Orange County Sanitation District

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Research Report 2012

2012
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 (TAG), a staff technical committee charged with 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 TAG membership provides scientific and engineering expertise and reflects the wide-ranging occurrence of research activities throughout the agency.

The TAG members in 2011-12 were:

Operations and Maintenance

- Jeff Armstrong
- Kim Christensen
- Michelle Hetherington

Engineering

- Jeff Brown
- Jim Burror
- Tom Meregillano
- Andre Miller
- Y. J. Shao

Facilities Support Services

- Carla Dillon

Part 1

Introduction and Overview

Part 1

Introduction and Overview

This document is a report of OCSD research activities for fiscal year 2011-12 carried out by various divisions in the Engineering and Operations & Maintenance departments. The document brings together in one place summaries of research-related expenditures (Part 2), summary (Part 3) and detailed (Part 4) information about specific projects, and plans for relevant activities in the upcoming year (Part 5).

The activities during this year addressed a range of topics, with notable efforts in ocean monitoring activities and treatment process improvements. There also were cooperative projects with wastewater industry research organizations and with universities, arrangements that provided substantial leveraging of OCSD's funds.

Although information about each project is presented in Parts 3 and 4, the progress and benefits of several selected projects are highlighted below.

• Fuel cell demonstration	This uses a renewable resource (digester gas) to produce environmentally "clean" electricity and hydrogen for vehicle fuel with virtually no regulated air emissions. The energy station (fuel cell) and hydrogen fueling station have completed their first year of operation.
• Superoxygenation for odor control	After conducting intensive onsite sampling programs at two pump stations to provide accurate information about the wastewater characteristics, preparations have begun to install a superoxygenation system at the Main Street pump station. This will provide real-world data about the effective use of superoxygenation, with or without other chemicals, in a mixed force main/gravity main sewer system.
• OpenCEL process for digestion improvement	If effective, this sludge treatment will increase digester gas production and reduce residual biosolids amounts, leading to reduced O&M costs of several million dollars per year. Baseline digester performance data was collected during 2011-12, and the OpenCEL system will be installed in 2012-13.
• Food waste co-digestion	In addition to producing additional methane, co-digestion of food waste also might improve the overall digester operation, including increased VS destruction and biogas production from the municipal wastewater organic components.

New research projects will be undertaken in response to OCSD's current and future needs. Toward this end, OCSD is a member of iTAG, an international consortium of wastewater agencies, to facilitate identifying and evaluating emerging technologies from around the world that could be beneficial for OCSD. 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

Research Financial Summary

Part 2

Research Financial Summary

During 2011-12, the budget for research totaled $2.2 million, including $1 million as an annual allocation for operational research projects. (See Figure 2-1a.) This could be divided into three distinct types of expenditures: CIP Research, CIP Other, and Operating.

"CIP Research" includes the types of projects that historically were funded as individual line items in the CIP budget (e.g., SP-121 Superoxygenation) and now (as new projects are started) are funded from the annual allocation (project SP-125) that became part of the CIP budget in 2007-08. These projects include studies, pilot tests, and full-scale demonstrations of innovative products and processes related to collections system, treatment plant, and ocean monitoring operations. This category was 69% of the total research budget.

"CIP Other" includes capital (CIP budget) projects that are essentially research in nature but are funded from other parts of the CIP budget. In 2011-12, only one project was in this category: air emissions control of Central Generation engines (project J-79). This category was only 2% of the total research budget. [In previous years, the fuel cell demonstration costs (projects SP-132 and SP-134) were included in this category as the equipment was being installed. However, with construction completed and the equipment operating, OCSD's personnel costs are captured as project SP-125-4, which is part of the CIP Research total.]

"Operating" includes expenditures that are research in nature but will not lead directly to facility improvements or modifications and thus are not included in the CIP budget. In 2011-12, these expenditures were for memberships in various research-related organizations; in other years, this category has included projects (often cooperative projects through research organizations) that were funded from specific division budgets. This category was 29% of the total research budget.

Figure 2-1b shows the distribution of actual expenditures for 2011-12. While the budget was $2.2 million, the expenditures totaled only $1.2 million. This is primarily because the annual allocation ($1 million) appears in the budget as a level amount over several years, whereas actual project expenditure schedules typically follow an S-curve with lower than average expenditures near the beginning as new projects are started and higher expenditures in later years. For example, although substantial installation activities for a major project (OpenCEL process evaluation) occurred in 2010-11 and 2011-12, the contract provides for a single payment (up to $300,000) for these activities when they are completed, which will occur in 2012-13. That also will mark the beginning of monthly lease payments ($32,000) during the duration of the test period.

The actual expenditures for the other groups (CIP Other and Operating) were 98% of their budgeted amounts for the year.

Figure 2-2 shows the actual expenditures broken down by focus category. Other than organization memberships (53%), the largest fraction (18%) is for projects related to ocean monitoring activities, closely followed (17%) by projects related to process alternatives or improvement (such as changes in anaerobic digester operations). Smaller fractions are devoted to categories such as environmental improvement, odor and corrosion control, and air quality issues. Details about the projects in each category are presented in Parts 3 and 4 of this report.

Leveraging OCSD Funds

Through its participation in cooperative projects with research institutions and other agencies, OCSD leverages funds to receive substantial benefits without funding the entire cost of a project. Figure 2-3 illustrates the leveraging achieved for these projects, separating the fuel cell demonstration project from other projects due to its notably larger budget. The fuel cell project shows 13:1 leveraging of its total $8.0 million cost, and the other projects show 18:1 leveraging of a total $0.5 million cost. (While previous years have had multiple "other" projects, the only such project in 2011-12 was a WERF project dealing with trace organic compounds.) Overall, for a total cost of $0.6 million, OCSD benefits from projects budgeted at $8.5 million.

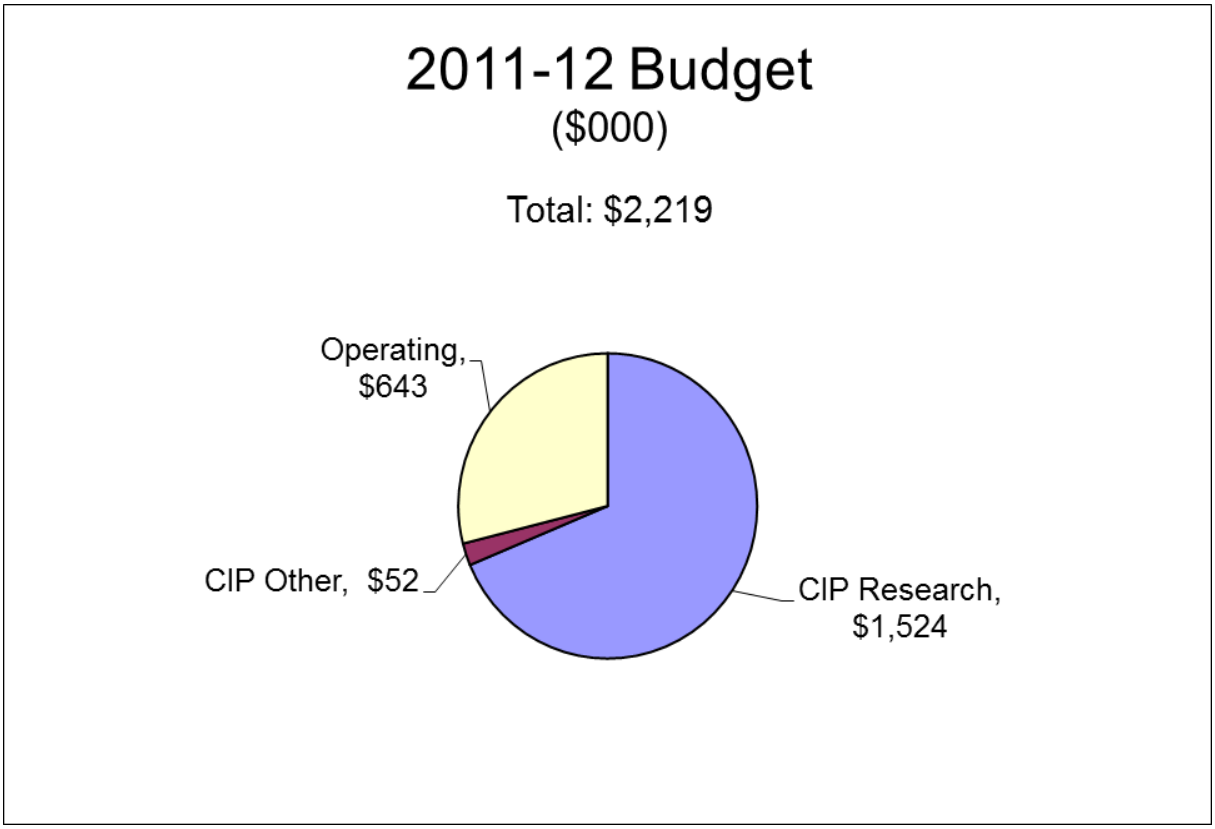

Figure 2-1a. Research Budget by Expenditure Type

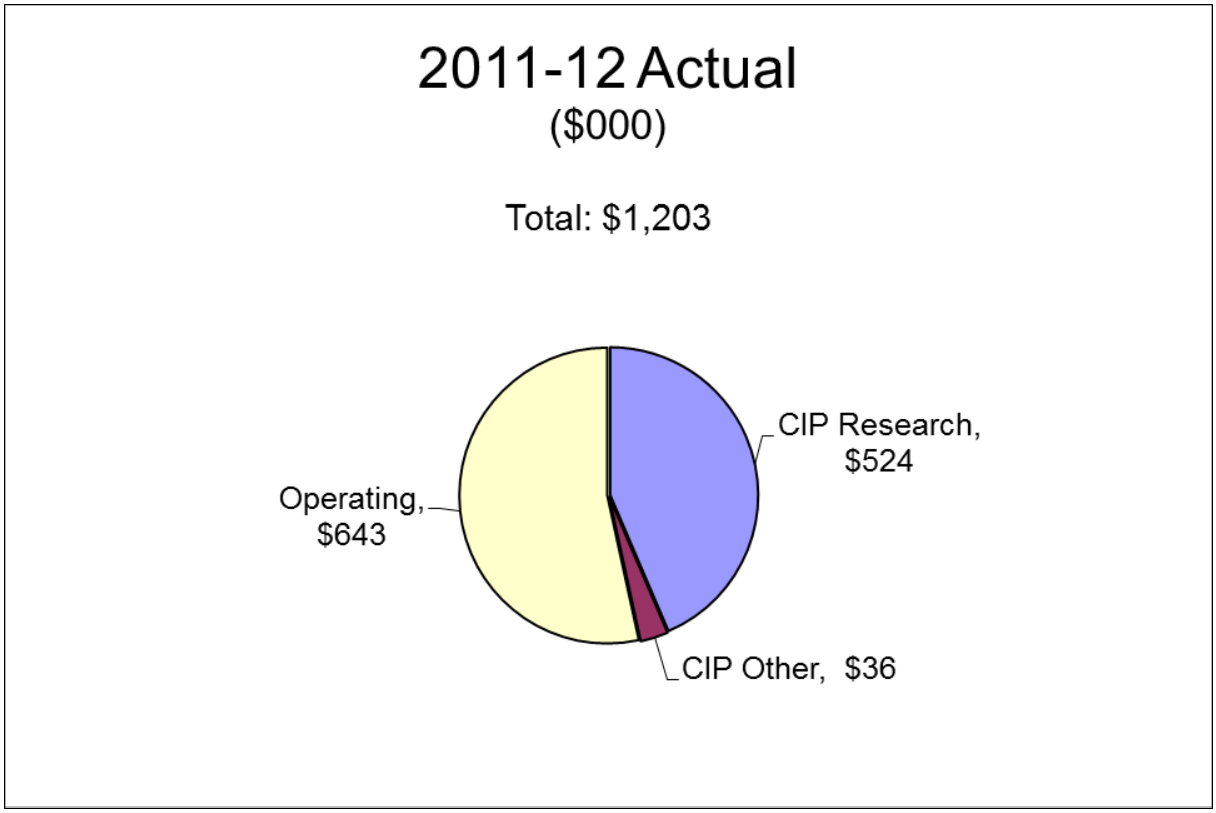

Figure 2-1b. Actual Research Expenditures by Expenditure Type

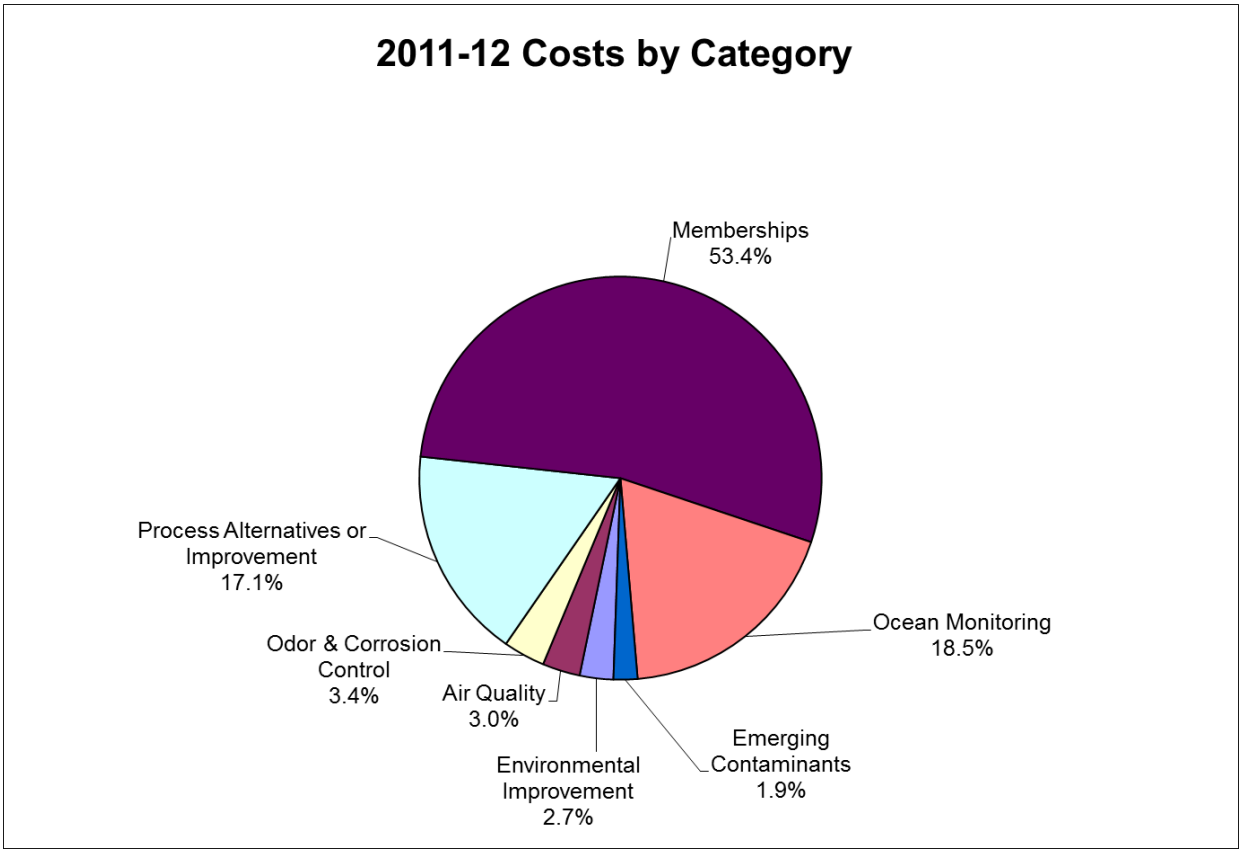

Figure 2-2. Actual Research Expenditures by Focus Category

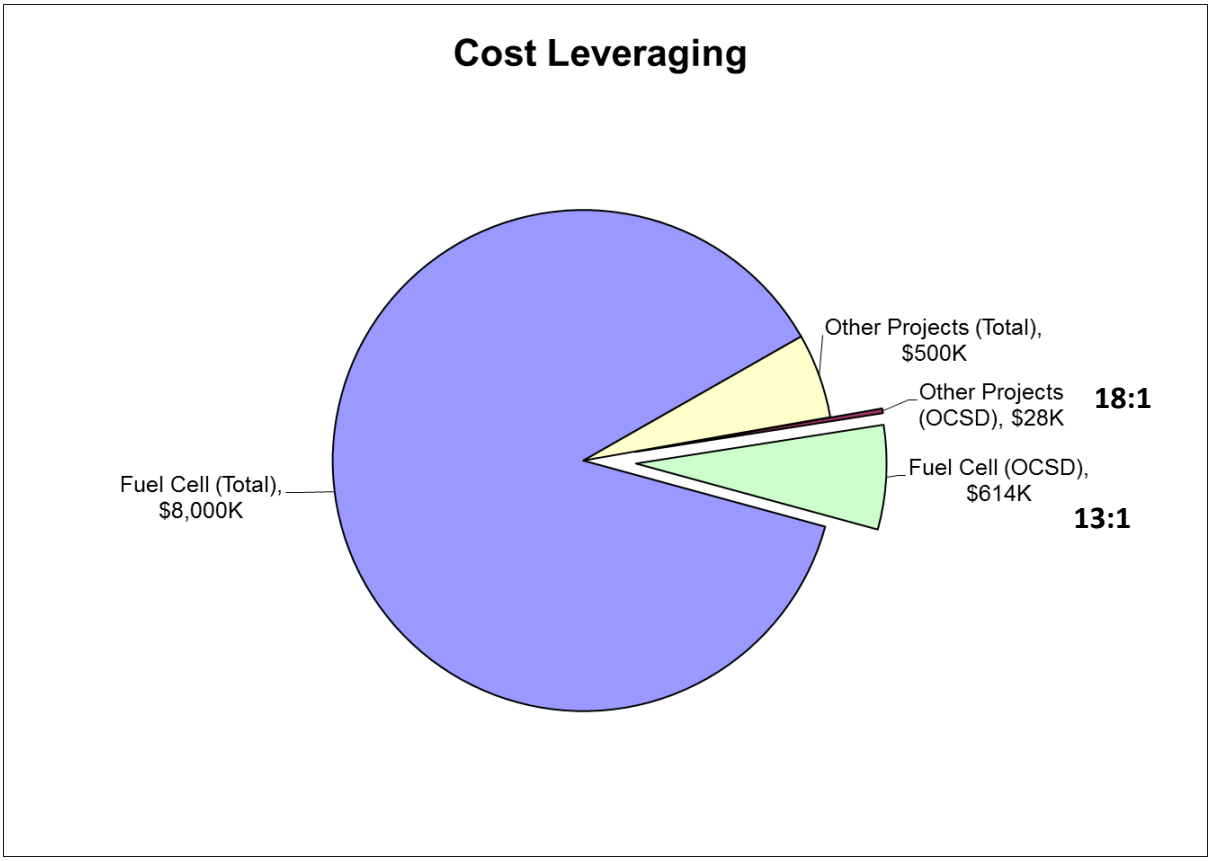

Figure 2-3. Cost Leveraging Achieved in Research Projects

Part 3

Summary of Projects and Memberships

OCSD Research Summary 2011-12: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2011-12	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2012-13)
Environmental Improvement	Fuel cell demonstration	$500,000 for installation; $81,400 for operation	$32,579	$8.0 million	Air Products & Chemicals, Fuel Cell Energy, SCAQMD, US DOE, UC Irvine, CARB	Demonstrate fuel cell operating with digester gas fuel to produce electricity and hydrogen	Energy Station (fuel cell) and Hydrogen Fueling Station have been operating for one year. Through April, over 5 million cubic feet of digester gas was processed, and over 1 million kWh of energy was exported to the OCSD grid. As of June, one automaker had executed agreements for access to the station and payment of fueling services and had begun fueling operations, and two other automakers had executed the access agreement and were in discussions regarding the payment agreement.	Continue the 3-year test program with the fuel cell fed with digester gas producing electricity and providing hydrogen to the vehicle fueling station.
Air Quality	J-79 Central Generation engine emissions control	$9.1 million for J-79 $20,000 for SP-125-11	$32,272 (close-out of J-79); $4,150 (SP-125-11)	---	---	Identify methods to comply with stricter air emissions regulations affecting the Central Generation engines	Improved exhaust emissions controls will allow Central Generation engines to operate without violating air emissions regulations. An oxidative catalyst system to reduce CO and air toxics emissions passed a long-term test at P2. Full scale installation of a dual oxidative / reductive catalyst system and a digester gas cleaning system was completed in February 2010, and testing began in March 2010. Research monitoring activities were conducted from April 2010 through March 2011. The results showed a significant	The draft final report for J-79 was submitted to SCAQMD in early August 2011. One of the report's recommendations was to continue research in optimizing the performance of the urea injection system. Work will continue in 2012-13 to demonstrate consistent compliance with the rule limit while minimizing the resulting increase in ammonia slip.

OCSD Research Summary 2011-12: Projects

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							reduction in emissions of NO_x, CO, and VOCs, including a 99% compliance rate with the new NO_x limit. SP-125-11 was chartered in late 2011 to allow further research into optimizing the system's urea injection rates with the goal of maintaining continuous (100%) compliance with the NO_x limit. It includes continued data monitoring and analysis. Optimization adjustments and data monitoring thus far under SP-125-11 show a tighter level of NO_x control, but with a corresponding increase in ammonia slip.	
Odor & Corrosion Control	Superoxygenation for odor control	$850,000	$40,384	---	---	Investigate using dissolved oxygen rather than chemicals for controlling odors and corrosion in sewers and treatment plants	Following intensive onsite sampling programs at two locations in 2010-11, full-scale superoxygenation installations were evaluated at several locations. Planning for a system at the Main Street pump station was begun late in 2011-12.	The superoxygenation system installation at the Main Street pump station will be completed. This will be a permanent facility sized to oxygenate the full flow through the pump station. At the same time, it will be a research facility to explore the use of superoxygenation in collections system applications.

OCSD Research Summary 2011-12: Projects

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Process Alternatives or Improvement	OpenCEL process for digestion improvement	$850,050 (most will be reimbursed if CIP project for permanent installation occurs)	$138,625	---	---	Investigate improved anaerobic digestion efficiency with OpenCEL predigestion sludge treatment	Effective sludge treatment would increase digester gas production and reduce residual biosolids amounts, leading to reduced O&M costs of several million dollars per year. Baseline digester performance data collection started in Q4 2010-11 and continued throughout 2011-12.	Full-scale onsite testing of the OpenCEL process will begin in Q2 2012-13 and continue throughout 2012-13.
Process Alternatives or Improvement	Food Waste Co-Digestion	$200,107	$42,822	---	---	Investigate the potential benefits and challenges of including food waste as an additional feedstock to existing OCSD digesters	In addition to producing additional methane, co-digestion of food waste also improves the overall digester operation, including increased VS destruction and biogas production from the municipal wastewater organic components.	The 2012-13 activities will include the technical and economic analyses of the data collected during the bench scale test.
Process Alternatives or Improvement	Deep well biosolids injection	$63,000 to date; ultimate cost undetermined	$0	---	---	Investigate biosolids management through underground conversion of biosolids to methane	The City of Los Angeles has a five-year experimental demonstration project to inject biosolids deep underground, where it will be converted to methane and later recovered. OCSD had a feasibility study done for similar activity at both treatment plants; both locations are feasible, but Plant 1 would be geologically preferable. A full-scale system would cost $8 million to engineer and construct.	The Los Angeles results will continue to be monitored; further evaluation at OCSD will be done as appropriate.

OCSD Research Summary 2011-12: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2011-12	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2012-13)
Process Alternatives or Improvement	Process modeling	$252,250	$8,216	---	---	Develop biological and hydraulic computer models to help optimize plant performance	Staff has developed a model for the Plant No. 1 activated sludge facility (AS1 and AS2), the Plant No. 2 oxygen activated aeration facility, and the trickling filter solids contact (TF/SC) process. The AS2 model will be used during process performance testing in late 2012.	The models will be used as part of the secondary optimization testing in 2012-2013. Since this work is becoming part of O&M's normal process operations efforts, it will be removed from the "research" category after 2011-12.
Process Alternatives or Improvement	Ferric chloride dependence elimination or mitigation	$15,769	$15,769	---	---	Conduct a literature search to identify options for reducing or eliminating reliance on ferric chloride	UCI conducted an extensive literature search to identify more sustainable and economical options for reducing or eliminating OCSD's dependence on ferric chloride and to provide a better understanding of the science underlying enhanced primary treatment and digester gas hydrogen sulfide production and control.	Project completed.

OCSD Research Summary 2011-12: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2011-12	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2012-13)
Emerging Contaminants	Trace organic chemical removal during wastewater treatment	$38,840	$23,100	$500,000	WERF (Water Environment Research Foundation)	Determine the effects of wastewater treatment processes on various trace chemicals (pharmaceuticals, EDCs, PCPs)	Leveraged OCSD contribution to project to determine the fate and transport of a suite of trace organic chemicals during conventional wastewater treatment and to determine quantitative structure/activity relationships so that removal of any chemical could be modeled. OCSD shared data from previous internal studies and provided samples from the Plant 1 activated sludge system operating in nitrifying mode.	Probably none, although OCSD could be asked to participate in the model validation activities.
Ocean Monitoring	Southern California Bight Regional Study 2008	$125,000 (in-kind services only)	---	$7,00,000	SCCWRP (So. Cal. Coastal Water Research Project) with 90 participating organizations	Collect regional information on contaminant effects and other stresses on ocean ecology	All field sampling completed and final reports prepared. Study results and recommendations provided to the SCCWRP Commission in June 2012.	Planning for Bight'13.
Ocean Monitoring	Ocean Modeling of Receiving Waters (SP-125-9)	$262,300	$129,430		---	Develop a high-resolution (75 meter) ROMS (Regional Ocean Modeling System) module and incorporate it into an existing operational ROMS system	Completed development and integration of the 75 meter module into ROMS.	Complete evaluation and calibration of 75 meter module and initiate operational system by September 2012. Report to be completed by June 2013.

OCSD Research Summary 2011-12: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2011-12	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2012-13)
Ocean Monitoring	ROMS Calibration Data Collection (SP-125-10)	$98,200	$31,630		---	Collect oceanographic receiving water data for ROMS calibration	Field sampling complete, and data provided to modelers. Data analysis and reporting are underway.	Report to be completed by June 2013.
Ocean Monitoring	Sediment Profile Imaging (SPI) Near the Orange County Outfall (SP-125-8)	$67,310	$61,536	---	---	Compare results of SPI surveys in 1999 and 2012 to determine if treatment changes have changed sediment quality near the outfall	SPI provides information on sediment physical characteristics that core sediment monitoring does not. Results indicated that there has been no appreciable change over time.	Project completed.
Ocean Monitoring	Spatial Variability of Ocean Sediments (Phase II)	Unknown (due to unknown number of sampling sites needed)	$65,000	---	SCCWRP (So. Cal. Coastal Water Research Project)	Determine the optimal sediment station array for accurate map generation of OCSD's outfall footprint for sediment geochemistry analytes and benthic infaunal community metrics	Improved maps will provide better data for determining NPDES permit compliance and information on trends of sediment impacts from wastewater discharge.	The recommended sampling sites from Phase 1 were sampled in July 2010 and the data finalized by June 2011. This data is currently being analyzed to determine the need for a second round of field testing in July 2012. This ultimately will lead to an optimized cost-efficient mapping design and annual monitoring program. Phase II will run from July 2010 through June 2013.
Ocean Monitoring	Evaluation of ZID Water Quality: Low-flow Study	$4,000	$3,950	---	---	Determine if the effluent plume is concentrating during low-flow discharge periods	Provides information on potential contaminant exposure scenarios to benthic organisms in the receiving environment. Results indicated that plume concentration is occurring at low-flow periods.	Project completed.

OCSD Research Summary 2011-12: Memberships

Organization	OCSD Funding	Benefits of Membership	Key Projects & Accomplishments
University of Arizona Water and Environmental Technology (WET) Center	$3,000	The WET consists of an interdisciplinary group of research scientists working together to resolve water quality-related problems. The funding is supplied by the State of Arizona, the National Science Foundation, and a variety of companies and agencies. As a member, OCSD gets access to the Center's research results and, as a voting member of the Industrial Membership Board, can influence the direction of the research program. The Center's annual budget is approximately $750,000.	Previous work related to OCSD's operations focused on biosolids applications options and pathogen occurrence and transport. During 2011-12, WET provided progress reports on the following research projects: 1) Copper Mine Tailings Amended with Class A Biosolids: Long-term Effect on Soil Bacterial Populations, 2) Sustainable Revegetation of Copper Mine Tailings Through Land Application of Class A Biosolids, 3) The Effect of Land Application of Class A Pelletized Biosolids on Cotton Yield in Southern Arizona, 4) Survival of Ascaris Ova in Desert Soils, and 5) Impact of Various Biosolids Treatments on Survival of Infectious Prions.
International Technology Approval Group (iTAG)	$40,000	The iTAG is a global consortium of water and wastewater utilities coordinated by Isle Utilities / Isle Utilities USA. iTAG seeks to identify promising new technologies from around the world, present them to member utilities that might benefit from them, and match early stage technology developers with venture capital funding to assist in commercializing the technologies. iTAG collaboration groups are established in the US, UK, Australia, and Asia. The UK TAG has successfully commercialized about 75 new technologies over 7 years and secured $75 million in venture capital funding. Membership in iTAG includes access to a database of more than 2000 technologies that have been reviewed by Isle Utilities and to a forum for communicating with other member utilities about issues of common interest.	OCSD joined the iTAG late in 2010-11. Three onsite workshops have been held, each of which presented four or five new technologies to OCSD. These included processes to recover phosphorus from liquid streams, software to optimize odor control efforts in sewers, and new processing options for organic solids. Several of these are expected to be investigated further as OCSD research projects.
Southern California Coastal Water Research Project (SCCWRP)	$400,000	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 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. SCCWRP's budget for projects related to marine receiving waters is over $1.2 million.	SCCWRP is active in public health research including bacterial epidemiology studies and methods for the rapid detection of bacteria in recreational water. Through a 2007 joint use agreement, much of the SCCWRP microbiology research is performed at OCSD. This has provided OCSD the opportunity to participate in cutting-edge research related to public health concerns about water quality. In 2010, OCSD participated in a regional demonstration project for rapid detection of microbial indicators of fecal contamination that provided public access to beach water quality data. SCCWRP manages and maintains a data base of all data collected as part of the regional monitoring programs, which can be accessed for comparison to existing data from OCSD's monitoring program. OCSD staff meet regularly with SCCWRP staff to discuss questions of statistical analysis, sample design, program implementation, etc. Two recent examples include: 1) SCCWRP staff met with OCSD staff on multiple occasions to help develop a proposal for mapping the sediments surrounding the OCSD discharge in order to discern the footprint of any discharge-related change to the environment. 2) SCCWRP and OCSD staff have worked together to facilitate meetings with the four major POTWs and State Water Quality Control Board staff to analyze data and review determinations of water quality compliance with California Ocean Plan standards. These data have been used to distinguish receiving waters impacted by wastewater dischargers from "natural" conditions, a critical component to determining compliance with California Ocean Plan standards.

OCSD Research Summary 2011-12: Memberships

Organization	OCSD Funding	Benefits of Membership	Key Projects & Accomplishments
Water Environment Research Foundation (WERF)	$81,328	WERF is recognized as the country's leading independent scientific research organization dedicated to wastewater and stormwater issues. Over the past 20 years, it has produced 300 research reports valued at over $62 million. It is a nonprofit organization that operates with funding from subscribers and the federal government; the subscribers include wastewater treatment plants, stormwater utilities, regulatory agencies, consultants, and industrial companies. WERF's approach to research stresses collaboration among teams of subscribers, environmental professionals, scientists, and staff. All research is peer reviewed. As a WERF member, OCSD has access to all research results at no additional cost and also is able to become actively involved in steering the direction of WERF research projects through individual staff members' participation on Issue Area Teams.	WERF is a source of information about every major area of water and wastewater planning and treatment. Its "knowledge areas" include biosolids, climate change, conveyance systems, decentralized systems, nutrients, operations optimization, pathogens & human health, security & emergency response, stormwater, strategic asset management, trace organics, use attainability analysis, and water reuse. WERF has a "Program-Directed Research" initiative designed to focus on high-priority issues identified in consultation with WERF members. Recent developments that are relevant to key strategic areas for OCSD include: Trace Organics – WERF researchers recently completed Phase 1 of "Diagnostic Tools to Evaluate Impacts of Trace Organic Compounds" (project CEC5R08). The effort generated four companion pieces: a prioritization framework for trace organic compounds (TOrC), a report on diagnostic approaches and the analyses used to identify the causes of ecological impairments in aquatic systems, seven case studies, and a web-based database to evaluate TOrC data. Strategic Asset Management – WERF researchers are assembling a small group of utilities to pilot leading practices and tools for strategic asset planning and business risk management. The utilities plan to commit to adapting these practices to their own organization. They also will pilot two SIMPLE tools (tentatively Capital Validation and Business Risk Exposure) that have the greatest potential to improve decision-making related to their capital improvement programs. Nutrients – Recalcitrant dissolved organic phosphorus hinders the ability of a treatment facility to meet total phosphorus values. Additionally, increased use of chemicals for phosphorus removal can significantly reduce the bioavailable amount in treated effluent and potentially reduce receiving water productivity. Waterborne Pathogens and Human Health – The Waterborne Pathogens and Human Health research challenge is now complete. The challenge yielded six research reports, a workshop summary report, and an educational video. Each project fills gaps in the understanding of relationships among pathogens, indicators, and human health in recreational waters. Climate Change – Recently, there has been evidence that low-probability weather events (floods, droughts, heat waves) are occurring more frequently and in different regions than in the past. Climate change is one possible explanation. WERF is collaborating with the Water Research Foundation to understand the implications of extreme weather events on water quality so that utilities may limit future vulnerabilities. Research for this project, "Water Quality Impacts of Extreme Weather-Related Events" (project CC4C10), began in spring 2011.

OCSD Research Summary 2011-12: Memberships

Organization	OCSD Funding	Benefits of Membership	Key Projects & Accomplishments
WateReuse Research Foundation	$25,000	The mission of the Foundation is to conduct and promote applied research on the reclamation, recycling, reuse, and desalination of water. The Foundation's research advances the science of water reuse and supports efforts to create new sources of high quality water while protecting public health and the environment. As a member, OCSD has access to the research results and can influence the choice of projects to be undertaken. The Foundation's work is particularly applicable to OCSD's participation in the Groundwater Replenishment System (GWRS).	The WateReuse Foundation has more than 70 projects under its research program. The Foundation's research covers a broad spectrum of issues, including chemical contaminants, microbiological agents, treatment technologies, salinity management, public perception, economics, and marketing. The Foundation currently funds or co-funds projects on the following topics that are relevant for OCSD: 1) Study of Innovative Treatment on Reclaimed Water 2) Comparisons of Chemical Composition of Recycled and Conventional Waters 3) State of the Science Review of Membrane Fouling: Organic, Inorganic and Biological 4) Investigating the Feasibility of a Membrane Biofilm Reactor (MBfR) to Achieve Low Nitrogen Levels for Water Reclamation and Reuse 5) Water Reuse in 2030 6) Tools to Assess and Understand the Relative Risks of Indirect Potable Reuse and Aquifer Storage and Recovery Projects 7) Development of Information Clearinghouse on Concentrate and Salt Management Processes – Phase I Evaluation of Impact of Nanoparticle Pollutants on Water Reclamation 8) Evaluating Emergency Planning Under Climate Change Scenarios to Better Assess the Role of Water Reuse 9) Implications of Future Water Supply Sources on Energy Demands 10) Risk Assessment Study of PPCPs in Recycled Water to Support Public Review 11) Treatment, Public Health, and Regulatory Issues Associated with Graywater Reuse 12) Lower Energy Treatment Schemes for Water Reuse 13) Guidance for Implementing Reuse in New Buildings and Developments to Achieve LEED / Sustainability Goals 14) Review of Nano-material Research and Relevance for Water Reuse 15) Establishing Nitrification Reliability Guidelines for Water Reuse 16) Enzymes: The New Wastewater Treatment Chemical for Water Reuse 17) Regulated and Emerging Disinfection Byproducts during the Production of High Quality Recycled Water
University of California, Irvine: Urban Water Research Center (UWRC)	$35,000	The Urban Water Research Center's (UWRC) mission is to advance the understanding of the urban water environment to assist efforts promoting health, enhancing the efficient use of water resources, and protecting environmental values. It includes over 70 faculty members and a variety of UCI departments and takes a multidisciplinary approach to research. The Center's work addresses topics such as water supply, demand and distribution; water quality issues for drinking and recreational use; and using wetlands to reduce water pollution from urban runoff. When OCSD's membership fee is used to support specific research, the overhead charges normally assessed by the university for sponsored research are reduced substantially.	In a previous year, UCI completed a carbon footprint model of the OCSD treatment plants. In 2011-12, as an additional research project, UCI conducted an evaluation of alternatives to ferric chloride for settling primary solids and for hydrogen sulfide control in the digesters.

OCSD Research Summary 2011-12: Memberships

Organization	OCSD Funding	Benefits of Membership	Key Projects & Accomplishments
National Water Research Institute (NWRI)	$62,500	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 graduate fellowships and other water-related educational programs, developing outreach material such as reports and videos, holding workshops and conferences to promote new issues and technologies, providing peer-review panel services for local and state water agencies, managing projects or programs for water agencies and others, and awarding scholarly and practical achievements in water research with a national prize.	NWRI currently funds exploratory research projects in the following areas that could be of interest to OCSD in future years: 1) Developing a Simple, Rapid Molecular Method to Test for Ammonia Oxidizing Bacteria for Water and Wastewater 2) Recovery of Metal Ions from Membrane Concentrates 3) Source, Fate, and Transport of Endocrine Disruptors, Pharmaceuticals, and Personal Care Products in Drinking Water Sources in California 4) Fecal Indicator Bacteria Source Tracking in the Middle Santa Ana River 5) Assessment of Water Reuse as an Approach for Meeting Future Water Supply Needs 6) Reuse of Graywater 7) Regulatory Aspects of Direct Potable Reuse in California 8) A Proposal to Better Value Reliable Water Supplies

Part 4

Detailed Project Information

Project Category:

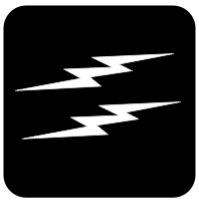
Environmental Improvement

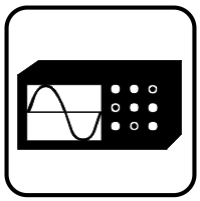
Project Type: ☐ New ☒ Continuing

2011-12 Project Description

Project Title:

Fuel Cell Demonstration for Energy and Hydrogen Production





Contact: Jeff Brown, Engineering

Purpose: Demonstrate a fuel cell power plant using digester gas as fuel and producing hydrogen for vehicle fuel and electricity for onsite use

Description:

A fuel cell is an electrochemical device to generate electricity. Its fuel is a carbon source, such as digester gas, and its operation produces only water, waste heat, and trace gaseous emissions as byproducts. The electrochemical process occurring in a fuel cell is a direct form of fuel conversion that is much more efficient than conventional combustion-based electricity generation. Compared to combustion processes, fuel cell operation results in dramatically reduced emissions of such pollutants as nitrogen oxides (NO_x), sulfur oxides (SO_x), and carbon dioxide (CO_2).

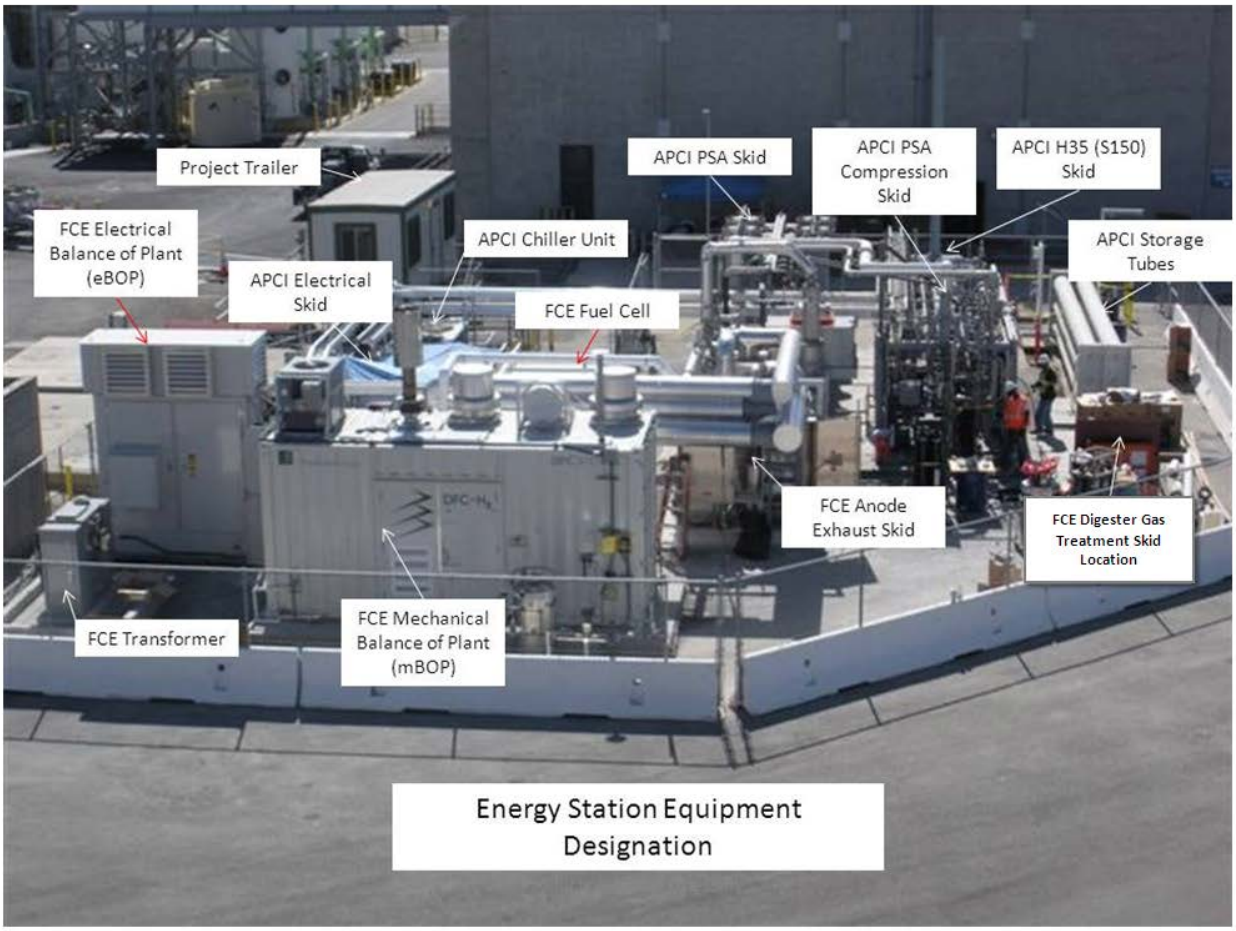
OCSD is the host site for a public / private collaborative demonstration with the University of California, Irvine (UCI), U.S. Department of Energy, California Air Resources Board (CARB), South Coast Air Quality Management District, Air Products and Chemicals (APCI), and FuelCell Energy (FCE). A 300 kW fuel cell is installed at Plant No. 1 to use a portion of the treatment plant's digester gas to generate electricity for on-site use. In addition, hydrogen gas is produced and compressed for fueling vehicles at a publicly accessible fueling station as part of the California "Hydrogen Highway."

The specific fuel cell technology selected for this project has qualified for several environmental certifications, such as the Leadership in Energy and Environmental Design (LEED) program and the Renewable Energy Standards (RES). It also qualifies as an "ultra-clean" technology by exceeding all CARB emission standards.

2011-12 Project Description

The project calls for APCI and FCE to design, install, operate, and maintain the fuel cell system and UCI's National Fuel Cell Research Center to operate the fueling station. The entire installation is expected to operate for three years (starting in mid-2011).

The elements of this project that are included under the general goal of "demonstrating the fuel cell power plant operation" include determining the amount of digester gas cleaning that is needed to make it a suitable fuel, documenting the operating efficiency of the power plant and its component processes, determining the maintenance requirements for the system, and verifying the expected lack of air pollutant emissions. Appropriate samples will be collected throughout the test program by the participating organizations, and all test results and operating records will be reviewed by OCSD and the other participants.



2011-12 Project Description

Since digester gas is considered a renewable energy source, this project has received significant financial incentives, including $2.7 million from CARB. OCSD was responsible for preparing the site and installing the utilities needed for the project. OCSD's share of this $8 million project is $500,000 plus project oversight costs during the test period.

Results:

Following commissioning activities (such as leak checking and system purging with nitrogen), the initial operation of the fuel cell plant (Hydrogen Energy Station) on natural gas began on 13 September 2010. The following early results were realized:

- Initial power operations, including power conditioning of the fuel cell, resulting in an increase in power output of 40 kW/day for 7 days, reaching 300 kW net AC on 20 September 2010, with excess electricity exported to the OCSD in-plant grid.

- Following initial power operation, the water-gas shift, water removal, and PSA feed compressor systems were placed into service.

- Initial integration with the PSA system at 50% feed gas rates took place on 23 September 2010. There was a system trip shortly after integration which demonstrated the performance of the deintegration process in the field.

During the months of October and November 2010, the fuel cell was operated at various loads on natural gas, and the hydrogen purification system was operated periodically to test the integration/deintegration of the two systems. During this initial operating period, the Power Conditioning Unit (PCU/Inverter) associated with the fuel cell had difficulty maintaining its connection with the local electrical grid. Experts from FuelCell Energy characterized the grid quality and identified changes required to the power conditioning system to match the highly inductive power factor (0.6 to 0.8) and larger voltage sags (5% to 10%). Troubleshooting efforts began in early December. On 14 December, a module within the inverter was damaged by an electrical fault.

During the period through 31 December 2010, over 1,000 hours of operation in "electricity only" and "electricity + hydrogen" modes were completed. During the period from January to March 2011, the inverter was repaired, and the fuel cell operated for one month at 100 kW power output and one month at 200 kW power output. The total on-stream time producing power was 93.4% (excluding inverter repair time).

The hydrogen quality was checked and met all performance specifications. Hydrogen was vented locally pending completion of commissioning of the hydrogen refueling station.

2011-12 Project Description

During the period from April to June 2011, the major activities were the installation and commissioning of the ADG (anaerobic digester gas) clean-up system. ADG was first introduced to the fuel cell system on 25 May 2011, and the operating parameters were tuned to allow for natural gas to be supplied automatically in case of a decrease or interruption of the ADG supply.

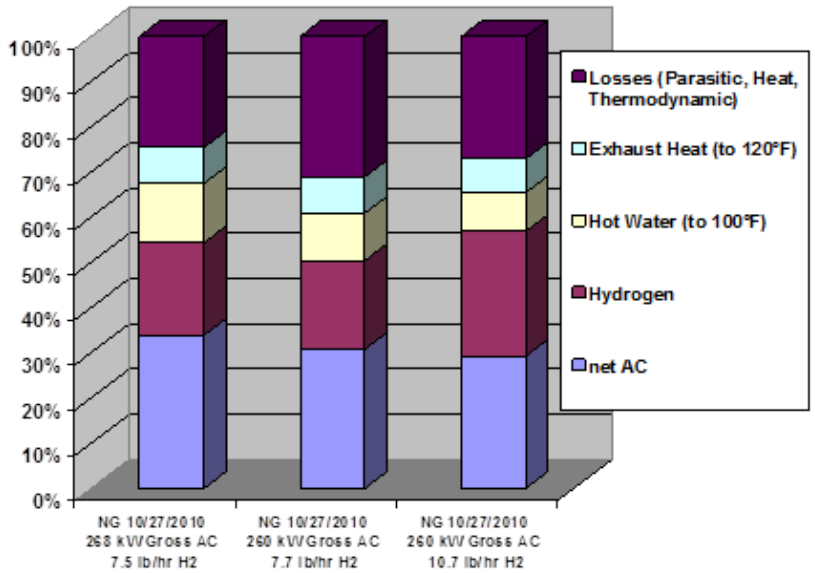
The formal opening of the fuel cell (Energy Station) and hydrogen fueling station was held on 16 August 2011 with 140 invited guests in attendance.

During the period from July to September 2011, the fuel cell produced a total of 334,933 kWh of electricity. A total of 195,018 kWh was exported to the local grid, with the remaining power being consumed by the fuel cell, digester gas clean-up, and hydrogen purification systems. The hydrogen purification system was operated as needed to supply hydrogen to storage. Independent of any fueling station usage, a portion of the hydrogen is sent from storage to the ADG clean-up system to assist in removing sulfur compounds. The remaining hydrogen now can be routed back to the fuel cell rather than being vented as was the case during the initial operation in 2010.

The fuel cell continued to experience operational issues related to the power quality. A total of 115 trips (excluding trips less than 15 minutes apart) were experienced during this three-month period. These trips limited hydrogen production since the system was programmed to deintegrate the hydrogen purification system each time the fuel cell power production was interrupted.

Operating limitations due to power quality issues continued through the end of 2011. After modifications within the power grid at OCSD, no trips related to power quality have occurred since 31 January 2012.

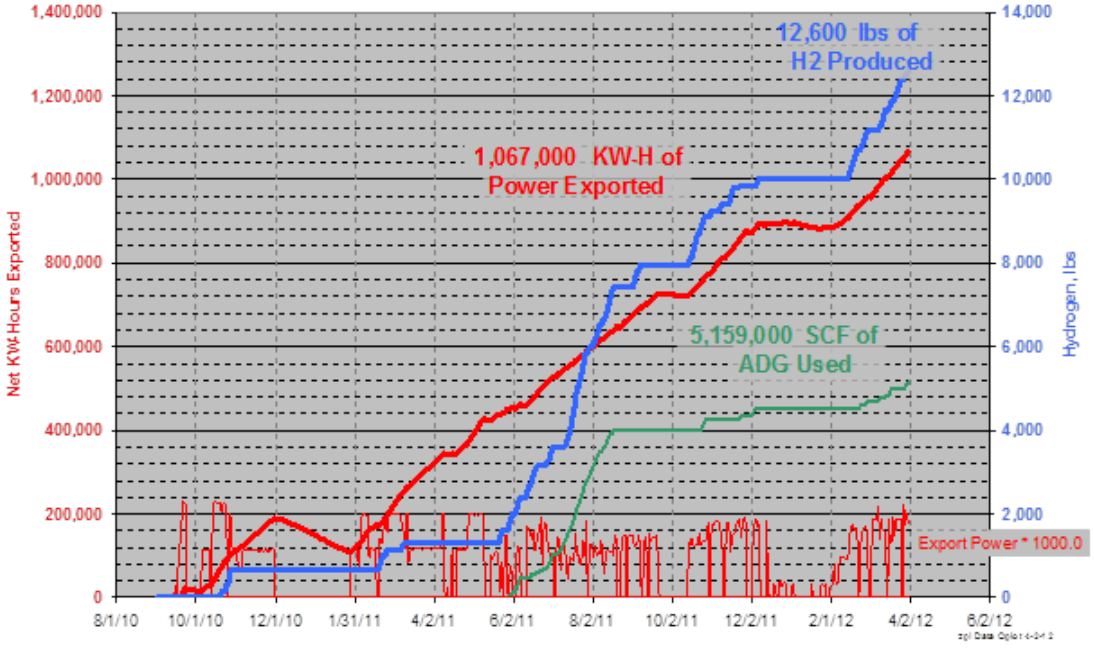
During operation on ADG, a detailed heat and material balance was performed to determine the overall efficiency of the fuel cell energy station. The calculated efficiency of 53.3% (electricity plus hydrogen) exceeded the program target of 50%. The components of the energy balance are shown in the bar graph to the right.



2011-12 Project Description

An overall operations summary (through April 2012) of the fuel cell energy station is shown in the figure below. Over 5 million standard cubic feet of ADG was processed, and over 1 million kWh of electricity was exported to the OCSD grid.

Operations Summary (through April 2012)



Status:

The operation of the integrated system is continuing into the second year of the planned three-year test. Also, as of 30 June 2012, one automaker had executed agreements for access to the fueling station and payment of fueling services and had begun its fueling operations, and two other automakers had executed the access agreement and were in discussions regarding the payment agreement.

Project Category:

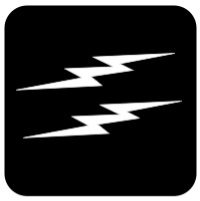
Air Quality

Project Type: ☐ New ☒ Continuing

2011-12 Project Description

Project Title:

Central Generation System (CGS) Engines Air Emissions Compliance (Project J-79)



Contact: Lisa Rothbart, Engineering

Purpose: Evaluate catalytic emissions reduction systems for CGS engines

Description:

CGS engines are the largest sources of air pollution at OCSD. They emit both criteria pollutants (NO_x, CO, VOC, particulates, SO_x) and substances identified as air toxics.

The goal of the J-79 project is to evaluate and test technologies to reduce emissions from the CGS engines to address AQMD Rules 1110.2, 1401, and 1402. Several identified technologies that reduce NOx, CO, and VOC emissions were evaluated in detail based on technical and economic factors such as proven performance, availability, long-term performance, commercial application, site specific constraints, and cost. Based on the results of this evaluation, a pilot test of a Selective Catalytic Reduction (SCR)/Catalytic Oxidizer System is being conducted on one CGS engine at Plant 1. This selected post-combustion technology has been proven effective for controlling NOx, CO, and VOC emissions from combustion units using natural gas. However, the CGS engines run on digester gas, which can lead to fouling or rapid performance degradation of catalytic oxidizers. Therefore, a digester gas cleaning system is also included as part of the pilot testing program.

The design of the pilot testing program includes one full-scale platform-mounted SCR/catalytic oxidizer system that has been installed on Engine #1. Based on pilot testing previously performed at Plant 2, the digester gas cleaning system has proven successful in removing contaminants such as siloxane and hydrogen sulfide from the digester gas, making the catalyst life comparable to an IC engine installation operating on natural gas. The pilot testing will use one layer of catalyst in the catalytic oxidizer housing and two layers of catalyst in the SCR housing to collect data for compliance with upcoming (year 2012) emission limits. The digester gas cleaning system will use specially designed carbon adsorption to clean all digester gas produced at Plant 1.

2011-12 Project Description

Results:

The pilot testing program assessed the performance of NO_x, CO and VOC removal by the SCR/catalytic oxidizer system and provided information for use in full-scale design. The monitoring requirements for the program included the following:

- Testing the catalytic oxidizers while running the engines on 90 to 100 percent digester gas.
- Performing source testing once during the initial start-up of the system using CARB approved sampling methods for NO_x, CO, and total VOCs and using CARB Method 430 or EPA Method 323 for formaldehyde and other aldehydes.
- Performing periodic monitoring of NO_x and CO performance at the inlet and two outlets of the two catalytic oxidizers using hand-held analyzers.
- Performing quarterly source testing of VOCs using SCAQMD Method 25.1 and formaldehyde using modified CARB Method 430 and EPA Method 323 at the inlet and outlet of the catalytic oxidizer.
- Performing bi-weekly source testing of specified organics (air toxics) and sulfur compounds at the inlet and outlet of the fuel gas cleaning system and the inlet and outlet of the catalyst system utilizing EPA Method TO-15 and SCAQMD Method 307-91.
- Performing quarterly testing of siloxane removal using MS/FID.

The catalytic oxidizer reduces carbon monoxide and air toxics (e.g., formaldehyde, acrolein) emissions from the engine exhaust. Urea is injected into the engine exhaust ductwork between the catalytic oxidizer and the SCR catalyst to reduce NO_x emissions. The digester gas cleaning system is filled with activated carbon media to remove siloxanes and other compounds that could potentially foul the oxidative and SCR catalysts.

The projected cost for the pilot testing was $530,000 for the SCR/catalytic oxidizer and digester gas cleaning system and $2.4 million for construction and related expenses during the test. Equipment for full-scale installations on the remaining seven CGS engines would cost approximately $31 million.

Status:

Engineering services for the J-79 Project were provided by Malcolm Pirnie, Inc. (MPI). Olsson Construction provided installation services for the earlier catalytic oxidizer pilot test at Plant 2 and installed the pilot testing equipment at Plant 1. The construction began in October 2009 and was completed in February 2010. Testing activities began in late March

2011-12 Project Description

2010 and continued through March 2011. A research report was prepared by MPI, with the final report submitted to South Coast AQMD in August 2011.

The results of the successful research showed significant reductions in NO_x, CO, VOCs, and air toxics emissions. The South Coast AQMD rule limits for CO and VOC were consistently achieved. The rule limit for NO_x was achieved for 99% of the data collected during the one-year monitoring period. NO_x limit exceedances, which occurred in 1% of the data, were experienced during times of high engine load (> 100% load) and also when the natural gas / digester gas fuel ratio changed. In its research report, MPI recommended further research to optimize the urea injection rates to improve NO_x removal during different engine operating scenarios.

In late 2011, project SP-125-11 was started in response to MPI's recommendations. Under MPI's direction, a series of adjustments was made to the urea injection system by Johnson-Matthey. Continuous emissions data was recorded and sent to MPI for analysis. These optimization efforts continued until the system was temporarily shut down in mid-February due to a sudden decrease in performance of the oxidative catalyst, which was caused by contaminant breakthrough in the digester gas cleaning system and was unrelated to the urea optimization work. The oxidative catalyst was removed, samples were sent out for analysis, and the catalyst was regenerated to the extent possible via cleaning. Optimization efforts and data monitoring under SP-125-11 will recommence once the oxidative catalyst is put back into service, which is expected to occur by the fall of 2012.

Project Category:

Odor and Corrosion Control

Project Type: ☐ New ☒ Continuing

2011-12 Project Description

Project Title:

Superoxygenation Process Evaluation

Contact: Jeff Brown, Engineering

Purpose: Evaluate an oxygen-based process for odor and corrosion control

Description:

Hydrogen sulfide (H_2S) is the principal cause of odors and corrosion in our sewers and treatment plants. H_2S is formed only when there is a deficiency of oxygen. Maintaining dissolved oxygen levels is a challenge in normal treatment situations because bacteria consume much of the oxygen, and some dissolved oxygen is released from water into the atmosphere when the water is turbulent.

A process for dissolving large amounts of pure oxygen in water (superoxygenation) using a device called a "Speece cone" was tested successfully at the Seal Beach pump station in 2005 as part of our efforts to evaluate cost-effective odor control technologies. Subsequently, three parts of OCSD's treatment system were identified as potentially benefitting from superoxygenation: the collections system, headworks / primary treatment, and secondary treatment (activated sludge). The goals in the first two areas would be to provide oxygen to reduce odors and corrosion. In secondary treatment, the goal would be to provide the required process oxygen less expensively than is done now using air blowers or oxygen diffusers.

2011-12 Project Description

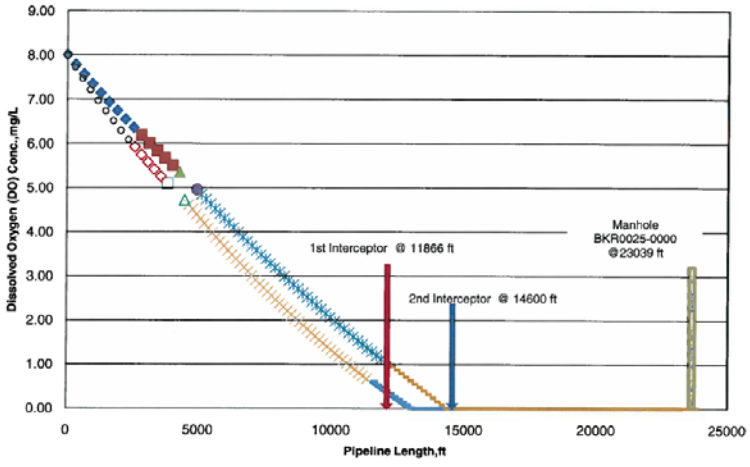
Results:

Previous work at OCSD found that superoxygenation would not be technically feasible for the headworks / primary clarifiers because there would not be enough contact time available for the added oxygen to react. For the activated sludge processes, using superoxygenation was found to be technically feasible but not cost effective.

For odor control at certain pump stations, superoxygenation appeared to be technically feasible and potentially less expensive than alternative chemical treatments. These locations could be candidates for superoxygenation with relatively minor modifications to the existing sites.

The Crystal Cove and Main Street pump stations were selected for additional study. Intensive onsite sampling programs were conducted at both sites to provide accurate information about concentrations and variations of sulfides, dissolved oxygen, and orthophosphate, as well as various physical and chemical characteristics of the wastewater (pH, temperature, oxygen uptake rate, and oxidation reduction potential). These data, together with computer models of the collections system served by these pump stations, were used to predict the effectiveness of superoxygenation treatment and to prepare preliminary designs of superoxygenation systems for both sites.

Based on the results of the data analysis, the implementation of a superoxygenation system at the Main Street pump station would be effective at controlling sulfides at the discharge of the force main and through an appreciable distance in the downstream gravity sewer. Computer modeling suggested that oxygen could not be the sole downstream odor



control agent used, though, because the dissolved oxygen concentration in the gravity sewer must be restricted to prevent hazardous oxygen-rich pockets from forming in the sewer headspace. There would not be enough oxygen remaining in the wastewater from superoxygenation to fully and reliably oxidize sulfides contributed from downstream laterals in the Baker- Gisler interceptor. The life cycle cost of superoxygenation for Main Street was calculated to be less than half the cost of ferrous chloride.

Superoxygenation's use in sewer mains containing both force mains and gravity segments is restricted by an expected need to prevent oxygen supersaturation of the wastewater in the gravity segments. The oxygen concentration in the force main can safely be very high, but at the point of transition to gravity operation, supersaturation may not be acceptable so as to prevent oxygen from being released and accumulating in the headspace.

Status:

Planning for the installation of a superoxygenation system at the Main Street pump station was begun late in 2011-12 with the intention of completing an installation in 2012-13. Unlike the previous installation at the Seal Beach location, this will be a permanent facility sized to oxygenate the full flow through the pump station. At the same time, it will be a research facility to explore the use of superoxygenation in collections system applications.

Several research questions have been identified for this facility to answer:

- As noted above, the expected oxygen depletion in the Baker-Gisler interceptor has been modeled to predict the sulfide control in the gravity sewer section. This modeling used measurements of sulfide levels and oxygen uptake rates and empirical equations describing the wall biofilm interactions and the water surface's reaeration rate. The results show positive DO (dissolved oxygen) concentrations, and thus sulfide control, for substantial distances downstream. Confirming the modeling results with actual data will aid in applying similar modeling to other potential superoxygenation sites.

- That the Baker-Gisler interceptor downstream of the Main Street pump station changes from a force main to a gravity line is important for an oxygen installation because a high DO concentration at the transition point could lead to oxygen off-gassing that could form an explosive atmosphere in the pipe. Limiting the DO to saturation conditions (~8 mg/L) certainly should prevent off-gassing, but there is substantial evidence that 150% supersaturation conditions (~12 mg/L) can be maintained for several hours under the right conditions. A higher DO concentration at the gravity transition point would mean the sulfide control would extend farther downstream, which would reduce or eliminate the need for supplemental (and higher cost) odor control measures. Since OCSD has no experience using

superoxygenation in a gravity sewer, this installation will allow that application to be explored, and the results should be valuable for applying the technology in other parts of OCSD's system.

- Oxygen probably will not prove to be the only odor control treatment that is used throughout the collections system. How best to use oxygen and other chemicals together will be explored. There is a theoretical argument that nitrate added at the same time as oxygen will remain unreacted until the oxygen is depleted. If correct, this could lead to essentially a "timed release" chemical dosing strategy in which oxygen is dissolved, nitrate is added at the same place or another convenient point downstream with a positive DO concentration, and the nitrate becomes active only when the oxygen becomes depleted. Alternatively, there is a possibility that superoxygenation would promote the establishment of a pipe surface biofilm layer containing ammonia-oxidizing bacteria (AOB) that would produce nitrate for downstream use as an electron acceptor for sulfide control. This would be a welcome side benefit of superoxygenation, as nitrification is reported to be unaffected by DO levels up to (at least) 38 mg/L provided there is adequate time for acclimation. Further, supersaturation with DO should help drive DO deeper into the biofilm and so support a larger biomass of AOBs.

- A related project is being considered to test an advanced odor modeling software program (SeweX). This program models sulfide formation throughout a sewer network, including the effects of any sulfide controls that are applied, thus allowing chemical dosing locations and treatment schedules to be optimized. The initial evaluation would model one section of the collections system. If the Baker-Gisler interceptor were used for this, then the accuracy of modeling oxygen's effects, in addition to the accuracy of modeling other chemicals' effects, could be determined. This would be valuable information for deciding whether SeweX should be applied to the entire collections system.

Project Category:

Process Alternatives or Improvement

Project Type: ☐ New ☒ Continuing

2011-12 Project Description

Project Title:

OpenCEL Process Evaluation

Contact: Jeff Brown, Engineering

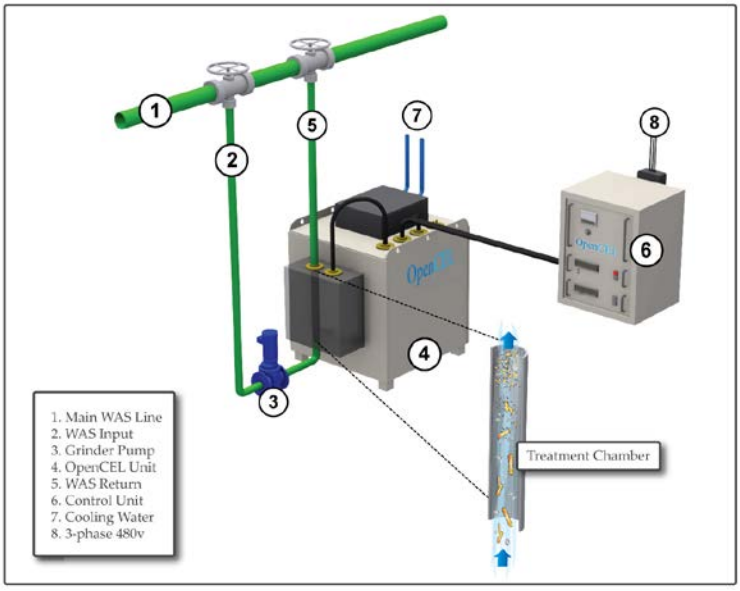
Purpose: Evaluate a process to improve digester efficiency and minimize residual solids

Description:

Anaerobic digesters convert volatile solids to methane gas, but their conversion efficiency is not 100%. Solids from secondary treatment (such as waste activated sludge or WAS) are particularly difficult to convert; a typical digestion cycle might convert only one-third of the available secondary volatile material.

Breaching the cellular membrane is the rate-limiting step for anaerobic digestion of WAS. Various methods of digestion pretreatment have been shown effective at laboratory scale since the late 1970's, but scalability problems, excessive power requirements, and other factors generally have kept them from achieving full-scale practical use.

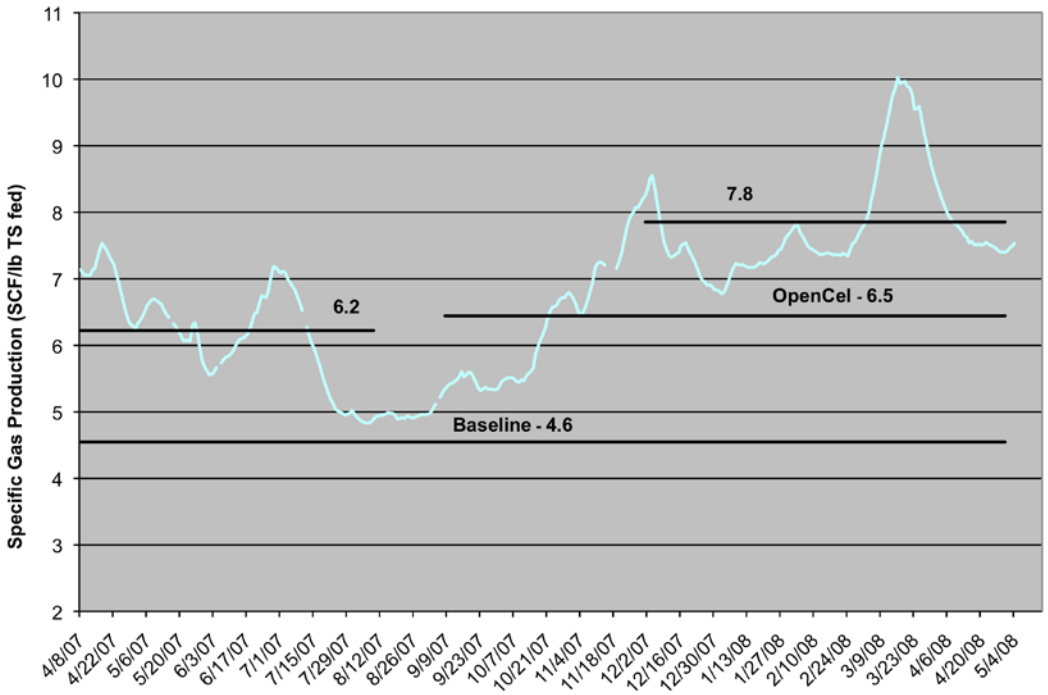
The OpenCEL process is a proprietary Focused Pulsed (FP) treatment that creates reversible disruptive conditions within cellular membranes. These forces are generated by a rapid, pulsed electric field using high voltage, high frequency, microbursts of conditioned electricity. Applying enough electrical energy to the WAS results in irreversible opening and breaching of the cell membrane. This releases the intracellular material, making it readily available for further reaction and conversion to methane in the digester. The net result would be increased digester gas production and reduced amounts of residual biosolids.



2011-12 Project Description

Results:

OpenCEL has been used in a full-scale commercial installation at the wastewater treatment plant in Mesa, AZ, since 2007 to treat a mixture of thickened primary solids and WAS. The results have been impressive: the WAS volatile solids reduction (VSR) has increased from ~30% VSR to ~70% VSR, and the biogas production has increased ~60%. Analyses of the digester microbial population showed increases in the relative abundance of acetate-utilizing methanogens, indicating the cell lysis caused by the treatment increased the availability of simple volatile acids.



Biological Methane Potential (BMP) tests in 2009 on OCSD's WAS by Arizona State University showed BMP increases after treatment that supported OpenCEL's expectations for successful performance. Preliminary cost analyses suggested that using OpenCEL could save OCSD on the order of $2-4 million/year at each plant (depending on the specifics of each plant's operation and the value placed on WAS heating). The equipment cost for full WAS treatment at each plant would be ~$4 million.

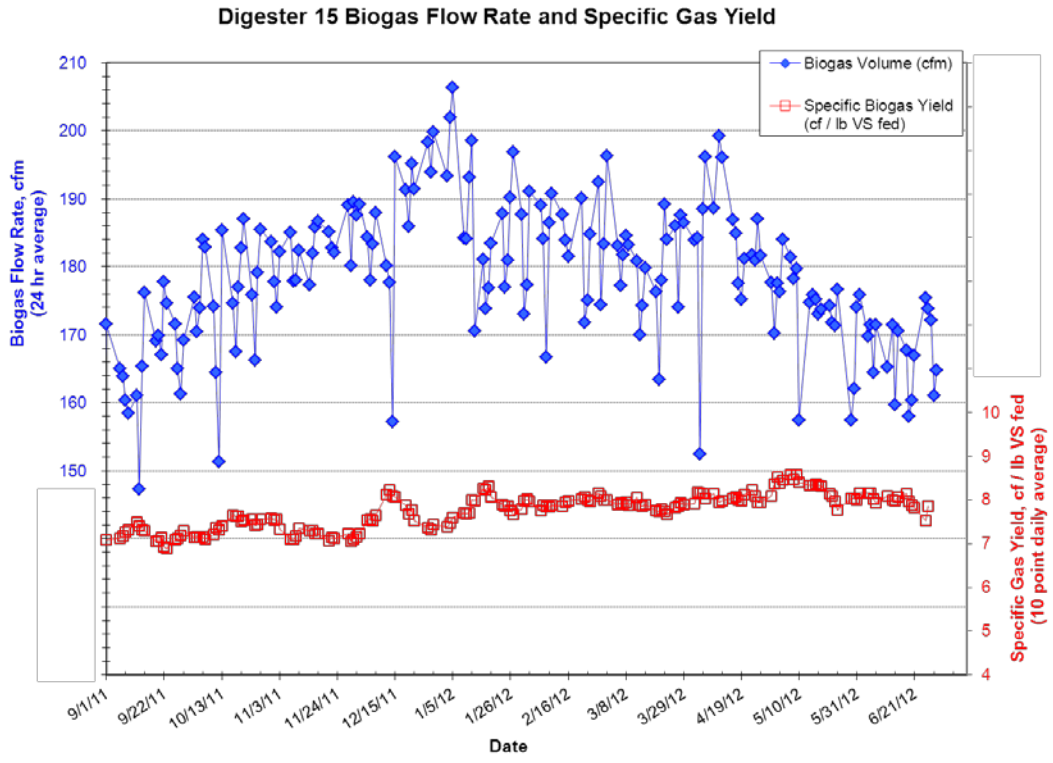
A test program for an OpenCEL installation on digester 15 at Plant 1 was developed to compare the digester performance (e.g., biogas production and quality; VSR) with and without OpenCEL treatment. In addition, digester 16 without OpenCEL was designated as an experimental control so any changes in digester 15's performance could be correctly

2011-12 Project Description

attributed to OpenCEL (affecting digester 15 only) or other factors (affecting other digesters as represented by digester 16).

The first necessary step was to establish the baseline digester performance at the test conditions without OpenCEL treatment. The secondary sludge (TWAS) feed proportion in digesters 15/16 was increased from about 23% to about 40% starting in October 2010, and the digesters were allowed to adjust to the new feed conditions. Gas flow meters were installed in the gas exit piping to measure the flow from both digesters individually and their combined flow (as a data quality control check). Usable readings were being recorded by the beginning of September 2011.

The figure below presents daily average biogas production and specific yield data for digester 15. The actual production or flow rate (ft^3/min) varies with changes in daily feed volume and possibly other factors. But the specific biogas yield (the amount of biogas produced per pound of volatile solids fed to the digester, ft^3/ lb VS) is relatively constant in the range of 7-8 ft^3/ lb VS, which is typical for mesophilic anaerobic digesters.



The installation and startup of the OpenCEL equipment is expected in Q2 2012-13. The performance test is expected to continue throughout 2012-13.

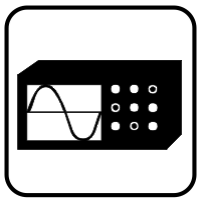
Project Type: ☐ New ☒ Continuing

2011-12 Project Description

Project Title:

Deep Well Injection of Biosolids

Solids Handling & Digestion



Research & Development

Contact: Tom Meregillano, Engineering

Purpose: Consider underground disposal as a biosolids management practice

Description:

Managing the biosolids produced by wastewater treatment is a continuing concern for OCSD. Beneficial land application to provide soil nutrients, composting, and processing into industrial fuel are among the options that the agency has pursued. Another future possibility involves putting biosolids far underground.

The City of Los Angeles is pioneering the nation's first project to produce green energy from a renewable bioresource using deep well injection with its experimental Terminal Island Renewable Energy (TIRE) project. Using techniques that are similar to enhanced oil recovery operations, the TIRE project injects biosolids in depleted oil and gas reservoirs more than a mile underground. The earth's high internal temperatures and pressures will convert the biosolids to methane gas and carbon dioxide, but the carbon dioxide will remain trapped (sequestered) in the deep subsurface layers. The project's permit allows a five-year period to evaluate the potential for high temperature treatment of the biosolids, biodegradation and conversion to methane and carbon dioxide, permanent sequestration of the majority of the carbon dioxide, and recovery of the methane from the sandstone formation for energy use in surface facilities.

Results:

The TIRE injection process is being operated and maintained by Terralog Technologies, a company specializing in this type of work. Since OCSD is interested in the deep well injection option, Terralog previously was contracted to complete a technical feasibility and design

report for deep well injection at OCSD facilities. The report included a detailed geologic review of the areas around both treatment plants and a preliminary design concept of a deep well injection facility to inject up to 400 wet tons per day of biosolids or 200,000 gallons per day of dilute sludge or brine.

Terralog's report concluded that the areas around both OCSD plants have the appropriate geology for biosolids injection with containment and confinement zones at depths of 4,000 to 6,000 feet. Plant 1 would be preferred for an injection operation because the geology is less complex and there are fewer existing oil wells nearby. Plant 2 also has more seismic risks due to the Newport-Inglewood fault zones.

Concerns about earthquakes and ground movement were addressed by Terralog. The target injection zones are relatively shallow (5,000 feet depth) compared to natural seismic zones in the area (30,000 feet depth). There are more than 24,000 deep production and injection wells in Los Angeles County and Orange County, including more than 1000 wells within a few miles of Plant 1. These existing wells have experienced decades of seismic activity with no dangerous releases of gas to the surface during earthquakes because metal casings on wells merely deform slightly under seismic strains rather than breaking. Higher standards of design and construction would be used for biosolids injection wells, and more stringent monitoring and operational safeguards would be applied.

Fresh water aquifers are generally protected from deep well injection based on the difference in subsurface depth of the groundwater aquifers (200 - 1,200 feet) compared to the injection zone (5,000 feet). There also is natural geological protection to prevent the injected biosolids from migrating because multiple sealing shale layers would inhibit any fluid migration.

A deep well injection test at OCSD would require a Class V (experimental) permit from the EPA. Public and technical workshops would be necessary before applying for the permit.

Status:

TIRE is nearing its fourth year of successfully injecting biosolids into deep, depleted subsurface geological formations. The current project is operating under an existing Underground Injection (UIC) permit pending approval of a new UIC permit for an additional five years. The City of Los Angeles has proposed the following changes:

- Constructing a fourth well at the existing project site. This well would be drilled to 7,500 feet as opposed to current wells drilled to 5,300 feet. At this new depth, the injection operation would facilitate further analysis of its productivity.

2011-12 Project Description

- Deepening the existing monitoring and injection wells from 5,300 feet to 7,500 feet.

- Constructing project replacement wells as necessary during the demonstration phase, allowing for responses to operational well problems and unforeseen conditions (e.g., natural disasters, mechanical failures).

- Alternating or simultaneous injection into two wells to facilitate the previously approved injection capacity.

To date since 2008, the City of Los Angeles:

- Diverted over 96,400 tons of biosolids from land application;

- Sequestered over 13,000 metric tons of carbon dioxide (CO_2);

- Eliminated approximately 443,000 miles of heavy truck traffic and the associated exhaust emissions, pollutants, odors, and dust;

- Eliminated emissions of 12 tons of NO_x and 11.2 tons of CO; and

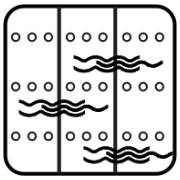
- Reduced biosolids management costs by $3.2 million since the injection operations began.

Project Type: ☐ New ☒ Continuing

2011-12 Project Description

Project Title:

Process Modeling



Contact: Michelle Hetherington, Operations & Maintenance

Purpose: Establish biological and hydraulic models to optimize plant performance

Description:

The Biowin biological model program is being used for this project. In addition to extensive sampling, calibration is required to ensure that modeled results are close to actual sample results.

Results:

A model has been developed for the Plant 1 activated sludge facility (AS1) and the new activated sludge facility (AS2). The calibrated AS1 model has been used to evaluate, optimize, and predict process performance. The AS2 model will be used to develop and predict the process performance during testing scheduled to start in October 2012. Model runs and model calibration verification will be completed in late 2012 after AS2 diurnal sampling and analytical testing is complete.

The data used to calibrate the AS1 model was used for the AS2 model and was compared to the AS2 design input data. The calibration data indicate slightly higher sludge yields then are predicted using design input data. AS2 has been operating since April 2012 and the sludge has been consistent with the AS2 model. AS2 optimization continues.

Models were completed for the Plant No. 2 oxygen activated sludge plant, the trickling filter solids contact (TF/SC) basin, and the Plant No. 1 trickling filter. Additional samples and analytical data will be collected in 2012-2013 to calibrate the models.

Status:

Staff will calibrate the Plant No. 2 process models and use them for secondary process optimizations in 2012-13. This work now is considered part of Operations' normal activities, so this project will not be part of the research program after 2011-12.

Project Type: ☐ New ☒ Continuing

2011-12 Project Description

Project Title:

Anaerobic Co-Digestion of Food Waste

Contact: Andre Miller, Engineering

Purpose: Evaluate food waste co-digestion

Description:

Background:

OCSD currently operates two treatment plants processing nearly 210 MGD of wastewater. The sludge generated from the primary and secondary processes is stabilized in anaerobic mesophilic digesters. Plant 1 currently operates 10 digesters with a total working capacity of 19.28 MG, and Plant 2 operates 15 digesters with a total working capacity of 19.6 MG. OCSD projects an average primary sludge loading at Plant 1 of 250,000 lb/day in 2010 increasing to 350,000 lb/day in 2030. At Plant 2, the primary sludge loading is projected to decrease from 300,000 lb/day in 2010 to 100,000 lb/day in 2030 due to sludge diversion to Plant 1. The secondary sludge production at Plant 1 is projected to increase from about 25,000 ft^3/day in 2010 to up to 60,000 ft^3/day in 2030, and the Plant 2 secondary sludge production is projected to increase from about 25,000 ft^3/day in 2010 to up to 40,000 ft^3/day in 2030.

Assuming a reasonable digester volatile solids (VS) loading of 0.15 lb/ft^3/day (compared to the current operational target of ~0.10 lb/ft^3/day) and a residence time of 20 days, Plant 1 will be operating at its full digester capacity in 2030, while the Plant 2 digesters will have capacity available for additional organic wastes (e.g., restaurant FOG or processed food waste). If organic wastes were added at a rate of 0.04-0.05 lb VS/ft^3/day (for a plant-loading-to-organic-loading ratio of approximately 2.5:1), this would be equivalent to about 125,000 gallons/day of restaurant FOG or 250 tons/day of food waste. For a typical co-digestion process, this could result in additional electricity production of 3200 kW (a 63% increase at Plant 2).

2011-12 Project Description

Study Objective:

This project is designed to investigate the potential benefits and challenges of including food waste as an additional feedstock to existing OCSD digesters. As co-digestion has been implemented, some municipalities have observed other benefits to the overall digester operation, including increased VS destruction and biogas production from the municipal wastewater solids components. This project starts with waste characterization and laboratory testing and culminates with a limited full-scale demonstration using OCSD digesters.

This project is expected to include the following tasks:

TASK 1: Co-digestion studies using OCSD sludge and food waste

Semi-continuous fed laboratory anaerobic digesters will be operated to mimic the expected full-scale digester operating conditions. At the 2030 loading condition the Plant 2 digesters potentially could receive a co-waste VS loading of 35-45% of the municipal sludge. However, a higher co-waste loading is possible prior to 2030 or if co-digestion is carried out in selected digesters in 2030 (e.g. 50:50 VS loading in 10 digesters and 100% sludge loading in the remaining digesters.). Hence, batch tests will be performed using five reactors: a control (100% municipal sludge), three test reactors (10%, 30%, and 50% food waste COD loading), and a fifth reactor containing 50% restaurant FOG waste. Operating the digesters at varying organic waste VS loads facilitates development of cost curves that will include the effects of increases in gas production, reductions in dewatered solids production (resulting in reduced residual solids hauling costs), and reductions in polymer/coagulant requirements for dewatering. This will help in deciding the optimum organic waste loading plan based on all of these factors rather than on energy production alone.

The digesters will be fed daily with the appropriate feed, and the systems will be monitored for influent and effluent solids (total and volatile), COD (total and soluble), pH, alkalinity, total nitrogen, phosphorus, gas production (volume and methane content), ash, protein, and carbohydrates. All tests will be performed according to the appropriate Standard Methods, and appropriate replicates will be used to assure data quality.

A respirometry study will also be performed for each case. In these tests, an initial amount of food and inoculum seed will be placed in bottles, and the bottles will be placed in a respirometer for continuous gas measurements. Respirometer studies provide a more detailed picture of the biodegradation and gas production rates (kinetics) as well as the full extent of the biodegrability of the waste streams and are a good supplement to the other reactor studies.

2011-12 Project Description

TASK 2: Odor production from co-digested solids

The effect of cake storage on odor production will be analyzed by storing duplicate samples in serum bottles and measuring headspace odor-causing chemicals (methyl mercaptan, dimethyl sulfide, dimethyl disulfide, acetone, indole, skatole, p-cresol) and ammonia over 14 days, using standard protocols developed at Bucknell University and Virginia Tech as part of an earlier WERF project (Adams et al., 2007). Odorant volatile organic compounds (OVACs) in the headspace will be analyzed using GC/mass spectrometer selective ion monitoring (SIM) methods at Bucknell University. Organic sulfur compounds will be analyzed by the GC/FID method. Protein analyses of digested cake solids and centrate will be analyzed using the Hartree (1972) modification of the Lowry, *et. al.* (1951) method.

TASK 3: Evaluation of possible microbial community changes during co-digestion

The objective of this task is to evaluate and understand if the changes in biosolids characteristics observed during co-digestion are due to changes in the microbial community in the presence of co-waste. Upon reaching steady state operation, replicate samples will be collected from control and co-digested reactors, and the total microbial DNA of digested biosolids will be extracted. Extracted DNA will be purified and quantified as a reference of the total microbial biomass. The PCR-DGGE technique will be used to produce microbial population fingerprints for both bacterial and archaeal domains of all digesters.

It has been hypothesized that co-digestion using organic waste tends to shift the methanogenic bacterial community. Methanogens reside within the archaeal domain. A community structure analysis can be performed to determine if the communities have changed as a result of the feed characteristics and if there has been a change in the dominant population(s). If some of the communities are different, the discreet bands representing individual microorganisms will be excised, amplified, cloned, and sequenced, and the results will be compared to the genomic DNA database to identify the bacteria and/or archaea.

TASK 4: Limited full-scale digester testing

Task 4 is a limited full-scale demonstration of co-digestion at OCSD. Two full-scale anaerobic digesters will be operated in parallel (as a test reactor and a control). The full-scale demonstration will be conducted to confirm the results from the previous tasks. Biogas production, reduction in dewatered solids production, reduction in polymer/coagulant dose for dewatering, and operational stability as indicated by

2011-12 Project Description

volatile acids and alkalinity concentrations will be used to monitor the process performance.

Waste Management Inc. will provide a ”Bio-Slurry” created by the processing of restaurant food waste. The food waste will be processed at nearby Waste Management facilities using technology that removes non-digestible contaminants and creates a slurry with a particle size of less than 5/8”. It is expected that this slurry will be easily pumped and metered into the OCSD digester using the existing infrastructure at the facility.

The Bio-Slurry will be delivered by tanker truck into an onsite holding/mixing tank to ensure homogenization of the feedstock. From there, it will be metered to the digester at controlled rates. The digester VS loading will be in accordance with the previous results of the lab-scale tests, which will determine the operational parameters for this full-scale test. In addition to evaluating the digester operation with the added food waste, the full-scale test will be used to address any difficulties with fugitive odor control and slurry transfer into the digester, which are areas that could not be tested in a laboratory setting.

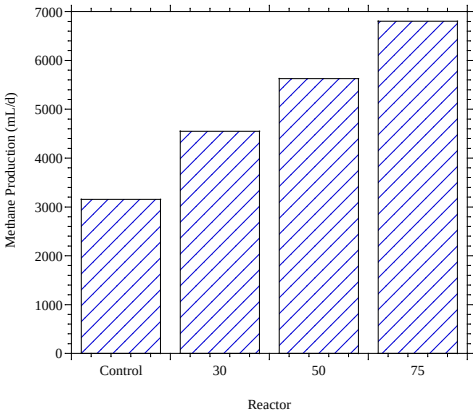
Schedule:

The bench-scale studies were conducted during 2011-12. Once it begins, the limited full-scale test is estimated to take nine months to complete.

Results:

Food wastes were added to OCSD sludge in three laboratory-scale digesters, resulting in COD increases of approximately 30, 50, and 75%. A control reactor with only the OCSD sludge was also operated. The OCSD sludge consisted of 80% primary sludge and 20% secondary sludge from Plant 1.

The data indicated that adding food waste increased the gas production in the digesters. Methane production gradually increased from 3000 mL/day in the control digester (no food waste) to nearly 6,800 mL/day in the digester with the largest amount of food waste. Furthermore, on a COD-normalized basis, the amount of methane generated from the food waste was significantly higher than from the control reactor. This indicated that the food waste had higher methane generation potential than the OCSD sludge.



2011-12 Project Description

The suspended and volatile solids in the digesters containing food waste were higher (~15% at the highest food waste loading) than in the control reactors. This indicated the presence of some inert materials in the food waste. However, dewatering of the digested sludge indicated that the digested solids from the digesters with food waste were dewatered more effectively than from the control reactors. The percent solids in the food waste-added cakes were ~ 2% higher than the control. As a result, the net dewatered mass estimates indicated that the mass of post-digestion residual solids were not significantly different (-5% to +3%) between the control and the food waste-added cases. This is particularly notable since the highest food waste digester received nearly 30% more solids than the control digester, yet the net dewatered residual solids mass requiring disposal was not significantly different.

Odor analyses of the digested cake indicated a greater than 30% reduction in the production of odor-causing volatile organic sulfur compounds from the food waste-added digesters in the two higher loading cases. Additional analyses are underway for other odor causing compounds such as dimethyl sulfide and methane thiols.

Status:

Additional analyses of the digester samples early in 2012-13 will focus on various operational parameters, dewatering characteristics (polymer dose, centrate quality, cake quality), odor production, and microbial community analyses. These results will inform a decision about proceeding with the full-scale testing.

2011-12 Project Description

Project Title:

Ferric Chloride Dependence Elimination or Mitigation: Literature Search

Contact: Shabbir Basrai, Operations & Maintenance

Purpose: Conduct a literature search to identify options for reducing or eliminating ferric chloride usage

Description:

Ferric chloride is used to enhance solids coagulation in chemically enhanced primary treatment and to control hydrogen sulfide in anaerobic digester gas. Even though it is effective in reducing overall process costs and achieving regulatory compliance, the current restricted supply options and the high product price prompted the District to look for alternatives.

The purpose of this project was to conduct an extensive literature search to identify more sustainable and economical options for reducing or eliminating OCSD's dependence on ferric chloride and to provide a better understanding of the science underlying enhanced primary treatment and digester gas hydrogen sulfide production and control. The scope of the literature search included other chemicals and alternative process technologies.

The University of California, Irvine (UCI) was chosen to conduct the literature search because, as an academic institution, they had ready access to relevant technical journals, periodicals, and databases.

Results:

Consistent with the project scope of work, UCI provided an Option Matrix to document all identified options from the literature search. The deliverables also included an Executive Summary listing the key findings and recommendations for OCSD, a catalog of literature identified in the study, and electronic copies of the literature.

Status: This project has been completed.

Project Category:

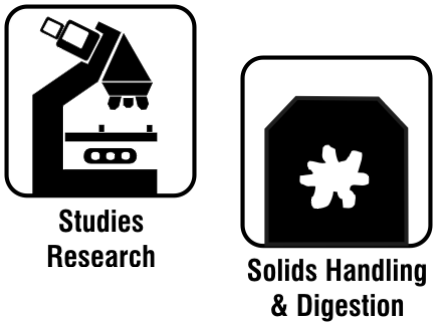
Emerging Contaminants, Ocean Monitoring, and General Topics

Project Type: ☐ New ☒ Continuing

2011-12 Project Description

Project Title:

University of Arizona Water and Environmental Technology (WET) Center



Contact: Tom Meregillano, Engineering

Purpose: Benefit from membership in a National Science Foundation-sponsored research center devoted to water quality-related research

Description:

OCSD supports and benefits from the research performed at the National Science Foundation Water & Environmental Technology (WET) Center administered through The University of Arizona. Although OCSD joined for their expertise in research related to land application of biosolids, the WET Center also researches water quality issues, reclaimed water, emerging contaminants, water and wastewater treatment technologies, new laboratory methods, climate change, and other cross-media issues related to OCSD's business activities.

Approximately 70% of the WET Center's funding is furnished by the State of Arizona through grants and public education funding. The remainder comes from annual contributions by individual members such as OCSD. For our annual contribution of $3,000, OCSD gets access to research costing approximately $1 million annually into the most pertinent issues in our industry today. OCSD also has direct input to the program and voting rights as a member of the Industrial Membership Board. The Center is also critical because their research is done in the same arid desert region where our biosolids are land applied, making their field studies more directly pertinent to the OCSD Biosolids Program than studies done in other regions.

2011-2012 Project Description

Results/Status:

During 2011-12, OCSD has been tracking the progress of the following research activities from the WET:

Research Projects: Progress Reports

Title	Authors	Summary
Copper Mine Tailings Amended with Class A Biosolids: Long-term Effect on Soil Bacterial Populations	Ian Pepper, Huruy Zerzghi, Stu Bengson, Brandon Iker, Monisha Banerjee, John Brooks	This study evaluates the effect of surface application of dried Class A biosolids on 10 microbial populations within copper mine tailings. Mine tailing sites were established at ASARCO Mission Mine close to Sahuarita, Arizona (1998). The addition of Class A biosolids to copper mine tailings in the desert southwest increased soil microbial numbers, activity and diversity.
Sustainable Revegetation of Copper Mine Tailings Through Land Application of Class A Biosolids	Ian Pepper, Huruy Zerzghi, Stu Bengson, Ed Glenn	Two copper mine tailing sites were amended with Class A biosolids in December 1998 (Site 1) and December 2000 (Site 2). Sites were located within 1 km of each other and were physically and chemically similar. At Site 1, biosolids were incorporated by disking into the tailings. At Site 2, biosolids were not incorporated, resulting in a 12-15 cm layer of biosolids on top of the tailings. The high moisture holding capacity of this layer of biosolids resulted in approximately twice as much soil moisture within the surface (0-30 cm) tailing depth at Site 2 than Site 1. The higher soil moisture at Site 2 resulted in significantly higher revegetation and enhanced microbial activities.
The Effect of Land Application of Class A Pelletized Biosolids on Cotton Yield in Southern Arizona	Ian Pepper, Huruy Zerzghi	In recent years, the demand for biosolids for crop production has increased due to economic reasons. A type of pelleted Class A biosolids (Top Choice Organic, TCO®) has recently become available for farmers. The primary objective of the study is to determine the efficacy of TCO for cotton production relative to traditional inorganic fertilizer. Overall, the study showed that TCO land application has the potential to enhance cotton production.

2011-2012 Project Description

Survival of *Ascaris* Ova in Desert Soils: A Risk Assessment	David Williams, Ian Pepper, Chuck Gerba	The goal of this study was to determine the effects of temperature and soil type on the survival of Ascaris ova in two biosolids-amended desert soils. The results of this study suggest that a waiting period of 120 days at average soil temperatures of 25 ^{o}C or 90 days at 37 ^{o}C after land application of biosolids to fields in which lettuce is planted would result in yearly risks of less than 1:10,000 for *Ascaris* from consumption of the lettuce with an ova concentration of 4 ova/ g dry solids.
Impact of Various Biosolid Treatments on Survival of Infectious Prions	Syreeta Miles, Wenjie Sun, Jim Field, Chuck Gerba, Ian Pepper	This study evaluated the fate of infectious prions during various biosolid treatments, specifically mesophilic (35 °C) and thermophilic (50 °C) anaerobic digestion and lime stabilization. A 4.2-$\log_{10}$ decrease was observed under mesophilic conditions after 21 days, while thermophilic conditions resulted in a 4.7-$\log_{10}$ decrease. When Class B mesophilically digested biosolids were treated with lime, a 2.9-$\log_{10}$ reduction of infectious prions was observed within the first two hours. Overall these results suggest that infectious prions are reduced significantly during anaerobic digestion and lime treatment and that land application of biosolids is not a viable route of human exposure to prions.

Status:

As a continuing member, OCSD maintains access to the Center's considerable research results and, as a voting member of the Industrial Membership Board, continues to participate in and provide input to the research program.

2011-12 Project Description

Project Title:

Marine Impacts and Trace Pollutants Studies

Studies
Research

Misc. &
Support Projects

Description:

OCSD participates in a number of projects related to marine life, ocean conditions, and trace pollutants. Often these are cooperative projects with industry organizations (e.g., WERF) or universities (e.g., UC Riverside). OCSD's role can range from minor (serving on project oversight committees) to more substantial. The analytical capabilities of the environmental sciences laboratory often are useful for researchers and provide opportunities for collaboration through in-kind contributions of sample analyses by OCSD.

Significant projects during 2011-12 related to marine topics and trace pollutants included the following.

- Southern California Bight Regional Monitoring Program 2008 (SCCWRP Cooperative Project)

  Contacts: Ron Coss and George Robertson, Operations and Maintenance

  This project collected regional information to assess cumulative impacts of contaminant inputs and to evaluate relative risk among different types of stresses. It was conducted through SCCWRP and involves over 90 participating organizations.

  The Bight'08 Survey was organized into six technical components: (1) Coastal Ecology, (2) Shoreline Microbiology, (3) Water Quality, (4) Hard Bottom, (5) Areas of Special Biological Significance (ASBS), and (6) Nutrient Overenrichment in Wetlands. OCSD was directly involved in the first three components.

  Bight'08 built on the information from previous Bight Studies (1994, 1998, and 2003) and expanded the scope by including new participants, answering additional questions, measuring more parameters, and using novel methods. The inclusion of multiple participants, many of them new to regional monitoring, provided several benefits such

as cooperative interactions with different perspectives and interests. Participants included a combination of regulators, dischargers, and researchers who developed an appropriate set of regional-scale management and scientific questions addressed by the study.

All field sampling work was completed and final reports were written.

The total SCCWRP budget for Bight'08 is $7 million. OCSD provided $125,000 for taxonomic and nutrient analysis, plus in-kind services (e.g., vessel and staff time for field surveys).

Study findings and recommendations were presented to the SCCWRP Commission in June 2012 and a kick-off meeting for Bight'13 will take place in August 2012.

- Ocean Current Measurement Program

  Contact: George Robertson, Operations and Maintenance

  The purpose of this study is to measure ocean currents in the vicinity of the OCSD ocean outfall. This is an on-going study that provides data used in determining compliance with our ocean discharge permit.

  The ocean current measurement program has several objectives. Its primary purpose is to provide data to aid in the compliance evaluations with OCSD's ocean discharge permit, while also advancing the understanding of physical processes that affect dispersion of the wastewater plume. These studies have contributed significantly to our understanding of mixing and transport processes on the San Pedro shelf near the OCSD outfall. In particular, the studies have increased the knowledge of three key processes – subtidal flows, internal tides, and sea breeze currents – that are important for understanding the behavior and fate of the wastewater discharge and for evaluating the contributions to near-shore bacterial contamination.

  As part of the Environmental Impact Report for the Outfall Land Section and Ocean Outfall Booster Station (OOBS) Piping Rehabilitation project (project J-112), ocean current data collected as part of this ongoing monitoring was used to evaluate the fate and transport of the discharge from OCSD's 78-inch outfall and the potential to impact the surf zone and other areas used for swimming and recreation.

- Ocean Modeling of Receiving Waters

  Contact: George Robertson, Operations and Maintenance

  This project is to develop a high resolution version of the Regional Ocean Modeling System (ROMS) for use by OCSD during the J-112 project. Once developed, it will be available for future modeling of the 78-inch outfall as well as for modeling the normal discharge from the 120-inch outfall. Once the 75-meter model has been calibrated, it will be incorporated into an existing operational ROMS model that includes real-time data assimilation to improve projections. Model runs of existing physical oceanographic conditions ("nowcast") are created every six hours. These runs include a 48-hour forecast (updated every six hours).

  Work has progressed in two integrated steps. Development of the 75-meter resolution model is complete, and hindcast runs are currently being done to evaluate the model output. Concurrently the 75-meter model has been integrated into the ROMS operational model for testing. All work to make the model operational is to be completed by September 2012. The model evaluation and reporting will be completed by June 2013.

  The budget for this project, including staff time and contingencies, is $262,300. The expenditures for fiscal year 2011-12 were $129,430.

- Sediment Profile Imaging Near the Orange County Outfall

  Contact: Jeff Armstrong, Operations & Maintenance

  Benthic organisms are routinely used as cost-effective indicators of environmental quality because they don't move around much (unlike fish), are a crucial component to aquatic habitats, and are sensitive integrators of changes in water and sediment quality. A variety of benthic indices have been developed to evaluate these communities. Two benthic health indices (BRI and ITI) routinely used by the District in compliance assessments showed steady improvements from 1985 to 1999. However, since around 2004, both of these indices have declined near the outfall diffuser, indicating a change of conditions and potential degradation of the benthic habitat near the wastewater discharge.

  Sediment-profile imaging (SPI) using the REMOTS® camera system is a reconnaissance survey technique that provides information on overall benthic habitat quality. Data relating to sediment-animal relationships, including sediment composition and layering, bioturbation, and redox layer depths are collected. A multivariate index is then calculated to rank stations for comparisons over time. With SPI, samples (i.e., images)

can be collected and processed more quickly than conventional benthic analysis protocols. However, SPI cannot provide specific information on the types and numbers of animals found and the actual chemical make-up of bottom sediments.

The District conducted an SPI study in 1999 at outfall stations to determine existing (baseline) seafloor conditions prior to planned increases in solids loading. The initial results indicated that the outfall and reference stations represented minimally impacted habitats and that organic loading was not having a detrimental impact on local (outfall) benthic populations. A follow-up study after the increase in solids loading was not conducted as there were no observed changes in sediment characteristics or in the benthos that raised any concerns to warrant additional studies.

Recent changes in treatment, such as increased levels of secondary treatment, reduced organic loadings to sediments, disinfection, and GWRS may be having unmeasured effects on biological communities near the outfall. By comparing current SPI images to those collected in 1999, OCSD staff could determine if any changes have occurred in sediment characteristics and quality near the outfall. This information will allow staff to better formulate proposed studies specifically designed to identify causal mechanisms for the observed biological impacts and may contribute to the final design of an optimized near-field benthic station grid from the Sediment Mapping Strategic Process Study (SPS).

This project has been completed.

- Evaluation of ZID Water Quality: Low-Flow Study

  Contact: George Robertson, Operations & Maintenance

  OCSD conducted a Strategic Process Study (SPS) as part of its NPDES discharge permit Monitoring and Reporting Program. In the 2010 Ocean Monitoring Annual Report, OCSD scientists reported observed changes in benthic organisms up to 1,000 meters away from the District's ocean outfall diffuser with significant impacts seen within 60 meters. These changes had not been associated with routinely monitored conventional sediment geochemistry parameters. However, they occurred during major construction and treatment level changes, including the onset of effluent disinfection in August 2002 and the beginning of the Ground Water Replenishment System (GWRS) operation in January 2008. Sediment geochemistry values represent time-integrated measures of the mass of contaminants discharged by OCSD and are used as indicators of the potential impact to receiving waters. While mass (how much of a material is in the sediments) is an important metric, organisms respond to exposures based on concentration, not mass. Therefore, one possible impact mechanism could be the exposure of animals to a more highly concentrated effluent at low flows that contain reverse osmosis (RO) reject waste from the GWRS. Flow and concentration also are important criteria in the initial

dilution of the wastewater field. A second mechanism might be the change in particle size due to the GWRS RO reject stream since particle size is a critical component in the fate and transport of discharged material to the ocean.

OCSD's Core water quality monitoring typically occurs between 8:00 AM and 3:00 PM, which is when effluent flows are increasing or near maximum values. Sampling of the plume at low flow and comparing it to the previous Core water quality sampling data could highlight changes in effluent quality that are not normally captured and indicate whether a more concentrated plume is present in the receiving water environment during these periods. A previous low-flow sampling event conducted in May 2011 demonstrated changes in several receiving water quality measures associated with early morning low effluent flows.

This project has been completed, and the results indicated that plume concentration is occurring during periods of low flow.

- Ground Water Replenishment System Reverse Osmosis Reject Bioassay Study

  Contact: Robert Gamber, Operations & Maintenance

  There have been no observable toxicological impacts of Ground Water Replenishment System (GWRS) microfiltration and reverse osmosis (RO) waste (reject) streams on the whole effluent toxicity (WET) testing of OCSD's final effluent. While the microfiltration waste streams are returned to OCSD for treatment, the GWRS RO reject is combined with OCSD post-treatment streams and discharged without additional treatment. Moreover, the RO reject stream is estimated to comprise as much as 25% of the final effluent waste stream during periods of low flow (from 3:00 to 9:00 AM). The toxicity of GWRS effluent blends had been studied in a pilot project, but no subsequent RO reject bioassays were conducted after GWRS became operational. So it was decided to use OCSD's current bioassay test species to analyze for potential toxic effects of the RO reject stream because this stream has a direct effect on OCSD's final effluent composition and because a relationship had been observed between flow rates and changes in the benthic community.

  By conducting WET bioassays on the RO reject and environmentally relevant concentrations, OCSD assessed the potential biological impacts of the RO reject on the marine environment, including the benthic community, and the potential WET impacts of future GWRS expansion with an associated increase of RO reject waste streams. The RO reject bioassay study was planned as a component of a larger RO reject effluent characterization study, which would include chemical analysis and flow rate calculations.

  The RO reject bioassay project has been completed.

- Final Effluent Characterization

  Contact: Kim Christensen, Operations & Maintenance

  The objective of this study is to re-evaluate final effluent characteristics (such as particle settling and potential sedimentation rates, and chemical concentrations, including new constituents such as chlorination by-products) relative to a comparable study in 1998. Changes in treatment plant processes, such as disinfection and GWRS-related modifications, were to be included to determine the potential impacts to sediment quality and biota. In addition, physical and chemical characterization of GWRS RO reject flows were to be included to determine the potential for environmental effects from ocean discharge.

  This study attempts to recreate final effluent characteristics from 2002 and 2010 as closely as possible using the process streams available in 2012. Many process changes have occurred over this time, so the streams that make up the final effluent are very different from those in 2002 and 2010. Assumptions were made to produce final effluent characteristics that approximated the final effluent produced in 2002 and 2010.

  At the end of 2011-12, the data analysis and reporting for this project were in progress.

- Fish Liver Histopathology

  Contact: Jeff Armstrong, Operations & Maintenance

  Exposure to chemical contaminants is known to produce certain types of lesions in fish livers. From 1986 through 2003, the District regularly monitored for lesions and other histopathological abnormalities in several species of fish. Results showed that the prevalence of tumors and lesions was very low, and there was no discernible spatial trend relative to the outfall.

  As part of the investigation into changes in biota near the outfall, the use of fish liver histopathology was revisited since the previous studies were conducted prior to starting bleach disinfection of the final effluent and receiving RO reject flows, which may be concentrating contaminants, especially during low-flow periods.

  The District engaged Dr. Kristy Forsgren at the University of California, Riverside to conduct the study. Two flatfish species used extensively in the previous histopathology studies were sampled: hornyhead turbot (*Pleuronichthys verticalis*) and English sole (*Parophrys vetulus*). Ten of each fish were targeted from both the outfall and farfield stations (n=40) within a size range of 15–20 cm. Visual examinations of the liver

conditions were conducted in addition to the histological examinations. The data analysis will include a comparison of the two sites and comparison to historical data.

At the end of 2011-12, the data analysis and reporting for this project were in progress.

- Trace Organic Chemical (TOrC) Removal during Wastewater Treatment (WERF Cooperative Project CEC4R08)

  Contact: Jeff Brown, Engineering

  The goals of this large project were to determine the fate and transport of a suite of trace organic chemicals (TOrCs) during conventional wastewater treatment and to determine quantitative structure/activity relationships (QSARs) so that removal of any chemical could be modeled. Common TOrCs include pharmaceuticals, personal care products, hormones, and industrial endocrine disrupting chemicals. The results of this project will improve understanding of the occurrence and fate of TOrCs in municipal wastewater systems, assist in identifying a short list of TOrCs that can be used in monitoring efforts to assess process performance, and allow a utility to determine the most cost-effective method for TOrC reduction. The results were released in the 2012 WERF report *Trace Organic Compound Removal during Wastewater Treatment: Categorizing Wastewater Treatment Processes by Their Efficacy in Reduction of a Suite of Indicator TOrC* (CEC4R08).

  Phase 1 of the project included selecting viable indicator TOrCs that represent a wide range of physicochemical properties, followed by a comprehensive and critical review of currently available TOrC fate models. The project team ultimately selected the ASTreat model due to its free access, simplicity, and easily available input parameters. ASTreat proved to be a useful screening tool for predicting the removal characteristics of most TOrCs under full-scale treatment.

  During Phase 2, aqueous and biosolid samples from full-scale treatment processes of participating utilities were analyzed to determine and quantify select TOrCs present in raw sewage, in treated wastewater effluents, and accumulated in biosolids. The treatment processes included non- or partly- nitrifying activated sludge systems, nitrifying/denitrifying activated sludge systems, and biological phosphorus removal processes. These efforts were augmented by controlled laboratory- and pilot-scale experiments to further develop and evaluate observed relationships between operational parameters and TOrC removal. Additional laboratory-scale experiments derived biotransformation rate constants for the fate model calibration.

  One of the key findings pertained to the relevance of solid and liquid stream interactions for TOrC attenuation during wastewater treatment. The research indicated

that highly and moderately sorbable TOrCs can be found in significant amounts on the wasted solids from secondary treatment systems. In addition, related tests of a full-scale anaerobic digestion process revealed that several recalcitrant TOrCs were not reduced during anaerobic digestion, but were found in increased concentrations in the digested sludge. Together, these findings highlight the potential for accumulations of hydrophobic, non-degradable TOrCs in liquid stream processes and on biosolids.

OCSD was a minor participant in the larger WERF study, sharing data from previous internal studies, allowing samples to be taken from the Plant 1 activated sludge system operating in nitrifying mode, and contributing about $40,000 in cash and in-kind expenses to the total $500,000 project cost.

Project Type: ☐ New ☒ Continuing

2011-12 Project Description

Project Title:

Orange County Spatial Variability of Ocean Sediments – Phase II

Ocean Outfall Systems

Contact: Jeffrey Armstrong, Operations & Maintenance

Purpose: The goal of this two-phased study is to strengthen OCSD's ability to detect changes in sediment quality in its receiving waters monitoring area and insure the accuracy of NPDES permit compliance assessments.

Description:

Problem Statement:

Maps are an extremely effective data summary tool used to demonstrate spatial extent and magnitude of environmental conditions. Maps help put information about contaminant gradients relative to sources into context over the entire area of interest. Maps of environmental conditions in the area of interest across multiple years will help identify changes in spatial extent (i.e., is the outfall footprint expanding or shrinking over time?). However, the ability to create maps with scientific rigor is difficult and rarely accomplished as sampling grids are often too sparse to capture the necessary spatial variability for reliable predictions at unsampled locations. In addition, many tools used in map creation do not describe confidence in the mapping contours. The District publishes contour maps of pollutants and sediment physical parameters in the Marine Monitoring Annual Report. These maps are based on the placement of existing sediment sampling stations prescribed in the NPDES discharge permit. This sampling scheme is likely not optimal for accurately assessing the outfall footprint for contaminants discharged with the treated wastewater effluent.

2011-12 Project Description

Study Objective:

The objective of this study is to review the District's historical benthic sediment data to determine the optimal sediment station array for accurate map generation of the District's outfall footprint for sediment geochemistry analytes and benthic infaunal community metrics. Improved maps will ultimately provide better data for the determination of NPDES permit compliance and provide managers, regulators, and other stakeholders with the best available information on spatial and temporal trends of sediment impacts from wastewater discharge. As a result of this study, we will be able to answer the following questions: (1) How representative is our existing station grid of the outfall area? (2) Are we undersampling some areas and/or oversampling others? (3) What is the most cost-efficient grid spacing to provide accurate mapping contours? (4) How many additional stations are necessary to characterize spatial variance in the area around the discharge or other areas of influence (e.g., Santa Ana River); and (5) What analyses (e.g., chemical parameters, biological indices) will provide the best resolution for mapping the area?

This phase of the study will be conducted in five discrete tasks conducted serially, each with associated products (see Study Outline below). The specific products will include estimates of sample spacing and resulting spatial variability estimates from the current monitoring grid. In addition, an enhanced sample design will be created that will ensure quantifiable spatial variability estimates (also known as a "variogram"). A map of the station locations and a table of latitude/longitude will be created for sediment mapping sampling and analysis. The project will also include the transfer of mapping technology from SCCWRP to OCSD. Implementation of the sediment mapping study design will be evaluated at the conclusion of this study based upon a review of the results, the study value, and fiscal constraints.

Study Collaborators:

Dr. Kerry Ritter, Southern California Coastal Water Research Project (SCCWRP), supported the study with assistance in modeling the spatial variability (variograms), spatial statistics, and spatial designs. She currently is completing a comparable sediment mapping project with the City of San Diego.

Dr. Jeffrey Armstrong, the project leader, worked with Dr. Ritter to provide data and assist with statistical analyses as needed.

Phase II is scheduled to run from July 2010 to June 2013. It is an OCSD self-funded project. There is no estimated budget for this phase due to the unknown number of samples

required. The number of additional sampling sites for Task 1 is 60, while the sampling sites for Task 4 are yet to be determined.

The study outline for Phase II is as follows.

TASK 1: Sample and analysis for variability assessment (to be completed by OCSD)

The goal of this task is implementation of the optimal sampling design created in Phase 1, Task 3. Implementation will include field sampling and laboratory analysis. At a minimum, the indicators to be measured include sediment grain size, chemistry, and benthic infauna.

Products:

- Sampling to be completed by July 2010
- Chemistry analysis to be completed by Aug. 2010
- Benthic infaunal analysis completed by Dec 2010

TASK 2: Spatial variability assessment

This task will focus on analyzing the data collected during Task 1. Data analysis will include variogram modeling, spatial regression models for trends in spatial and temporal gradients, and the effects of unique spatial heterogeneity (i.e., outliers). Finally, an initial contour map, based on the results from Task 1, will be prepared. Based on kriging models, the contour map will focus on representative indicators and include estimates of confidence.

Products:

- Preliminary variogram modeling
- Initial contoured image maps of kriged values with estimates of kriging errors

TASK 3: Design cost-efficient mapping study / annual monitoring program

Based on the spatial variance calculated during Task 2, a cost efficiency curve will be generated that weighs prediction errors versus sample density. This cost efficiency curve will be used to create an optimal sample design for mapping that maximizes contour resolution and confidence for the minimum amount of resources. Several designs will be explored including uneven sample allocation and nested sample designs.

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Products:

- Cost efficiency curve
- Written description of optimized sample design
- Map of station locations and table of latitudes and longitudes

TASK 4: Sample and analysis for final map (to be completed by OCSD)

The goal of this task is implementation of the cost-efficient sampling design created in Task 3. Implementation shall include field sampling and laboratory analysis. Indicators should be focused on monitored parameters currently collected by OCSD including sediment grain size, chemistry, and benthic infauna.

Products:

- Sampling to be completed by July 2011
- Chemistry analysis to be completed by Aug. 2011
- Benthic infaunal analysis completed by Dec 2011

TASK 5: Production of final map

The goal of this task is to prepare the final maps for OCSD's Annual Report. A complete set of indicators can be evaluated. The contour maps will include kriged predictions and estimates of confidence. In addition, the map production capability and assessment will be transferred to OCSD for making future maps.

Products:

- Final contoured image maps of kriged values with estimates of kriging errors by June 2012
- Technical transfer of kriging techniques to OCSD staff by June 2012

Status:

Tasks 1 and 2 have been completed. The final field sampling event is completed and samples are awaiting laboratory analysis.

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Dr. Ritter left SCCWRP in July 2012 and will no longer be working on the project. Laboratory analyses will continue with data analysis to follow when a new statistician is hired by SCCWRP. The project is on schedule at this point.

Phase II Schedule

TASK 1: Sample and analysis for variability assessment (OCSD) - Sampling (July – September 2010) - Laboratory analysis	7/10 – 12/10
TASK 2: Spatial variability assessment - Preliminary variogram modeling - Initial contoured image maps of kriged values with estimates of kriging errors	3/11
TASK 3: Design cost-efficient mapping study/ annual monitoring program - Cost efficiency curve - Written description of optimized sample design - Map of station locations and table of latitudes and longitudes	7/11
TASK 4: Sample and Analysis (OCSD) - Sampling - Laboratory analysis	7/11 – 12/11
TASK 5: Production of final map - Final contoured image maps of kriged values with estimates of kriging errors - Technical transfer of kriging techniques to OCSD	6/13

Part 5

2012-13 Research Plan

Part 5

2012-13 Research Plan

Several major project milestones are planned during 2012-13 and are described below. These will reflect substantial progress on efforts relating to environmentally responsible energy production and operating practices and to increased treatment process efficiency, among others. (A general description of the upcoming work on these and other continuing projects is found in the project summary table in Part 3 of this report.)

Fuel cell demonstration at Plant 1: Fuel cells provide perhaps the most environmentally benign method of generating electricity. The 300 kW OCSD installation starts with a renewable resource (digester gas), generates electricity for plant use and hydrogen for vehicle use, and emits only water, trace amounts of gases, and heat. This project involves a number of organizations, including the U.S. Department of Energy, the California Air Resources Board, the South Coast AQMD, and the University of California. FY 2012-13 will be the second year of a planned three-year test.

OpenCEL process for digester improvement: This technology is intended to improve the digestibility of TWAS, resulting in greater biogas generation and reduced residual solids amounts. The baseline biogas production from a selected digester at Plant 1 was measured during 2011-12, and the effectiveness of the OpenCEL treatment will be tested in full-scale use in 2012-13.

Processed food waste as an additional digester feed source: This has been investigated at laboratory scale and might move into a limited full-scale test. Food waste is highly digestible itself, but the laboratory results also suggest that its presence in a mixed-feed digester can alter the conditions in ways that improve the digestibility of the entire digester contents.

Superoxygenation for odor control in the collection system: This continues to be of interest as a way to reduce the use of other chemicals. The onsite sampling and preliminary design efforts that were completed for selected pump stations have led to a planned full-scale installation at the Main Street pump station. This will allow staff to investigate the concurrent use of superoxygenation and chemicals in a combined force main/gravity flow sewer, which will be invaluable in planning superoxygenation's expanded use throughout the collection system.

New projects: Improving the efficiency of core wastewater treatment activities is an on-going effort. One way to improve efficiency is to adopt new technologies that provide cost or efficiency advantages over existing practices. New projects in 2012-13 will include testing an advanced computer model of odor formation in sewers to optimize staff's odor control efforts, investigating the final effluent plume's fate, transport, and impact on the ocean, and continuing to evaluate supercritical fluid destruction of organic solids.

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