule:



Project Title:

Evaluating Manhole Inserts for Controlling Odors and Emissions at Critical Points of the Collection System

Contact: Reza Sobhani, Operations

Purpose: Evaluating manhole insert application as an alternative to manhole sealing for controlling odors and air emissions.

Lead: OCSD

Description:

Manhole inserts are passive containers of filter media that are installed under manhole covers. Odorous air from the sewer system enters the insert from the bottom and is released through outlet vents in the top. Odors are degraded as the air passes through the filter media. This project evaluated the effectiveness of manhole inserts as alternatives to manhole sealing at critical points in the collection system.

The objectives of this study were to:

1. Determine if inserts can prevent fugitive odor emission and decrease odor complaints near trunk lines and collection system facilities (e.g., pump stations).
2. Determine if inserts would obstruct collection system ventilation, which could exacerbate trunk line corrosion.
3. Determine the costs and the required maintenance practices.

Four sites were selected for the evaluation. Baseline data were collected at each site, then a manhole insert was installed. For ten months, data were collected on sewer pressures and temperatures and on H_2S concentrations above the manhole. The following table presents the test locations and the insert and media used in each manhole.

Manhole Locations and Inserts Tested

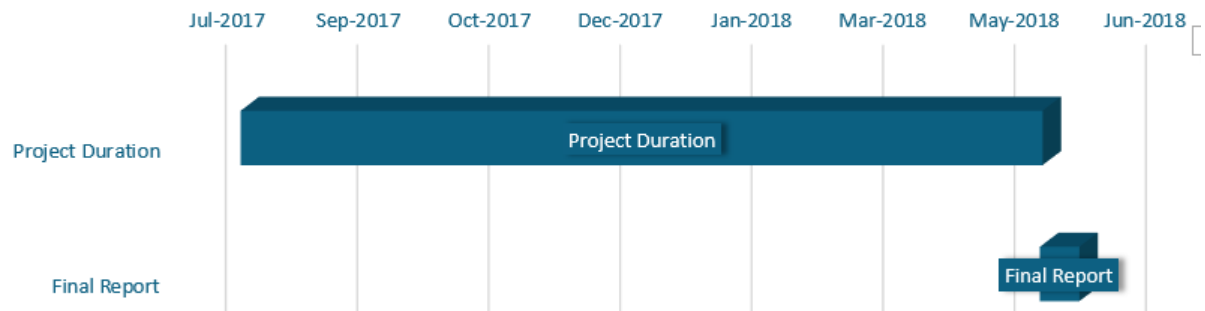
Manhole ID	Intersection	Manhole Insert	Media
KNT0080-0635	Heil / Mycroft Lane (Huntington Beach)	Bioteg Biofilter	Bioteg BPC (biofilter)
KNT0080-0650	Heil / Bradbury Lane (Huntington Beach)	Syneco Pan	Persnickety (polymeric amine)
KNT0275-0130	I405 / Seal Beach Blvd. (Seal Beach)	Wolverine	Darco (catalytic carbon)
KNT0275-0135	I405 / Seal Beach Blvd. (Seal Beach)	Wolverine	Sulfatreat (iron oxide)

Conclusions:

- Biofilter media (i.e., Bioteg) and polymer amine (i.e., Persnickety) were found to tolerate higher H_2S concentrations, showed better removal efficiency, and were more suitable for treating H_2S spikes.
- Catalytic carbon (i.e., Darco) and iron oxide (i.e., Sulfatreat) had lower tolerance to high H_2S concentrations and consequently would not be good candidates for permanent use. Both media also showed obstruction and lack of ventilation six months after installation.
- Bioteg and Syneco appeared to be the more suitable selections for OCSD's collection system and its large manholes.
- The cost analyses of insert applications indicated that over four years, Bioteg would have lower total costs ($2,120) than Syneco ($2,895).
- Based on the observed removal efficiency, adaptability to the collection system, and total costs, Bioteg was recommended as the first choice and Syneco was recommended as the second choice for OCSD's use.
- The Wolverine insert was not recommended because it did not discharge water inflow effectively and was not suitable for large manholes.
- The Darco catalytic carbon and Sulfatreat media were not recommended. They needed longer retention times and were not suitable for treating high H_2S concentrations. Also, condensate and saturated moisture can reduce carbon's ability to remove H_2S from foul air.

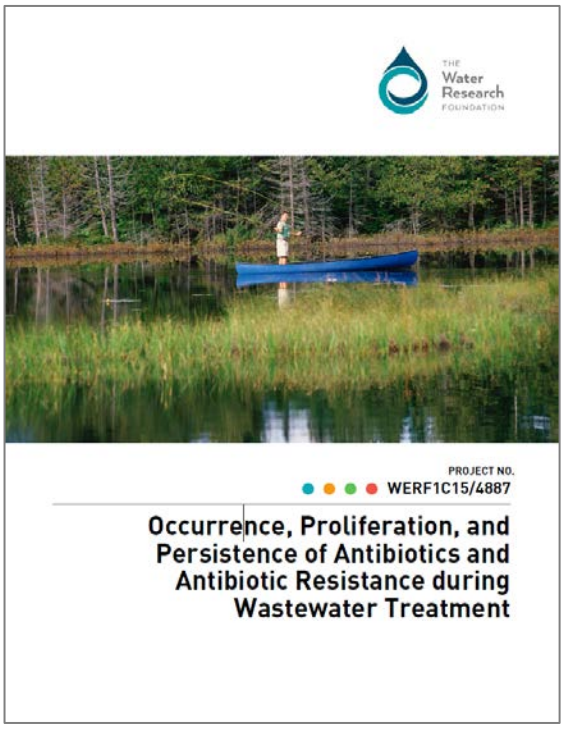
Budget: None (incorporated into general staff workload)

Schedule:



Project Title:

Occurrence, Proliferation, and Persistence of Antibiotics and Antibiotic Resistance during Wastewater Treatment (WERF1C15/4887)



Contact: Christopher Stacklin, Environmental Services
[WRF Project Subcommittee Advisor]

Purpose: Provide an overview of the state of the science of antibiotics and antibiotic resistance in wastewater.

Lead: WERF

Description:

The main objectives of this research were to characterize the impacts of solids retention time (SRT) and influent antibiotic concentrations in activated sludge systems on (1) general water quality parameters,(2) trace organic compound (TOrC) concentrations (including five target antibiotics), (3) microbial community structure, and (4) relative abundance and extent of antibiotic resistance (AR). The hypothesis was that longer SRTs and higher influent antibiotic concentrations would select for AR bacteria because of the extended exposure to antibiotics, the greater selective pressure on the microbial community, and the greater potential for horizontal gene transfer. In addition, it was hypothesized that the experimental conditions would promote bacteria that were increasingly resistant to antibiotics. Sampling throughout the treatment train at a full-scale facility was also performed to characterize the efficacy of tertiary treatment processes in mitigating the spread of AR upon discharge or beneficial use of treated wastewater effluent.

Results:

The resulting data indicated that there were positive correlations between culture-based AR and SRT, influent antibiotic concentration, and temperature, although the significance of each operational parameter varied by antibiotic. The corresponding ARG (antibiotic-resistant genes) data sometimes contradicted the culture-based data, but this may have been an artifact of abundant "free DNA" detected in the aqueous phase. Elevated antibiotic concentrations had no significant impact on general water quality parameters, TOrC attenuation, or microbial community structure. Significant changes in the microbial community structure were observed in laboratory-scale Sequencing Batch Reactors (SBR) as a function of SRT, as expected. Finally, the full-scale survey identified chlorination as an effective strategy to minimize the release of AR bacteria, but ozone, UV disinfection, and solids processing (i.e., centrate) appeared to select for AR in some instances. (That is, the centrate had a similar bacterial count as other streams in the study, but the antibiotic resistance was much higher than the other streams.)

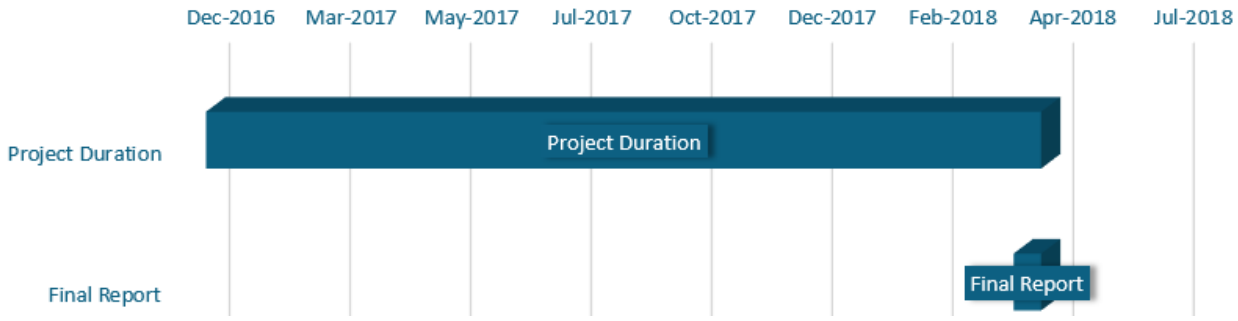
Status:

The project was completed in April 2018. The researchers identified knowledge gaps that require further research and provided recommendations for research that has potential benefits for stakeholders impacted by the spread of antibiotic resistance.

OCSD provided guidance on collections and treatment system operational impacts to sampling analytical results.

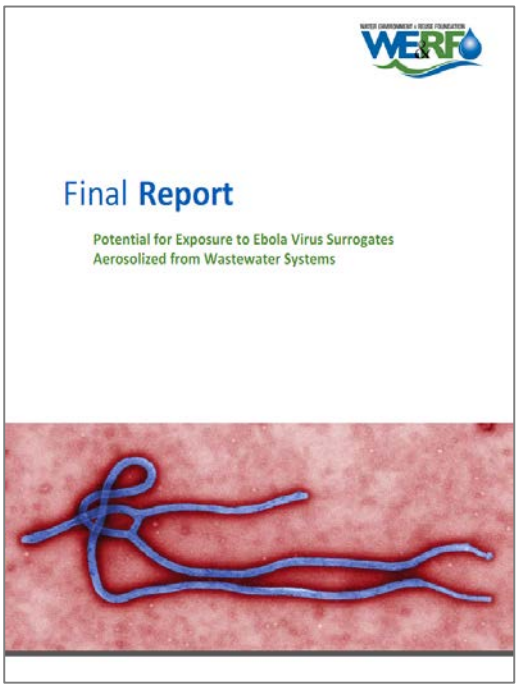
Budget: $3,000 (OCSD in-kind work)

Schedule:



Project Title:

Potential for Exposure to Ebola Virus Surrogates Aerosolized from Wastewater Systems (WERF2C15)



Contact: Christopher Stacklin, Environmental Services
[WRF Ebola Advisory Committee Member]

Purpose: Assess the potential for aerosolization of Ebola virus surrogates from wastewater systems.

Lead: WERF

Description:

The researchers evaluated partitioning of surrogate viruses, MS2 and Phi6, between the liquid, solids, and material surfaces of porcelain, concrete, polyvinyl chloride (PVC), and polypropylene. The researchers then considered risk for three wastewater systems: toilets, a lab-scale model of an aeration basin, and a lab-scale model of converging sewer pipes. The researchers measured the aerosol size distribution generated by each system, spiked viruses into each system, collected aerosol samples for analysis by plaque assay, and determined the emission rate of viruses into the air.

Results:

The approach used quantitative polymerase chain reaction (qPCR) to detect viruses. Results reflected the presence of genomic material of the viruses, but not every virus was necessarily infectious. In all cases, at least 94% of the virus particles, or virions, partitioned into the liquid

fraction. In real sludge, no more than 0.8% of virions partitioned to the solids and no more than 6% to the material surface.

Both MS2 and Phi6 partitioned more to the surface of concrete and polypropylene than to the surface of porcelain or PVC. Partitioning of viruses in wastewater between the liquid, biosolids, and material surface does not appear to mitigate the potential for aerosolization of virus, as most of the virus remained in the liquid phase.

Management and Policy Implications:

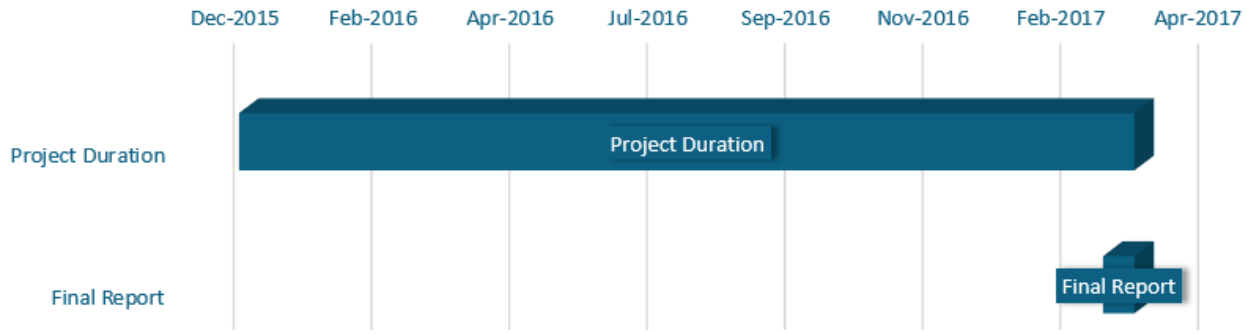
The viruses used in this study are considered reasonable surrogates for Ebola virus, but due to uncertainties about aerosolization and persistence of actual Ebola virus, the results should be applied with caution. Nevertheless, they can be used to inform risk assessments of inhalation exposure to Ebola virus found in wastewater.

Status:

The project was completed in March 2017. OCSD provided guidance on collection system operation and maintenance and potential exposure routes and regulatory implications.

Budget: $5,000 (OCSD in-kind work)

Schedule:



Project Title:

From Collection Systems to Tap: Resilience of Treatment Processes for Direct Potable Reuse (WRF REUSE-14-13)

Contact: Christopher Stacklin, Environmental Services
[WRF Participating Agency Representative]

Purpose: Develop guidelines for designing resilient direct potable reuse (DPR) process trains.

Lead: WERF

Description:

This project established suggested guidelines to enhance resilience in DPR treatment trains from wastewater sources through wastewater treatment and advanced water treatment. The researchers identified failure modes for unit treatment processes commonly considered for DPR applications along with associated monitoring for failure detection, consequences, and responses. Previous information gaps were addressed, including consideration of granular activated carbon, biologically activated carbon, and membrane bioreactors, dependencies such as power and data communication, and important interagency communications.

Results:

Guidelines for designing resilient DPR process trains from wastewater sources through wastewater treatment and advanced water treatment are presented based on principles of reliability, redundancy, robustness, and resilience integrated into existing risk evaluation methodology.

The risks of treatment failure can never be completely eliminated. Therefore, process

monitoring is critical since providing an effective response depends on detection. Hazardous events, including process malfunctions, wastewater source variability, natural disasters, and malevolent attack, and dependence on third party providers (such as power suppliers) can lead to consequences that affect utility mission objectives associated with both water quality and quantity.

Future research needs include risk assessments for wastewater treatment and wastewater source control stages and for specific processes (including granular and biological carbon and membrane bioreactors) to quantify pathogen log reductions and the removal of emerging contaminants, and to identify critical control points and monitoring recommendations. Monitoring will continue to be a significant focus of research that will likely produce significant advances in the near future.

Management and Policy Implications:

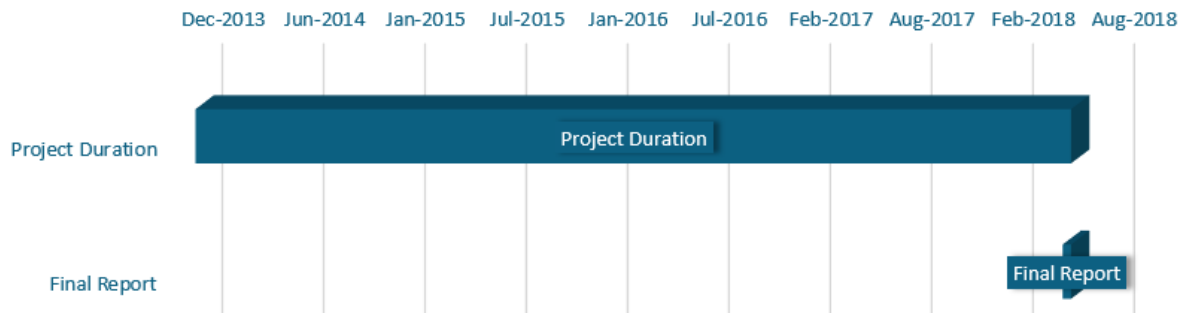
Resilience is enhanced by reducing an outage severity (duration and percentage of service area affected) by providing process redundancy, source redundancy (which provides opportunities for blending), storage, real-time monitoring, and automated responses to decrease response times. Response times may be shortened through improved communication and faster responses due to integrating standard operating procedures and Emergency Response Plan practices during regular staff training sessions. Specialized training is recommended for operators due to the increased complexity of monitoring, interpretation of data and alarms, and decisions required to respond. Process robustness depends on removal of key pathogens and emerging contaminants and may be enhanced by establishing and monitoring utility-specific intermediate treatment goals for each DPR water cycle stage.

Status:

The project was completed in June 2018. OCSD provided guidance on its enhanced source control program for the Groundwater Replenishment System including upstream monitoring strategies. Guidance included the impact of dynamic hydraulic detention time on pollutant loading and operator detection and response time relative to DPR systems.

Budget: $3,000 (OCSD in-kind work)

Schedule:



Part 3

Miscellaneous Research Activities

Part 3

Miscellaneous Research Activities

Not every question or investigation warrants a full and formal project. Sometimes a literature review or informal consultations with knowledgeable industry representatives will yield the desired information. Often these efforts will not be documented in a formal report or presentation, but the results will be communicated appropriately to the interested parties.

- Contamination of Anaerobic Digesters with Glass: Literature references about the possible contamination of anaerobic digesters by discarded glass material were examined to determine if this was a common problem in digesters processing food waste. It was determined that this had been observed in various installations but did not seem to be a particular issue for concern as OCSD proceeds with plans to implement food waste digestion at Plant 2.

- Digital Map Room: There is a desire to transition from maintaining files of paper copies of engineering drawings (e.g., as-built drawings from construction projects) and instead have a "digital map room" where users could view drawings on large screen displays, manipulate the drawings, and perhaps hyperlink to other information in various databases. Drawing on the resources of Isle Utilities to determine what other utilities do, various software applications were identified for OCSD to consider. These included RedEyeDMS, Igloo Vision, Digital Mentor, and Farallon Geographics Plant GIS. This information was provided to OCSD staff for appropriate consideration.

Part 4

Future Research Projects

Part 4

Future Research Projects

Several projects that have been developing are expected to show major progress in 2018-19. These include evaluations of advanced secondary treatment processes, supercritical water oxidation, and wastewater superoxygenation.

- Advanced Secondary Treatment Processes

  Description: As reported in the 2016-17 Research Report, a review of many advanced secondary treatment processes was completed in cooperation with Isle Utilities. The focus was on fixed film processes (both attached growth and suspended growth) that would be suitable for OCSD's large-scale use, were commercialized or had completed third-party validation testing in relevant operational environments, and could meet OCSD's current effluent quality requirements. Twenty-three processes were screened, compared, and ranked.

  In 2017-18, OCSD continued investigating the most promising secondary treatment processes. From this, it was recommended that two processes, Organica's Food Chain Reactor (FCR) and Aqua Nerida's granular activated sludge, be evaluated in greater detail. Site-specific engineering evaluations are planned in 2018-19 as projects RE17-04 (Aqua Nereda) and RE17-05 (Organica).

  Estimated Schedule: Completion in FY 2018-19
  Estimated Budget: $250,000 each

- Supercritical Water Oxidation (AquaCritox)

  Description: As reported in the 2016-17 Research Report, supercritical water oxidation (the AquaCritox process) has been investigated by OCSD since 2011. As of June 2017, there was an ongoing European Union-funded AquaCritox evaluation in Valencia, Spain. That project concluded as scheduled but without exploring the full range of AquaCritox capabilities because of insufficient project funding.

  AquaCritox's technology owner, the SCFI Group, decided to construct two mobile AquaCritox demonstration units that could be transported to potential clients' sites for tests of several months. The first unit constructed, which was commissioned in late 2017, is intended for applications with lower operating temperatures than WWTP installations would have. The second unit, which would be suitable for OCSD, is expected to be available in 2019 and could be key to an extensive onsite process

test. SCFI has expressed its intention to make this second unit available to OCSD as soon as it is available.

Estimated Schedule: TBD
Estimated Budget: TBD

- Wastewater Superoxygenation

  OCSD started investigating the superoxygenation technology from ECO2 Technologies more than 10 years ago and has considered this a viable option for odor and corrosion control in pump stations and treatment plants. As part of the upcoming rehabilitation of the Seal Beach Pump Station, Engineering staff requested a review of competing proven superoxygenation technologies, if any. A process from BlueInGreen LLC (Fayetteville, AR) was identified as a possible candidate. As project RE17-07, this will be investigated, first as an engineering evaluation, then possibly with an equipment test.

  Estimated Schedule: Completion in FY 2018-19
  Estimated Budget: $80,000

Appendix A

iTAG
(international Technology Approval Group)

Part 1: iTAG Program Description and Technologies Reviewed

An important element of OCSD's commitment to keeping current with developments in the wastewater industry is its membership in the (international) Technology Approval Group (known as TAG or iTAG). This is a global innovation forum involving some of the world's leading water and wastewater utilities. The TAG model was launched in the United Kingdom in 2005 by Isle Utilities, an engineering consulting firm focused on promoting new technologies and approaches in environmental practices.

Individual utilities have performance and sustainability objectives, but typically they do not have the time or staff to visit all the global trade shows, read every engineering journal, and meet with every sales representative to identify and evaluate potentially innovative solutions to save water, energy, and chemicals. At the same time, business developers of new technologies have a difficult time drawing the attention of the utilities who might benefit from their products.

Addressing these problems was Isle's goal in starting iTAG. With its staff of nearly 60 water professionals in several countries, Isle identifies and assesses new technologies for presentation to the iTAG member utilities. iTAG is structured to accelerate the development and adoption of new technologies by engaging the industry during a technology's precommercial stages of development (if it has not yet been commercialized) and by leveraging external investment from venture capital investors.

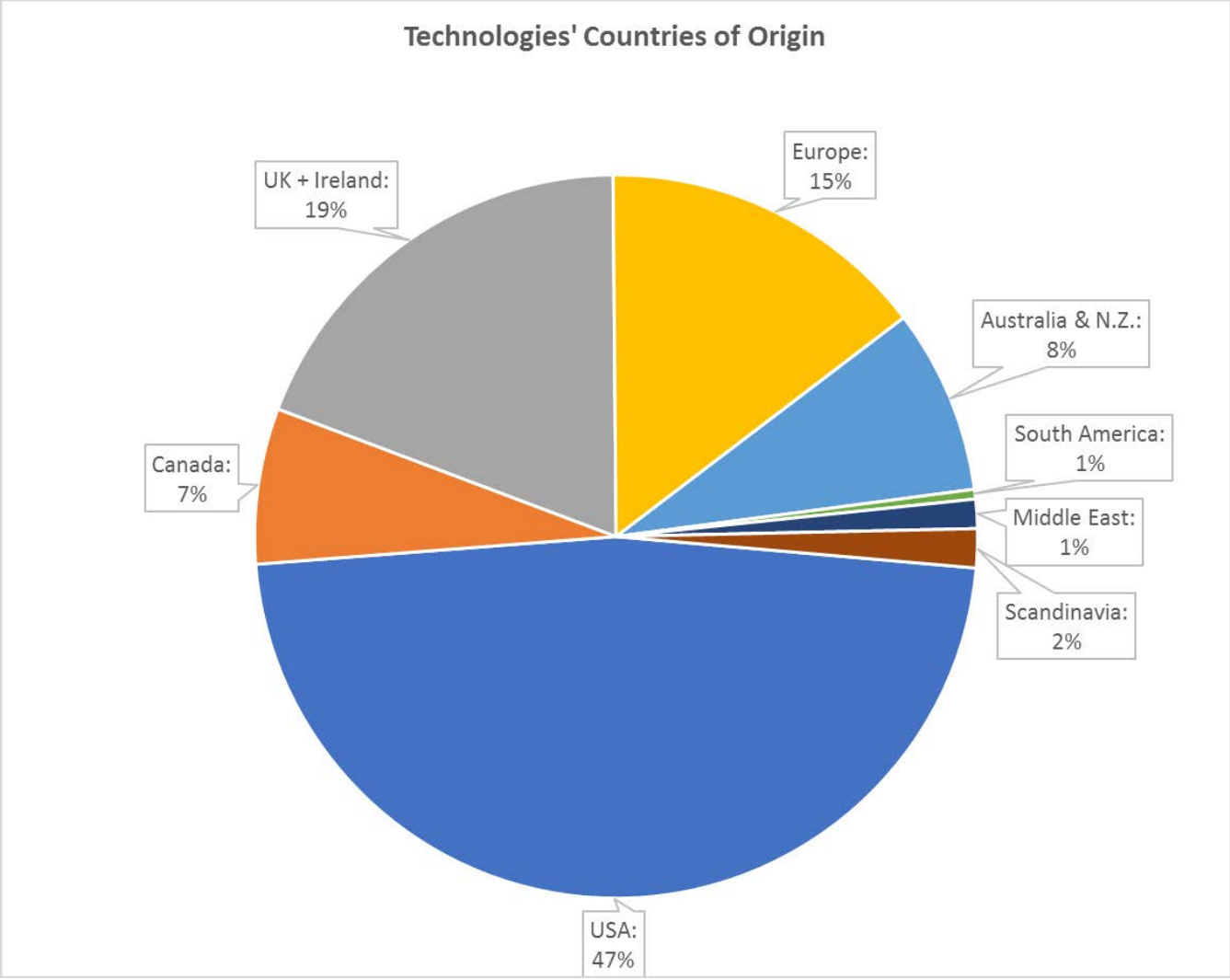
Since the inception of the US iTAG program in 2011 (with OCSD as the first member), it has grown to include regional iTAG groups in the Northeast, Texas, Ohio Valley, and Southeast, plus three in California. Currently, more than 40 US utilities are members of the iTAG forums. Other regional iTAG groups are located in Canada, the UK, Europe, South Africa, Australia, New Zealand, and Asia.

iTAG meetings now occur three times per year and provide opportunities for the member utilities to collaboratively review emerging technologies in relation to their own interests and needs. The members vote on the technologies they want to have presented at each meeting; afterwards, if there is sufficient interest by one or more utilities, this can lead to technology demonstrations and collaborative trials. Isle also has relationships with the US EPA, the Water Research Foundation, and the Water Environment and Research Foundation to enhance the opportunities for utilities to participate in collaborative projects and to disseminate the results to wider audiences.

Over the last ten years, Isle has evaluated over 100 new technologies each year, ranging from various new wastewater and solids treatment technologies to improved odor control approaches, process modeling software, predictive maintenance platforms, and novel ways to recover nutrients and energy. The information about the technologies presented at every

meeting around the world is available to every iTAG member utility through Isle's proprietary database. An additional benefit of iTAG membership is access to Isle's staff and resources for technology reviews and other consulting activities.

Through June 2018, a total of 230 technologies were suggested for possible presentations at OCSD's iTAG workshops. Of these, 114 were selected and presented at 23 workshops. The chart below shows the countries of origin of the 230 technologies. Although the USA accounted for the largest number of technologies, more than half were from other countries, consistent with the international scope of the iTAG program.



The table on the following pages shows the technologies that were considered for iTAG presentations. An asterisk after the technology name indicates it was selected for presentation.

Technology Name (* = workshop presentation)	Description	Origin
360 Water	Customized training, courses and modules for safe & efficient operation of water & wastewater equipment	USA
ABS Materials*	Glass based media to capture VOC's (also #69, not presented)	USA
ACWA Services	AMTREAT: High strength ammonia treatment system	UK
Advanced Biocatalytics*	ACCELL: Protein Surfactant Complex used to increase aerobic consumption while decreasing reproduction (also #42, not presented)	USA
Advanced Plasma Power	Combined gasification and plasma sludge destruction	UK
AeroThermal	Autoclave sludge pre-treatment (also #159, not presented)	UK
Alcoa	NEWT: Low footprint engineered wetlands for end-end wastewater treatment (also #210, not presented)	USA
Algae Enterprises	Algae-powered wastewater treatment (also #76, not presented)	Australia
Algaeventure Systems	Novel dewatering solution using water adhesion and capillary glands	USA
Ambio Biofiltration Ltd.*	Photoionisation: Odor control via UV light and a catalyst	Canada
AMDS*	Dissolved metals detection system	USA
Anaergia*	Omnivore: Retrofit package to increase anaerobic digester capacity (also #267, not presented)	USA
Analytical Technologies UK Ltd	Dissolved sulphide monitor for continuous monitoring with minimal maintenance	UK
ANDalyze*	Portable heavy metals detector	Germany
APG Neuros*	Highly adaptable blower for better control	Canada
AppliTek	Anasense: Online analyzer for VFA and ammonium measurements in anaerobic systems	Belgium
Aquaback*	Low cost, thin film distillation	USA
Aquen*	Forming flocs with optimal dewatering	Germany
Aqylon	Organic Rankine Cycle waste heat recovery	France
Arisdyne Systems*	Hydrodynamic cavitation digestion enhancement	USA
Artesis	Monitors condition to identify and diagnoses faults of motor driver equipment	UK
Assetic Predictor*	Strategic asset management and predictive modeling	Australia
Atlantis Technologies*	Low cost desalination technology	USA
Augury*	Combining the IoT and gold-standard practices for predictive maintenance	USA
Ayyeka	Plug and play creation of smart water networks	Israel
BacTest	Microbial respirometer to measure contamination in water	UK

Banyard	e-permits using cloud based data	UK
Bareau	Autogenerative high pressure digestion (also #104, not presented)	Netherlands
Baseform	Baseform SaaS: Wastewater utility software for infiltration & inflow (I&I) management and strategic infrastructure planning	Portugal
BBR Filter	Fluidized bed biofilter	Switzerland
BCR Environmental	Sludge conditioning and composting with chlorine dioxide to rid odors, enhance dewatering and increase methane production (also #30, not presented)	USA
BDP EnviroTech*	Biological double efficiency process	USA
Binder Group*	VACOMASS®: Precise airflow control valves for enhanced energy efficiency in biological treatment (also #244, not presented)	Germany
BioAir Solutions*	Biological treatment of odor and air pollutants	USA
BioCAST	Wastewater treatment and solids separation	Canada
BioCleaner*	Bioreactor with microbial media for wastewater treatment	USA
BioFiltro	Aerobic biological wastewater treatment (also #183, not presented)	Chile
BioForceTech*	BioDryer and P-FIVE: Biodrying and pyrolysis for low- energy biosolids management	USA
Biogas & Electric*	NOx and SOx reduction for biogas engines	USA
BioGill*	Nano-particulate membrane bioreactor that creates a high growth environment for bacterial and fungal biomass	Australia
Bio-Organic Catalyst	New category of additives to enhance biological treatment processes (also #180, not presented)	USA
Bio-Oxygen*	Odor control solution using electrode tubes to form reactive oxygen (also #10, not presented)	Australia
Bioptech*	Phosphorus removal and capture	Sweden
BioTector	Real time TOC monitoring (also #50, not presented)	Ireland
BioWISH*	Acceleration of enzymatic bio-chemical reactions to breakdown organics and reduce odor, VOCs, BOD, COD, phosphorus and solids	USA
BlueInGreen*	Side-stream gas dissolution	USA
Bluewater Bio	Advanced sludge process to increase capacity or meet stricter requirements	UK
Bluewater Bio*	Advanced biological wastewater treatment to increase existing capacity or meet tightening regulatory requirements (FilterClear) (also #20, not presented)	UK
Calix*	Sewer corrosion protection	Australia
Capilix*	Online measurement of ionic composition (also #26, not presented)	Netherlands
Charm Sciences Inc.	Coliphage detection as a fecal indicator	USA
Clearas*	Advanced biological nutrient recovery treatment (also #141, not presented)	USA

ClearCove*	Harvester: Enhanced primary treatment and headworks solution	USA
Clearwater Controls*	Device for pump deragging and optimization	UK
Cloevis*	Free nitrous acid for odor and corrosion prevention	Australia
Cloevis*	Free nitrous acid for odor and corrosion prevention	Australia
CNIguard	Monitoring and detection of critical infrastructure	UK
CNP*	Sludge optimization & struvite recovery after AD	USA
Confluence Group	Kona: Enterprise-class work & asset management solution built to enhance utility performance & decision making	USA
Connixt, Inc	Mobile apps for O&M, fieldwork	USA
ConSeal*	Rehabilitation of concrete in sewer environments	USA
Correlate Inc.	Virtual Energy Manager: Strategic Energy Management Software & Services	USA
Creative Water Technology	Low-temperature thermal distillation	Australia
Cresatech	Monitoring of low voltage (LV) supply to sites	UK
Criptonic Energy	Low-head hydro solution that utilizes sewage flow (also #140, not presented)	USA
Digital Mentor	Intuitive information storage and retrieval system	USA
DO2E	Digester for the oxidation and removal of FOG and odor (also #126, not presented)	USA
Drylet*	Aqua Assist: Unparalleled microbial activity acceleration leading to biosolids reduction in the 40-50% range	USA
Dynamic Flow*	Waste Water Meter: measurement of flow in pipes	UK
Earth Renaissance Technologies	Sulfur based wastewater treatment	USA
EasyFill	Haulage data collection to track and quantify plant loads to disposal sites	Australia
ECO Oxygen Technologies (ECO2)	SuperOxygenation: World's most efficient gas transfer solution	USA
ECO-SISTEMI	Compact modular system for wastewater treatment	Italy
Eco-Tabs*	Wastewater network bioremediation process	USA
EcoVia	Self-cleaning heat exchanger for wastewater	USA
EDI/BioChem	Integrated physical/virtual biological process operations management system	USA
EDLORE*	Augmenting reality for operations and maintenance	USA
Ekster and Associates*	Real time control system for activated sludge waste flow	USA
Electratherm*	Fuel-free, emission-free power from waste heat (also #232, not presented)	USA
Electro Scan*	Detection of leaks and ingress in collection systems	USA
ElectroCell	ElectroCell: Bio-electric cell lysis for enhancement of digestion and other biological treatment processes	USA
EMAGIN*	HARVI: Innovative artificial intelligence-driven platform for proactive management of critical wastewater infrastructure	Canada

Emefcy	Electrogenic Bioreactor (EBR) generates power with bacteria during treatment (also #27, not presented)	Israel
Emerson*	Rosemount Magflow Meter: Self-verifying flow meter	USA
E-MIGS	Drone for aerial surveys	UK
EmNet LLC	BLU-X: Smart water/real time decision support platform for optimization of wastewater collection systems	USA
Emrgy Hydro	Hydrokinetic power turbine for on-site power (also #152, not presented)	USA
Enaqua*	Activated fluoropolymer UV tubes for disinfection (also #154 & #205, not presented)	USA
Enbala Power Networks Inc.	Symphony by Enbala™: Intelligent demand management, generating additional revenue with energy intensive assets	Canada
Enertime	Sustainable electricity production (Organic Rankine Cycle) (also #157, not presented)	France
Enviplan	Solids separation using microfloatation (also #105, not presented)	Germany
Environmental Dynamics Int'l (EDI)	Symphony: Integrated physical / virtual biological process operations management system	USA
Envolure	Decision support for environmental bioprocesses	France
EPi Ltd*	Efficient pyrolysis unit to better and more cost effectively manage waste and maximize the generation of renewable energy (also #25, not presented)	UK
EST LTD	Ammonium sensor measures electric current from oxidizing NH3 to NH4+	UK
Evoqua*	Secondary treatment to increase biogas production (also #171, not presented)	USA
Ferrate Treatment Technologies*	Efficient onsite ferrate generation	USA
Floating Island International	Floating wetland treatment (also #85, not presented)	USA
Fluidion*	Power free sampler and analyzer	France
FT Pipeline Systems	PF Detect: Dual contained chemical dosing hose with leak detection function	UK
Genifuel Corporation*	Hydrothermal Processing: resource recovery and elimination of biosolids	USA
Great Circle Industries	Decentralized wastewater treatment and reuse (also #68, not presented)	USA
Greener Planet*	PrO2 delivers DO at a molecular level (without bubbles)	USA
Gryphon Environmental	Advanced belt-driver sludge drying	USA
GWR (FATHOM)	Utility optimization services for improving data and business processes associated with billing, customer service, asset management, and operations	USA
H2ope*	Compass: On-line feed forward coagulant control system	New Zealand

Hadronex*	Real-time sewer level and flow monitoring (also #48, not presented)	USA
Hawk Measurements*	Orca Sonar: Sonar-based submerged sludge bed measurement	USA
Heliex Power	Rotary screw expanders	UK
Herndon Group	WISE RT: Resource typing for emergency preparedness and response (also #208, not presented)	USA
Heron Innovators	Suspended AirFlotation (SAF): New approach to physiochemical separation by flotation	USA
Hydro Industries	Electrocoagulation to remove TSS, metals, FOG, COD and P	UK
Hydro Industries	Electrocoagulation to remove TSS, metals, FOG, COD and phosphorus (also #74, #86, & #107, not presented)	UK
HydroFLOW*	HydroFLOW I Range: Non-intrusive, chemical-free struvite prevention/removal and sludge dewatering enhancement	USA
HydroMax	p-CAT: Pipeline condition assessment	USA
Hydroventuri*	Novel venturi fine bubble air diffuser	UK
ID Modeling	Real time integrated decision support analytics	USA
IER Environmental Services	Gener-Ox: dissolved oxygen for odor and corrosion control (also #142, not presented)	USA
Igloo Vision	360°projection space for displaying any type of VR, BIM or 3D content	UK
InfoSense	Low cost sewer screening to target cleaning resources (also #131, not presented)	USA
InnovaPrep LLC	Microbial concentration by membrane filtration	USA
In-Pipe Technology	Fluidized composting for organic waste	USA
In-Pipe Technology*	Bacillus dosing to increase efficiencies by reducing influent loading and costs of sludge management, chemicals, energy, and FOG	USA
Invent	Online measurement of aeration alpha factor	Germany
Inventive Resources*	Manhole Odor Eliminator (MOE): Carbon filter odor control system for sewer vents, grease traps, and other manholes	USA
Invest-e Group*	Secondary and tertiary treatment with nutrient removal	Spain
IOSight	Business intelligence software for data management and reporting (also #115, not presented)	Israel
iota	SUREpoint telemetry: self-learning low pressure sewer monitoring system	Australia
iota	OneBox telemetry: solutions for CSOs and pressure sewer networks	Australia
IPEX*	Odor control and energy generation from collection system (also #90, not presented)	Canada
Keg	Hydraulic sewer jetting system with integrated, wireless, self-leveling sewer inspection camera	Germany
KORE Infrastructure	Biosolids into high-value products (also #169, not presented)	USA
Lhoist*	SLS45®: Highly reactive, low viscosity liquid lime as a replacement to caustic soda and other alkali.	USA

Lontra Ltd*	Compact variable capacity compressor (Blade Compressor) uses 20% less energy than conventional compressors (also #3, not presented)	UK
LuminUltra	Biological water quality monitor	Canada
Lystek*	Hydrolysis for biofertilizer production (also #123, not presented)	Canada
Mango Materials*	Transformation of methane biogas into bioplastics	USA
MANTECH*	Non-hazardous COD analysis	Canada
MAR Systems*	Selenium removal media	USA
MaxWest*	Designs and operates disposal facilities using gasification process to convert biosolids and other organic wastes into thermal energy and inert ash	USA
Meniscus*	Real time analytics platform for smart data management	UK
Microbe Detectives*	Solving microbial problems using DNA	USA
microLAN	BACTcontrol: automated, online monitor for rapid detection of total and specific bacteria	Netherlands
Micromidas*	Converts sludge into biodegradable plastics and increases treatment capacity	USA
Microvi*	Concentrated biocatalysts for contaminant removal	Australia
Millipore Sigma*	Total Nitrogen Test Kits: Single colorimetric test to replace the traditional TKN+Nitrate+Nitrite method for measurement of TN	USA
Modern Water	Continuous toxicity monitoring biosensor (also #148, not presented)	USA
MTA Messtechnik GmbH*	Pipe-Inspector: Cable-less video pipeline inspection with integrated acoustic leak detection	Austria
Mtv	Cloud-based sharing of operational expertise (also #65, not presented)	Switzerland
Natel Energy	hydroEngine: Distributed Hydro Power (hydroelectric turbines suitable for low-head, high flow) (also #198, not presented)	USA
New Sky Energy*	Converting waste gas streams into chemicals	USA
NJBSoft LLC*	Compliance Management Software	USA
NRP*	Natural biocatalyst for bacteria stimulation	USA
NVP Energy*	Low temperature anaerobic digestion	Ireland
O-Flexx	Energy generation from waste heat	Germany
OptiEnz Sensors	Continuous real-time in-situ organic chemical sensors	USA
Optimatics	Optimization software (also #170, not presented)	USA
OptimEDAR	Low cost aeration control	Spain
OptiRTC	OptiNimbus: Predictive control for maximized reuse	USA
Organica*	Fixed-bed biofilm activated sludge system	Hungary
Ostara*	Nutrient recovery to reduce struvite deposition and convert to fertilizer	Canada

Ovivo	DigestivorePAD: Post Aerobic Digestion to enhance biosolids management, nutrient removal, struvite prevention and odor control	USA
OxEmS	Electromagnetic tagging solution to identify and maintain buried infrastructure, including leak detection	UK
OxyMem*	Bubble-less membrane aeration	Ireland
Pacific Environment*	EnviroSuite: Predictive management and rapid analysis of odor issues for fast response and prevention	Australia
Parker Hannifin Corp.*	Momentus: Fouling-resistant, vibrating membrane process for concentration of brines and by-products from treatment	USA
Pasteurization Technology Group	Wastewater pasteurization, using reclaimed waste heat, for disinfection and reuse (also #70, not presented)	USA
PDX	Supersonic steam injection for enhanced digestion	UK
Pi2 Technologies	PODZ Horizon: Geomembrane with integrated odor filters	Canada
PICA	High-resolution, electromagnetic pipe inspection tools	USA
Planit	Smart Planning for Utilities: GIS-based asset management for efficient maintenance and works planning	New Zealand
Power & Water	Sonoelectrochemical water treatment	UK
PpTek*	Siloxane removal system to protect biogas engines	UK
Primozone	Low energy ozone generation	Sweden
Primus Line*	Rädlinger: High pressure, trenchless pipe lining system for trunk mains and sewer force mains	Germany
Process Instruments Ltd	Polysense - control system for polymer dosing (has other instrumentation solutions)	UK
Process System Enterprises*	PlantOptimiser: High-fidelity modeling and optimization of whole WWTP or individual treatment processes (also #228, not presented)	USA
ProKASRO	UV curing in sewer rehabilitation to allow for non-invasive GRP relining which is cured in-situ with specially developed UV lamps	UK
Prote*	No-risk WWTP optimization service	Poland
Pulsed Hydraulics*	Large Bubble Mixing System: Energy-efficient sequential large bubble vertical mixer for liquids and slurries	USA
Puralytics	Advanced oxidation process to disinfect and detoxify water	USA
Qualvista	Biogas Monitor: Online monitor for continuous detection of siloxanes in biogas	Finland
Quasar Energy Group*	High solids AD co-digestion with nutrient recovery	USA
Radio Data Networks*	FDT wireless smart flow detection transducer	UK
RedEye	Purpose-built, cloud and mobile engineering data management solution	Australia
RedZone Robotics*	SOLO and ICOM: Autonomous robot and software for sewer asset inspection and management (also #177, not presented)	USA
Reliant*	Effective clearance of FOG and H2S in collection	USA

Renewable Nutrients*	QuickWash: Scalable solution for phosphorus extraction and recovery from liquid or solid waste streams	USA
Resource Converting	Dryclone: Non-thermal drying system for biomasses	USA
Rewitec	Nano coating to reduce frictional mechanical wear	Germany
Rezatec	Proactive wastewater pipeline failure risk monitoring using satellite data	Canada
Riva Modeling	Asset management and planning software	USA
Robotic Pipe Repair*	Robotic pipe maintenance	USA
Royal HaskoningDHV*	Nereda aerobic granular sludge process (also #72, not presented)	Netherlands
RS Hydro	Real-time BOD monitoring system	UK
SCFI Group*	Supercritical water oxidation of sludge (Aqua Critox)	Ireland
Sensorex*	UV transmittance analyzer using UV-LED light source	USA
SensorWare Systems*	Automated data collection and sharing	USA
SeSys*	CCTV for hazardous environments	UK
SewerBatt	Sewer inspection tool	UK
SewerVUE*	Pipe penetrating radar technology for pipe inspection (also #128, not presented)	Canada
SISLtech*	WWTP control and optimization to significantly reduce energy use	Spain
SmartFlow	Electric field and current hydrolysis of sludge (also #88, not presented)	UK
Solvay Chemicals*	Peracetic acid as alternative to chlorine for disinfection (also #187, not presented)	USA
Sorbisense*	Effective pollution source tracking in discharge systems (also #118, not presented)	Denmark
Statiflo	Optimized chemical dosing using a free flowing mixer	UK
Strathkelvin*	Activated sludge plan controller	UK
SuperOx*	Supersaturated oxygenated water injection	USA
Sustainable Infrastructure Solutions	Anaerobic digestion and sludge management	Australia
Sustec	Continuous thermal hydrolysis process (also #160, not presented)	Netherlands
SwiftComply	Platform connecting sewer owners with hospitality businesses for real time sharing of FOG compliance data (source: Ireland / USA)	Ireland
Tecta-PDS	EPA-approved, automatic microbiological analysis system	Canada
TerraNova Energy	Hydrothermal carbonization of sludge	Germany
ThermoEnergy*	Developed a platform technology that uses physical chemical properties of wastewater to separate and recover high value process chemistries	USA
Thermowatt*	Energy generation from the collection system	Hungary

Toolcoach	Vibration timer to reduce injury	UK
Uhrig Kanaltechnik	Heat recovery system for sewer networks to reduce energy costs, offset carbon emissions and potentially generates revenue	Germany
Ultrasonic Systems	Combines ultrasonic and ozonation disinfection	Germany
Utility Service Group*	Ice pigging to clean mains (also #81, not presented)	USA
Utilix*	Accessible mapping and visualization of underground assets in the field	Australia
UVS Trenchless*	Identifies leaks quickly in non-conductive pipes	Australia
Vienna Water Monitoring	ColiMinder®: Rapid, online microbiological water quality monitoring	Austria
Viroment*	Vacuum solids separation	USA
Volute*	Sludge dewatering screw press	Ireland
Water Planet Inc.*	PolyCera Membrane: Ceramic membrane-like performance at polymeric membrane cost	USA
WesTech*	Compressible media filtration for wastewater solids and cBOD removal (also #155, not presented)	USA
Wright Tech	Biodryer: Utilizing microbial heat for low energy biosolids drying	Canada
Xogen	Electrolytic process to destroy pathogens in minutes (also #19, not presented)	Canada
Xylem*	Flygt ConcertorTM: Intelligent Wastewater Pumping System	USA
ZAPS*	Real time analysis of multiple water quality parameters	USA

Part 2: iTAG Workshop Details

The following table presents details about each iTAG workshop at OCSD, including the date, the agencies attending, and the technologies that were presented. The entries marked with a "+" are known to have had significant follow-up with OCSD; this could range from data exchanges to further evaluate a technology's suitability for OCSD to actual onsite testing at OCSD facilities.

Workshop # 1		2/16/2011	FY 2010-11
Attending Agencies:		OCSD	
Technologies Presented			
SCFI Group	+	Supercritical water oxidation of sludge (AquaCritox)	
Ostara	+	Nutrient recovery to reduce struvite deposition and convert to fertilizer	
BioWISH		Acceleration of enzymatic biochemical reactions	
Micromidas	+	Converts sludge into biodegradable plastics	

Workshop # 2		11/7/2011	FY 2011-12
Attending Agencies:		OCSD; AWWA; City of San Diego; NWRI	
Technologies Presented			
ThermoEnergy		Technology to separate and recover ammonia from wastewater	
Lontra Ltd		Compact variable capacity compressor (Blade Compressor)	
Cloevis	+	Free nitrous acid for odor and corrosion prevention	
MaxWest		Gasification process for biosolids and other organic wastes	

Workshop # 3		5/14/2012	FY 2011-12
Attending Agencies:		OCSD; City of Escondido; City of Los Angeles; Global Water; IEUA; IRWD; MWD; San Diego County Water	
Technologies Presented			
Capilix		Online measurement of ionic composition	
EPi Ltd		Pyrolysis to manage waste and maximize renewable energy generation	
SuperOx	+	Supersaturated oxygenated water injection	
In-Pipe Technology		Bacillus dosing to increase efficiencies by reducing influent loading	
BioGill		Nano-particulate membrane bioreactor	

Workshop # 4		11/8/2012	FY 2012-13
Attending Agencies:		OCSD; American Water; City of Escondido; Global Water; IEUA; IRWD	
Technologies Presented			
Hydroventuri		Novel venturi fine bubble air diffuser	
Organica	+	Fixed-bed biofilm activated sludge system	
Bluewater Bio		Advanced biological wastewater treatment: HYBACS and FilterClear	
Bio-Oxygen		Odor control solution using electrode tubes to form reactive oxygen	
ZAPS	+	Real time analysis of multiple water quality parameters	

Workshop # 5		4/8/2013	FY 2012-13
Attending Agencies:		OCSD; American Water; Columbus Water Works; City of Escondido; Global Water; EWA; IEUA IRWD; SMWD	
Technologies Presented			
Ferrate Treatment Technologies		Efficient onsite ferrate generation	
Thermowatt		Energy generation from the collection system	
ConSeal		Rehabilitation of concrete in sewer environments	
APG Neuros		Highly adaptable blower for better control	
ANDalyze		Portable heavy metals detector	

Workshop # 6		7/29/2013	FY 2013-14
Attending Agencies:		OCSD; EMWD; IRWD; EWA; EBMUD; IEUA; CVWD; SOCWA; San Francisco Public Utilities; City of Escondido	
Technologies Presented			
PpTek		Siloxane removal system to protect biogas engines	
Biogas & Electric		NOx and SOx reduction for biogas engines	
BlueInGreen		Side-stream gas dissolution	
Atlantis Technologies		Desalination using super capacitors	
MAR Systems		Adsorbent for selenium removal	

Workshop # 7		10/28/2013	FY 2013-14
Attending Agencies:		OCSD; EBMUD; IRWD; IEUA; SOCWA; Los Angeles Bureau of Sanitation	
Technologies Presented			
Royal HaskoningDHV	+	Nereda aerobic granular sludge process	
Utility Service Group		Ice pigging to clean mains	
ABS Materials		Glass based media to capture VOC	
SeSys		CCTV for hazardous environments	
Electro Scan		Detection of leaks and inflow in collection systems	

Workshop # 8		1/30/2014 FY 2013-14
Attending Agencies:		OCSD; EBMUD; EWA; Global Water; IEUA; IRWD; Los Angeles Bureau of Sanitation; City of San Diego; City of Escondido; National Water Company (Saudi Arabia)
Technologies Presented		
Microbe Detectives		Solving microbial problems using DNA
EDLORE		Augmenting reality for operations and maintenance
Fluidion		Power free sampler and analyzer
IPEX		Odor control and energy generation from collection system
Arisdyne Systems	+	Hydrodynamic cavitation digestion enhancement

Workshop # 9		4/15/2014 FY 2013-14
Attending Agencies:		OCSD; EBMUD; American Water; Coachella Valley WD; IEUA; IRWD; City of San Diego; City of Escondido; EWA; Los Angeles Bureau of Sanitation
Technologies Presented		
NRP		Natural biocatalyst for bacteria stimulation
SISLtech		WWTP control and optimization to significantly reduce energy use
Strathkelvin		Activated sludge plan controller
Meniscus		Real time analytics platform for smart data management
Volute	+	Sludge dewatering screw press

Workshop # 10		7/24/2014 FY 2014-15
Attending Agencies:		OCSD; EBMUD; IRWD; City of San Diego; EWA; American Water; Global Water; San Francisco PUC
Technologies Presented		
Bioptech		Phosphorus removal and capture
Clearwater Controls		Device for pump deragging and optimization
Hadronex	+	Real-time sewer level and flow monitoring
AMDS	+	Dissolved metals detection system
BioCleaner		Bioreactor with microbial media for wastewater treatment

Workshop # 11		10/23/2014	FY 2014-15
Attending Agencies:		OCSD; EBMUD; American Water; EWA; Global Water; IRWD. City of San Diego; City of Escondido; IEUA; City of San Luis Obispo; WERF	
Technologies Presented			
NVP Energy		Low temperature anaerobic digestion	
Lystek	+	Hydrolysis for biofertilizer production	
Evoqua		Secondary treatment to increase biogas production	
Cloevis	+	Free nitrous acid for odor and corrosion prevention	
SewerVUE		Pipe penetrating radar technology for pipe inspection	
Invest-e Group		Secondary and tertiary treatment with nutrient removal	

Workshop # 12	2/3/2015	FY 2014-15
Attending Agencies:	OCSD; EBMUD; IRWD; City of San Diego; City of Escondido; Coachella Valley WD; IEUA	
Technologies Presented		
BioAir Solutions	Biological treatment of odor and air pollutants	
New Sky Energy	Converting waste gas streams into chemicals	
SensorWare Systems	Automated data collection and sharing	
Aquen	Forming flocs with optimal dewatering	
Ekster and Associates	Real time control system for activated sludge waste flow	

Workshop # 13		4/23/2015	FY 2014-15
Attending Agencies:		OCSD; EBMUD; EWA; City of San Diego; IEUA; LACSD; Long Beach Water; Santa Ana Watershed Project	
Technologies Presented			
Robotic Pipe Repair		Robotic pipe maintenance	
Sorbisense	+	Effective pollution source tracking in discharge systems	
BDP EnviroTech		Biological double efficiency process	
Quasar Energy Group		High solids AD co-digestion with nutrient recovery	
Calix		Sewer corrosion protection	

Workshop # 14	7/23/2015	FY 2015-16
Attending Agencies:	OCSD; IEUA; LACSD; City of Escondido	
Technologies Presented		
CNP	Sludge optimization & struvite recovery after AD	
Microvi	Concentrated biocatalysts for contaminant removal	
Aquaback	Low cost, thin film distillation	
MANTECH	Non-hazardous COD analysis	
Viroment	Vacuum solids separation	

Workshop # 15		10/22/2015	FY 2015-16
Attending Agencies:		OCSD; EBMUD; IEUA; LACSD	
Technologies Presented			
OxyMem		Bubble-less membrane aeration	
NJBSoft LLC		Compliance Management Software	
Eco-Tabs		Wastewater network bioremediation process	
Radio Data Networks		FDT wireless smart flow detection transducer	
Clearas		Advanced biological nutrient recovery treatment	

Workshop # 16		3/1/2016	FY 2015-16
Attending Agencies:		OCSD; EBMUD; IEUA; LACSD; City of Escondido; American Water	
Technologies Presented			
Solvay Chemicals	+	Peracetic acid as alternative to chlorine for disinfection	
Reliant	+	Effective clearance of FOG and H2S in collection	
Assetic Predictor		Strategic asset management and predictive modeling	
WesTech		Compressible media filtration for wastewater	
UVS Trenchless		Identifies leaks quickly in non-conductive pipes	

Workshop # 17		6/7/2016	FY 2015-16
Attending Agencies:		OCSD; EBMUD; IEUA; LACSD; MWD; City of Escondido	
Technologies Presented			
Prote		No-risk WWTP optimization service	
Sensorex		UV transmittance analyzer using UV-LED light source	
Dynamic Flow		Waste Water Meter (WWM) for flow measurement in pipes	
Enaqua		Activated fluoropolymer UV tubes for disinfection	
Emerson		Rosemount Magflow Meter: Self-verifying flow meter	

Workshop # 18		8/11/2016	FY 2016-17
Attending Agencies:		OCSD; IEUA; LACSD; City of Escondido	
Technologies Presented			
H2ope		Compass: On-line feed forward coagulant control system	
ClearCove		Harvester: Enhanced primary treatment and headworks solution	
Mango Materials		Transformation of methane biogas into bioplastics	
Water Planet Inc.		PolyCera Membrane: Ceramic membrane-like performance at polymeric membrane cost	
Renewable Nutrients		QuickWash: Scalable solution for phosphorus extraction and recovery from liquid or solid waste streams	

Workshop # 19		3/9/2017	FY 2016-17
Attending Agencies:		OCSD; IEUA; LACSD; City of Escondido; City of Oceanside; LA Cleantech Incubator; South Tahoe PUD	
Technologies Presented			
MTA Messtechnik GmbH		Pipe-Inspector: Cable-less video pipeline inspection with integrated acoustic leak detection	
Hawk Measurements	+	Orca Sonar: Sonar-based submerged sludge bed measurement	
Genifuel Corporation	+	Hydrothermal Processing: resource recovery and elimination of biosolids	
Primus Line		Rädlinger: High pressure, trenchless pipe lining system for trunk mains and sewer force mains	
Process System Enterprises		PlantOptimiser: High-fidelity modeling and optimization of whole WWTP or individual treatment processes	

Workshop # 20		6/29/2017	FY 2016-17
Attending Agencies:		OCSD; IEUA; LACSD; City of Escondido; City of Thousand Oaks	
Technologies Presented			
Augury		Combining the IoT and gold-standard practices for predictive maintenance	
Electratherm		Fuel-free, emission-free power from waste heat	
Pacific Environment		EnviroSuite: Predictive management and rapid analysis of odor issues for fast response and prevention	
BioForceTech		BioDryer and P-FIVE: Biodrying and pyrolysis for low- energy biosolids management	
Greener Planet	+	PrO2: Delivers DO at a molecular level (without bubbles)	

Workshop # 21		11/7/2017	FY 2017-18
Attending Agencies:		OCSD; City of Escondido; City of Thousand Oaks; Denver Metro; IEUA; LACSD; South Tahoe PUD	
Technologies Presented			
Ambio Biofiltration Ltd.		Photoionisation: Odor control via UV light and a catalyst	
Drylet		Aqua Assist: Unparalleled microbial activity acceleration leading to biosolids reduction in the 40-50% range	
HydroFLOW		HydroFLOW I Range: Non-intrusive, chemical-free struvite prevention/removal and sludge dewatering enhancement	
Parker Hannifin Corp.		Momentus: Fouling-resistant, vibrating membrane process for concentration of brines and by-products from treatment	
RedZone Robotics		SOLO and ICOM: Autonomous robot and software for sewer asset inspection and management	
Vienna Water Monitoring		ColiMinder®: Rapid, online microbiological water quality monitoring	

Workshop # 22	3/1/2018	FY 2017-18
Attending Agencies:	OCSD; City of Escondido; City of Thousand Oaks; Denver Metro; IEUA; LACSD; South Tahoe PUD; Monterey One Water; Moulton Niguel WD; City of Englewood (CO); City of Roseville	
Technologies Presented		
Advanced Biocatalytics	ACCELL: Protein Surfactant Complex used to increase aerobic consumption while decreasing reproduction	
Binder Group	VACOMASS®: Precise airflow control valves for enhanced energy efficiency in biological treatment	
EMAGIN	HARVI: Innovative artificial intelligence-driven platform for proactive management of critical wastewater infrastructure	
Lhoist	SLS45®: Highly reactive, low viscosity liquid lime as a replacement to caustic soda and other alkali.	
Pulsed Hydraulics	Large Bubble Mixing System: Energy-efficient sequential large bubble vertical mixer for liquids and slurries	

Workshop # 23	6/5/2018	FY 2017-18
Attending Agencies:	OCSD; City of Escondido; City of Thousand Oaks; Denver Metro; IEUA; LACSD; South Tahoe PUD; Monterey One Water; Moulton Niguel WD; City of Englewood (CO); City of Roseville; City of Englewood (CO); City of Santa Barbara; Danish Water Alliance; SOCWA	
Technologies Presented		
Anaergia		Omnivore: Retrofit process to enhance anaerobic digester capacity and flexibility
Xylem		Flygt Concertor: Intelligent Wastewater Pumping System
Millipore Sigma		Total Nitrogen Test Kits: Single colorimetric test to replace the traditional 3-compound method for TN measurement
Inventive Resources	+	Manhole Odor Eliminator (MOE): Carbon filter odor control system for sewer vents, grease traps, and other manholes
Utilix	+	Accessible mapping and visualization of underground assets in the field

Appendix B

OCSD Organizational Memberships Related to Research

OCSD Organizational Memberships Related to Research

Organization	Description of Organization and Benefits of Membership
National Water Research Institute (NWRI)	NWRI sponsors projects and programs focused on ensuring safe, reliable sources of water. Its interests include encouraging public support of conservation and higher water use efficiency, implementing strategies to allocate and sustain water resources on regional and national levels, protecting existing water supplies from impacts on quality and quantity, developing technologies that identify and remove contaminants from water supplies, identifying treatment technologies that are cost- and energy efficient, and educating youth on water issues and future water needs. To leverage funding, NWRI arranges strategic partnerships with organizations in the water and wastewater industries. Its major activities include funding and guiding scientific research projects, supporting water-related educational programs, developing outreach material, holding workshops and conferences to promote new issues and technologies, providing peer-review panel services, managing projects or programs for water agencies and others, and awarding scholarly and practical achievements in water research with a national prize. OCSD's annual membership dues are $50,000 (Div. 740).
Southern California Coastal Water Research Project (SCCWRP)	SCCWRP's purpose is "to increase the scientific knowledge of how treated wastewater discharges, storm water discharges, and other human activities interact to affect coastal aquatic ecological systems, and thereby to ensure protection of these resources." Association with SCCWRP provides opportunities for OCSD to participate in regional research and development (such as ongoing nutrient cycling sampling) that facilitates a better understanding of the results of the individual wastewater dischargers by placing them in a regional context, engaging in regional discussions related to the interpretation of observations made by participating agencies, and participating in staff training and development activities related to ocean monitoring that might not otherwise be available. OCSD's annual membership dues are $450,000 (Div. 610).
Water Environment and Research Foundation (WE&RF)	WE&RF is the successor to the Water Environment Research Foundation and the WateReuse Research Foundation. Its mission is to lead independent scientific research dedicated to wastewater and storm water issues and to conduct and promote applied research on the reclamation, recycling, reuse, and desalination of water. As a WE&RF member, OCSD has access to all research results and also is able to become actively involved in steering the direction of research projects through individual staff members' participation on Issue Area Teams. OCSD's annual membership dues are $89,000 (Div. 740).

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OCSD 09/18