Orange County Sanitation District

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Research Report 2011

2011
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 2010-11 were:

Operations and Maintenance

- Jeff Armstrong
- Ron Coss
- 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 2010-11. The activities it describes were done by various divisions in the Engineering and Operations & Maintenance departments.

This 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). It also presents for reference the research project schedule that was developed in 2008-09 for the agency's Research Program Strategic Plan (Part 6).

The activities during this year addressed a range of topics, with notable efforts in air quality management, environmental improvement, and treatment process improvements. There also were cooperative projects with wastewater industry research organizations and with universities, arrangements which 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 been installed and commissioned.
• J-79 Central Generation engine emissions control	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. Testing a full scale installation of a dual oxidative / reductive catalyst system and a digester gas cleaning system was conducted from April 2010 through March 2011. Results showed a significant reduction in emissions of NO_x, CO, and VOCs.
• Superoxygenation for odor control	Intensive onsite sampling programs were conducted at two pump stations to provide accurate information about the wastewater characteristics. Using these data and computer models of the collections system, the effectiveness and life cycle costs of superoxygenation treatment at these sites and two others that had not been included previously were assessed.
• OpenCEL process for digestion improvement	If effective, this sludge treatment would increase digester gas production and reduce residual biosolids amounts, leading to reduced O&M costs of several million dollars per year. The baseline digester performance data collection started in Q4 2010-11.

• 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.
• Process modeling	A model for the Plant 1 activated sludge facility was developed and calibrated. The model has been used to evaluate sludge return ideas, to evaluate adding mixing, and to predict process changes. The new activated sludge plant also has been modeled, and the calibrated data were compared to the design input data.
• Trace organic chemical removal	OCSD's $20,000 contribution was leveraged 25-to-1 in this $500,000 WERF project. The expected benefits include more detailed knowledge of the fate of chemicals and an improved ability to model their removal in wastewater treatment processes. A testing cycle at OCSD was completed to ensure data relevant to our operations were included.

New research projects will be undertaken consistent with the research strategic plan's recommendations and in response to any changes in OCSD's needs. Toward this end, OCSD joined 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 2010-11, the budget for research totaled $2.11 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 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 and treatment plant operations. This category was 63% 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 2010-11, only two projects were in this category: air emissions control of Central Generation engines (project J-79) and the fuel cell demonstration [projects SP-132 and SP-134 (operating costs only)]. However, only the fuel cell projects actually contributed to the budget total because project J-79 essentially was completed in the previous year, so its minimal ongoing costs did not enter into the 2010-11 figures. This category was only 4% of the total research budget because OCSD's contribution to the construction costs of project J-79 and the fuel cell demonstration occurred in the previous year.

"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. The majority of these expenditures is for memberships in various research-related organizations; the remainder is for projects (often cooperative projects through the research organizations) that are funded from specific division budgets. Most often, these are projects involving Division 890 (Environmental Lab and Ocean Monitoring). This category was 33% of the total research budget.

Figure 2-1b shows the distribution of actual expenditures for 2009-10. While the budget was $2.11 million, the expenditures totaled only $1.11 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, the contract provides for a single payment (up to $300,000) for these activities when they are completed, which will occur in 2011-12. 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) essentially equaled their budgeted amounts for the year.

Figure 2-2 shows the actual expenditures broken down by focus category. Other than organization memberships (54%), the largest fraction (30%) is for 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 ocean monitoring activities. 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 14:1 leveraging of its total $8.0 million cost, and the other projects show 13:1 leveraging of a total $0.5 million cost. (Since several cooperative activities finished in 2009-10, the only "other" project in 2010-11 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.

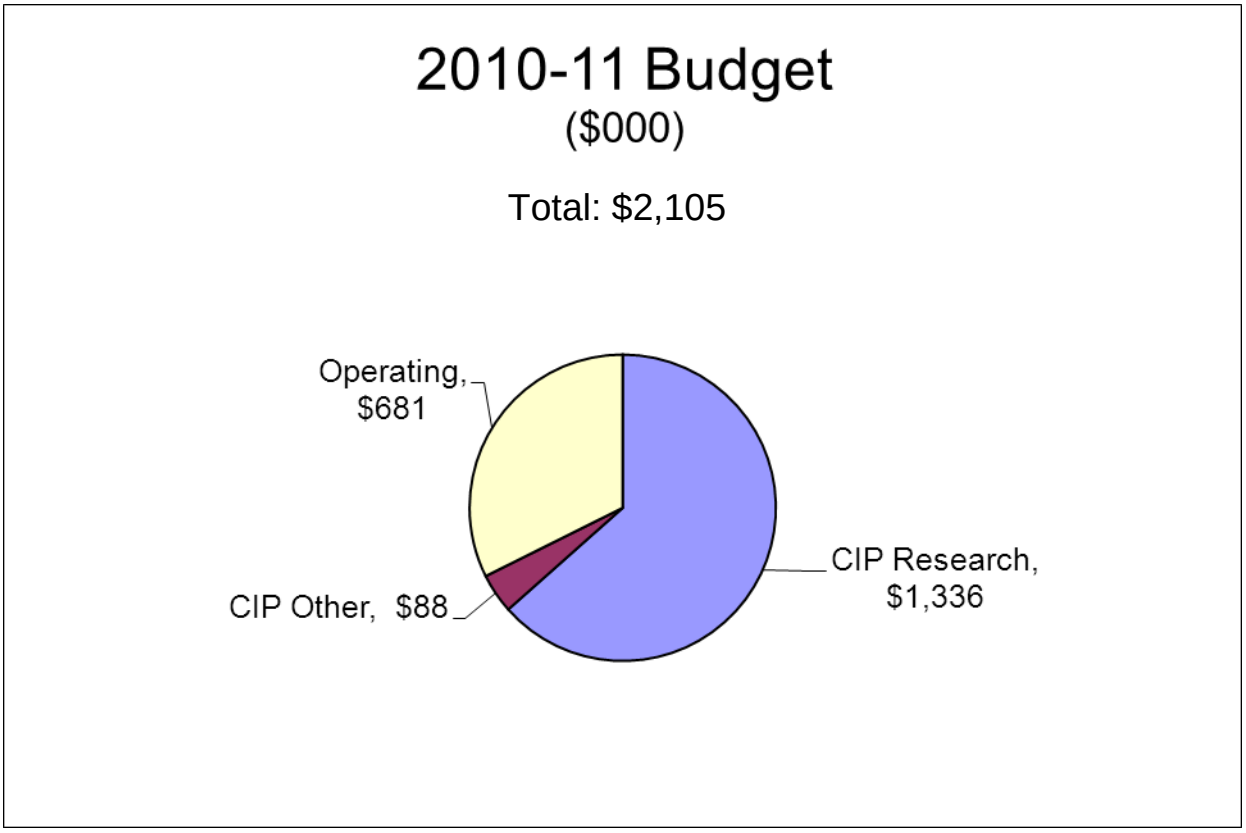


Figure 2-1a. Research Budget by Expenditure Type

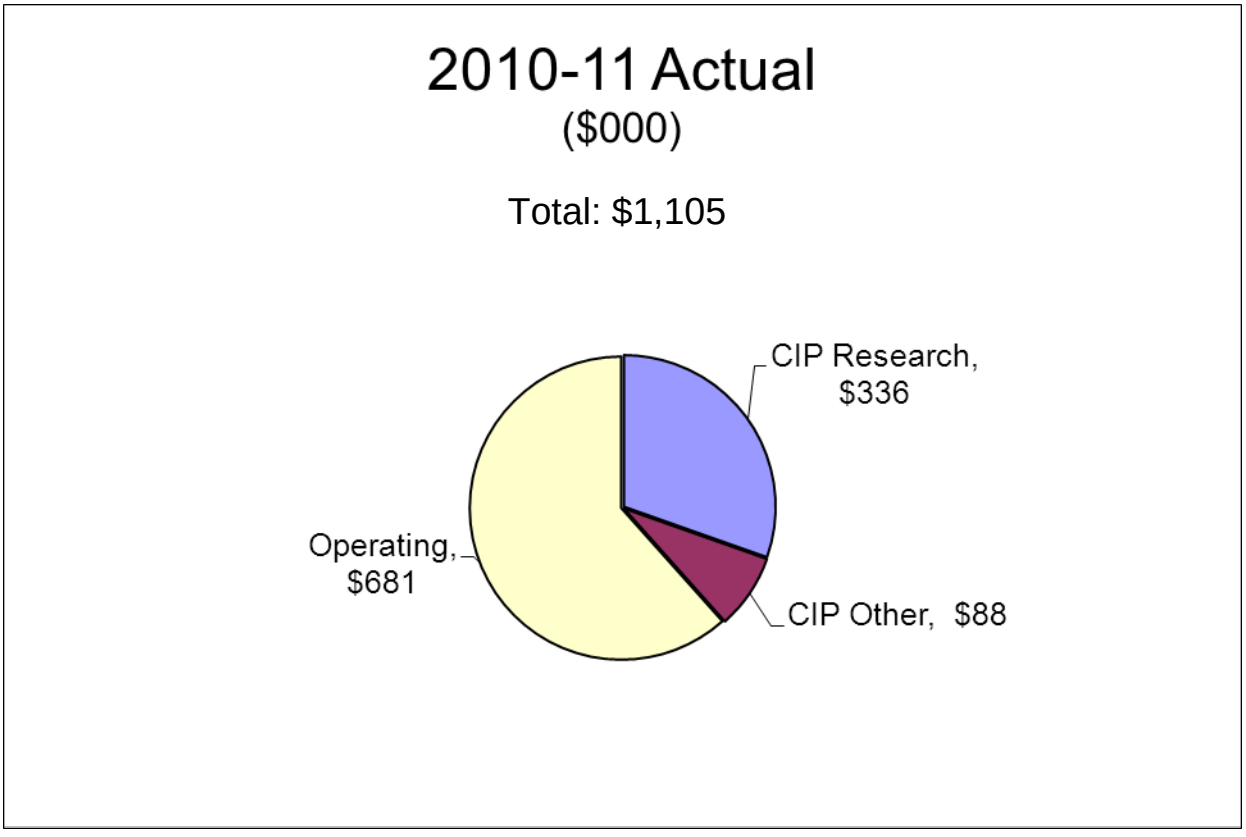


Figure 2-1b. Distribution of Research Expenditures by Expenditure Type

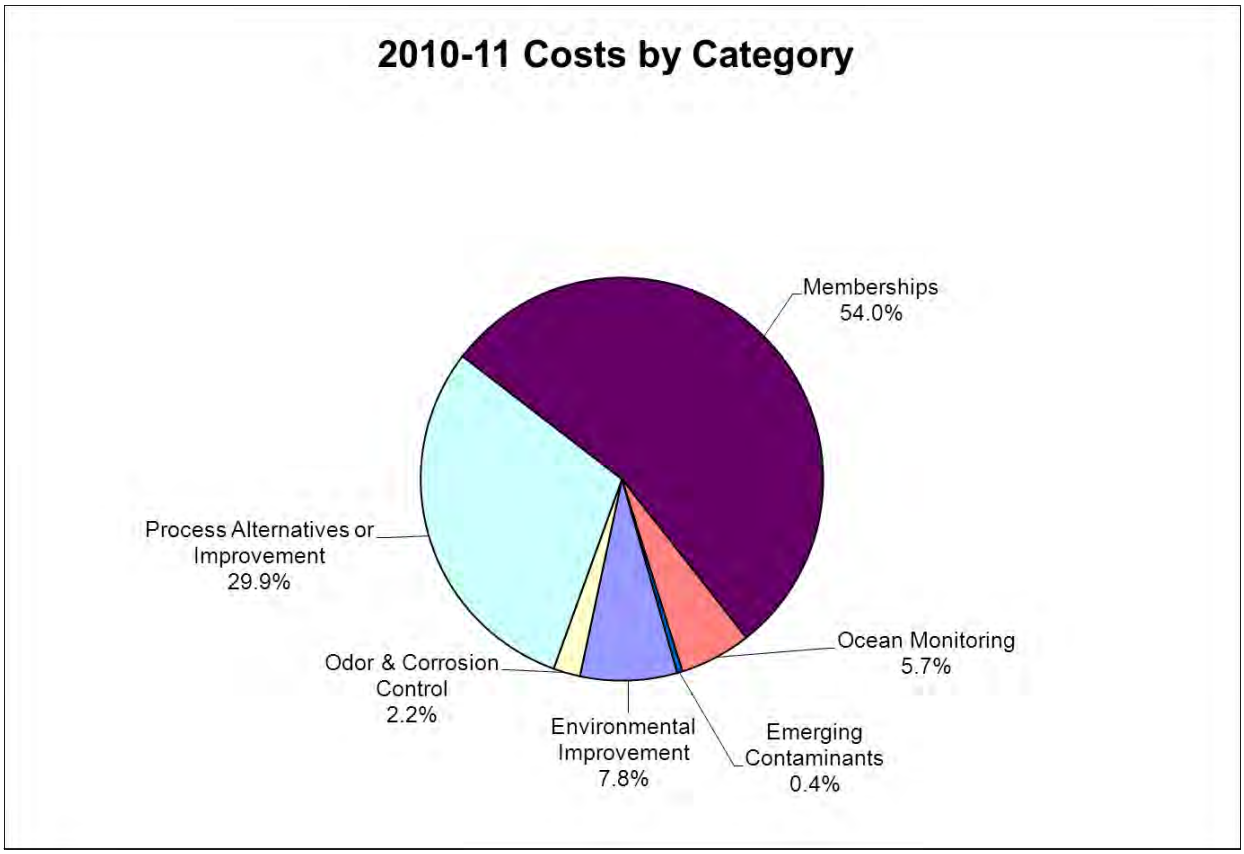


Figure 2-2. Actual Research Expenditures by Focus Category

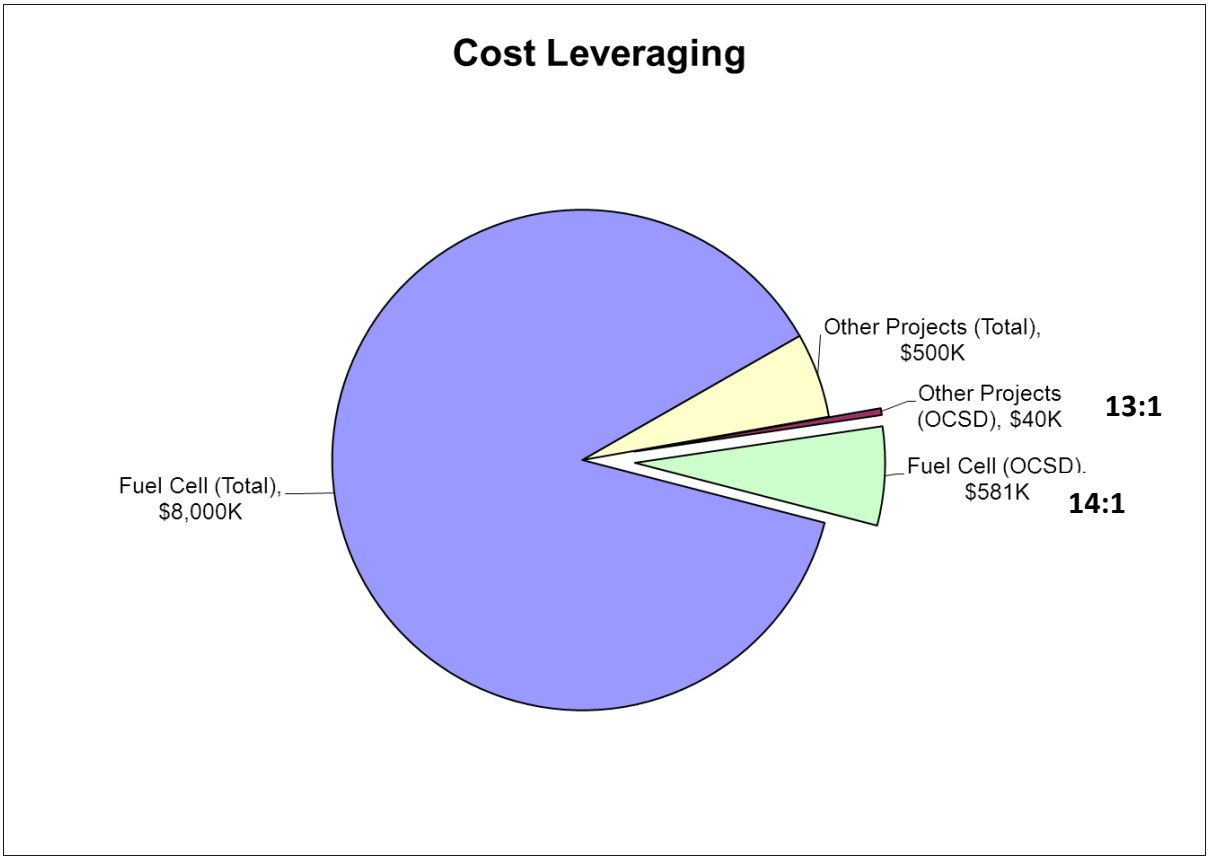


Figure 2-3. Cost Leveraging Achieved in Research Projects

Part 3

Summary of Projects and Memberships

OCSD Research Summary 2010-11: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2010-11	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2011-12)
Environmental Improvement	Greenhouse gases (GHG) emissions model	$35,000 + minor internal costs	Minor; 2009-10 costs included $35,000 to UCI's Urban Water Research Center)	---	UC Irvine	Develop model for predicting GHG emissions for various process configurations	UCI and OCSD developed a computer model in 2009-10 to evaluate the methane-equivalent emissions from various parts of OCSD's activities. This can be used to evaluate environmental impacts of current and proposed process options. In 2010-11, modifications were made to improve accuracy and usability.	Depending on the need, activities might include refining parts of the OCSD model and starting to integrate the OCSD model with a related model UCI might develop for OCWD.
Environmental Improvement	Fuel cell demonstration	$500,000 for installation; $81,400 for operation	$27,500	$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	Use renewable resource (digester gas) to produce environmentally "clean" electricity and hydrogen for fuel. Energy Station (fuel cell) and Hydrogen Fueling Station have been installed and commissioned.	Begin 3-year test program with fuel cell fed with digester gas producing electricity and providing hydrogen to the vehicle fueling station.
Environmental Improvement	Fuel Cell Feasibility Study SP-132	$100,000	$60,972	---	---	Perform a lifecycle cost analysis to determine whether OCSD should proceed with the planned CenGen Emissions Control Project (J-111) or consider a fuel cell replacement of all existing Central Generation engines.	After analyzing costs and considering risks, the recommendation was to continue with the planned upgrades to the CenGen engines.	None

OCSD Research Summary 2010-11: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2010-11	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2011-12)
Air Quality	J-79 Central Generation engine emissions control	$9.1 million	$3.0 million	---	---	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. Testing activities began in March 2010. Research monitoring activities were conducted from April 2010 through March 2011. Results showed a significant reduction in emissions of NO_x, CO, and VOCs.	The draft final report was reviewed by OCSD staff and SCAQMD. The project is closed, and no further work is expected in FY 2011-12.
Odor & Corrosion Control	Superoxygenation for odor control	$850,000	$24,500	---	---	Investigate using dissolved oxygen rather than chemicals for controlling odors and corrosion in sewers and treatment plants	Intensive onsite sampling programs were conducted at two pump stations to provide accurate information about the wastewater characteristics. Using these data and computer models of the collections system, the effectiveness and life cycle costs of superoxygenation treatment at these sites and two others that had not been included previously were assessed.	Recommendations for proceeding with full-scale installations will be considered. In addition, combining superoxygenation with chemicals to treat force mains followed by gravity sewers will be evaluated for effectiveness and feasibility.

OCSD Research Summary 2010-11: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2010-11	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2011-12)
Process Alternatives or Improvement	OpenCEL process for digestion improvement	$850,050 (most will be reimbursed if CIP project occurs)	$312,000	---	---	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.	Full-scale onsite test of the OpenCEL process will begin in Q2 2011-12 and continue throughout 2011-12.
Process Alternatives or Improvement	Food Waste Co-Digestion	$165,107	$25,788	---	---	This project is designed to 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 might improve the overall digester operation, including increased VS destruction and biogas production from the municipal wastewater organic components.	The 2011-12 activities will start with waste characterization and laboratory-scale digester testing and culminate with a limited full-scale demonstration using OCSD digesters. These activities will take place over a 12-month period.
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 2010-11: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2010-11	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2011-12)
Process Alternatives or Improvement	Process modeling	$252,250	$0	---	---	Develop biological and hydraulic computer models to help optimize plant performance	Staff has developed a model for Plant No. 1 activated sludge facility. The AS1 model was calibrated during the NDN process evaluation. The model has been used to evaluate sludge return ideas, to evaluate adding mixing to zone 4, and to predict process changes. The new activated sludge plant (AS2) has been modeled using the calibration data, and the calibrated data were compared to the design input data. The new facility will be in service in late 2011.	The Plant 2 OAS plant model is being developed and calibrated. Staff will continue to build and refine the models during 2011-12. 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.
Emerging Contaminants	Trace organic chemical removal during wastewater treatment	$20,000 + $20,000 (in-kind over 3 years)	$4,700	$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 $500,000 project. Expected benefits: more detailed knowledge of the fate of chemicals and greater ability to model their removal in wastewater treatment processes. One testing cycle at OCSD has been completed.	OCSD will provide technical expertise and review data. Once a model has been developed, OCSD might be a test site for validating it.
Ocean Monitoring	Southern California Bight Regional Study 2008	$125,000 (in-kind services only)	---	$1,095,000 plus in-kind services from various agencies	SCCWRP (So. Cal. Coastal Water Research Project) with 60 participating organizations	Collect regional information on contaminant effects and other stresses on ocean ecology	2008 study expands on 2003 survey to expand knowledge of such areas as coastal ecology, shoreline microbiology, and water quality.	Reports will issued over the next several years.

OCSD Research Summary 2010-11: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2010-11	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2011-12)
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. Phase 1 developed a list of 60 additional sites for sampling in addition to the 49 existing sites.	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 will ultimately lead to an optimized cost-efficient mapping design and annual monitoring program. Phase II will run from July 2010 through June 2013.

OCSD Research Summary 2010-11: 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 2010-11, there also was an increased emphasis on emerging pollutant chemicals in wastewater.
International Technology Approval Group (iTAG)	$40,000	The iTAG is a global consortium of water and wastewater utilities. Coordinated by Isle Utilities, an English consulting company, 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. This builds on a similar TAG collaboration model among UK utilities that has successfully commercialized about 50 new technologies over 5 years and secured $75 million in venture capital funding. Membership in iTAG includes access to a database of more than 1000 technologies that have been reviewed by Isle Utilities and a forum for communicating with other member utilities about issues of common interest.	OCSD joined the iTAG late in 2010-11. Nevertheless, the first semiannual onsite workshop was held in May to present several new technologies to OCSD. These included processes to recover phosphorus from liquid streams and new processing options for organic solids. In addition, staff has been reviewing other entries in the technology database.
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, engage in regional discussions related to the interpretation of observations made by participating agencies, and participate 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 $1.1 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 2010-11: Memberships

Organization	OCSD Funding	Benefits of Membership	Key Projects & Accomplishments
Water Environment Research Foundation (WERF)	$83,674	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 2010-11: 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 to promote health, enhance the efficient use of water resources, and protect 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 2009-10, UCI completed their work on the carbon footprint model of the treatment plants. In addition, OCSD staff began discussing UCI's involvement in an evaluation of alternatives to ferric chloride for settling primary solids (including the possibility of eliminating advanced primary treatment entirely) and for hydrogen sulfide control in the digesters. UCI's role in this project in 2011-12 will be literature reviews and specialized consulting on the alternatives. In 2009-10, UCI completed their work on the carbon footprint model of the treatment plants. In addition, OCSD staff began discussing UCI's involvement in an evaluation of alternatives to ferric chloride for settling primary solids (including the possibility of eliminating advanced primary treatment entirely) and for hydrogen sulfide control in the digesters. UCI's role in this project in 2011-12 will be literature reviews and specialized consulting on the alternatives.

OCSD Research Summary 2010-11: Memberships

Organization	OCSD Funding	Benefits of Membership	Key Projects & Accomplishments
National Water Research Institute (NWRI)	$50,000	NWRI sponsors projects and programs focused on ensuring safe, reliable sources of water. Their 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:

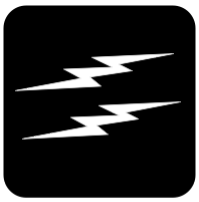
Environmental Improvement

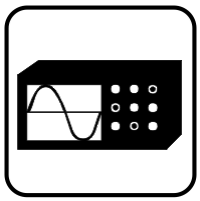
Project Type: ☐ New ☒ Continuing

2010-11 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 has agreed to be 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 will be 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 will be 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.

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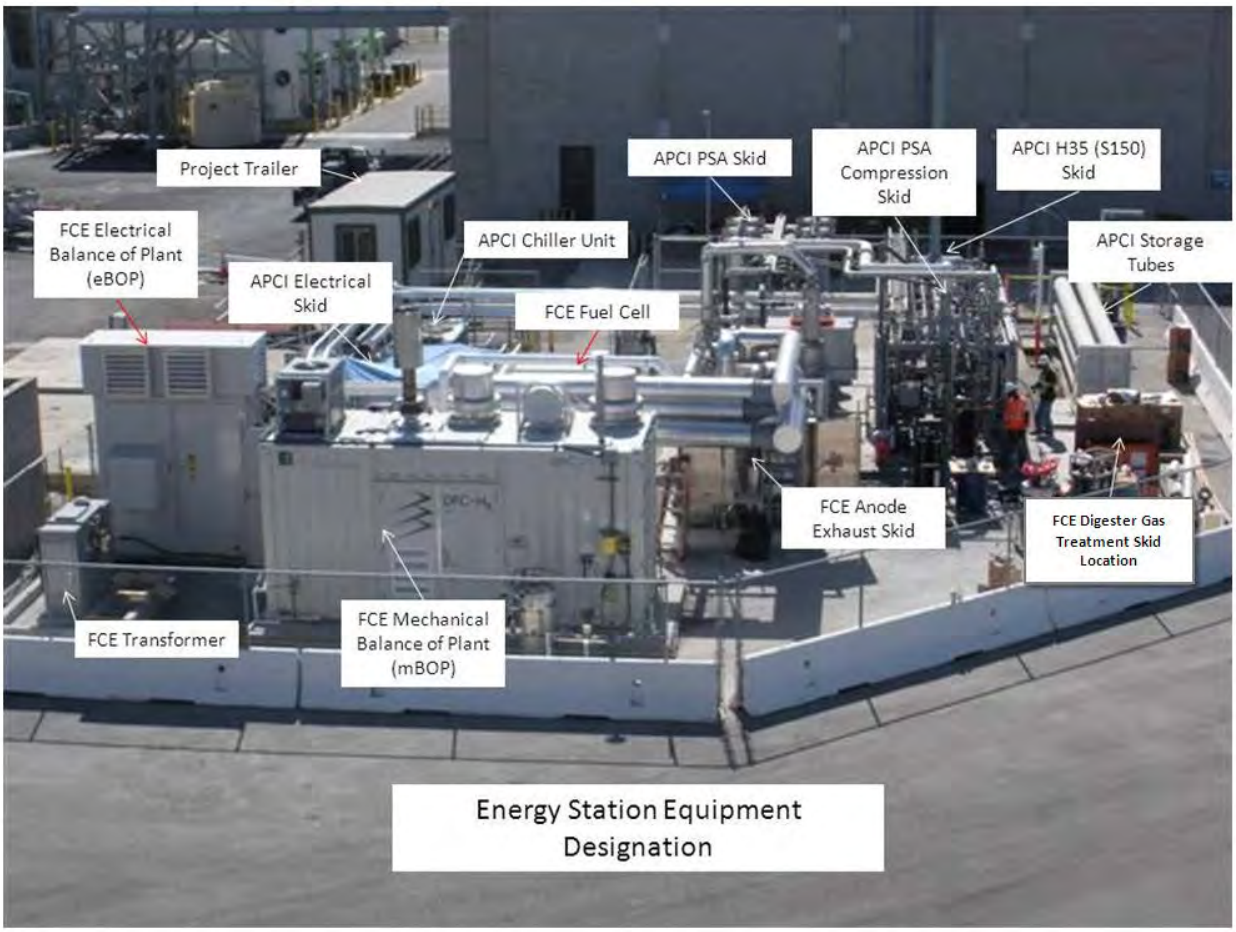
APCI and FCE will design, install, operate, and maintain the fuel cell system, and UCI's National Fuel Cell Research Center will operate the fueling station. The entire installation is expected to operate for three years.

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.



Since digester gas is considered a renewable energy source, this project has received significant financial incentives, including $2.7 million from CARB. Air Products and FuelCell Energy will operate and maintain the fuel cell and its ancillary equipment, and UCI will operate the hydrogen fueling station. OCSD is responsible for preparing the site and

2010-11 Project Description

installing the utilities the equipment will need. OCSD's share of this $8 million project is $500,000 plus project oversight costs during the test period.

Progress during 2010-11 included the following significant developments:

- August 2010 - Civil construction of the Energy Station completed.
- October 2010 - Civil construction of the Hydrogen Fueling Station completed.
- September 13, 2010 - First low-load power production from the fuel cell on natural gas.
- September 20, 2010 - Fuel cell operated at full load on natural gas.
- February 25, 2011 - First hydrogen gas production from the Hydrogen Fueling Station.
- March 10, 2011 - Initial test fills of fuel cell vehicles at Hydrogen Fueling Station.

Results: None; operating data will start being collected in FY 2011-12.

Status:

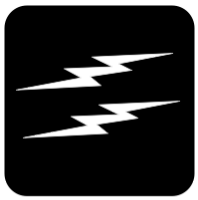
In June 2011, the anaerobic digester gas cleanup skid was installed and commissioned. This was the final step needed before starting to operate the Energy Station and Hydrogen Fueling Station together using digester gas as the input fuel.

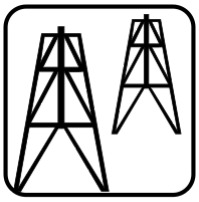
Project Type: ☒ New ☐ Continuing

2010-11 Project Description

Project Title:

Fuel Cell Feasibility Study (Project SP-132)





Contact: Jacob Dalgoff, Engineering

Purpose:

The purpose of this study was to perform a lifecycle cost analysis to determine whether OCSD should proceed with the Central Generation Emissions Control Project (J-111) or consider replacing the existing CenGen engines with fuel cells.

Description:

A 20-year lifecycle cost analysis was performed comparing the planned CenGen Emissions Control Project with fuel cells replacing the existing engines at both treatment plants. This study was limited to considering base load fuel cells sized to use all available digester gas as fuel. The 20-year lifecycle cost analysis included the major capital, soft, operational and maintenance costs. In addition, emissions fees, incentives, and emissions credit reductions were considered. The risks associated with both technologies also were considered.

Results:

The study recommended that OCSD continue the planned upgrades to the CenGen engines. It also recommended that fuel cells be analyzed again as part of the next Energy Master Plan and noted that other projects currently being implemented at OCSD will provide additional data and information for that analysis.

Status:

Closed

Project Category:

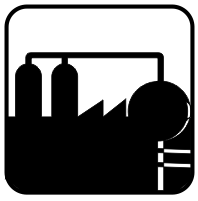
Air Quality

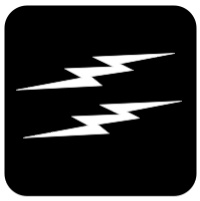
Project Type: ☐ New ☒ Continuing

2010-11 Project Description

Project Title:

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





Contact: Lisa Rothbart, Engineering
Dave MacDonald, Engineering (CIP Project Manager)

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.

Results:

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

- Test the catalytic oxidizers while running the engines on 90 to 100 percent digester gas.
- Perform 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.
- Perform periodic monitoring of NO_x and CO performance at the inlet and two outlets of the two catalytic oxidizers using hand-held analyzers.
- Perform 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.
- Perform 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.
- Perform 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.

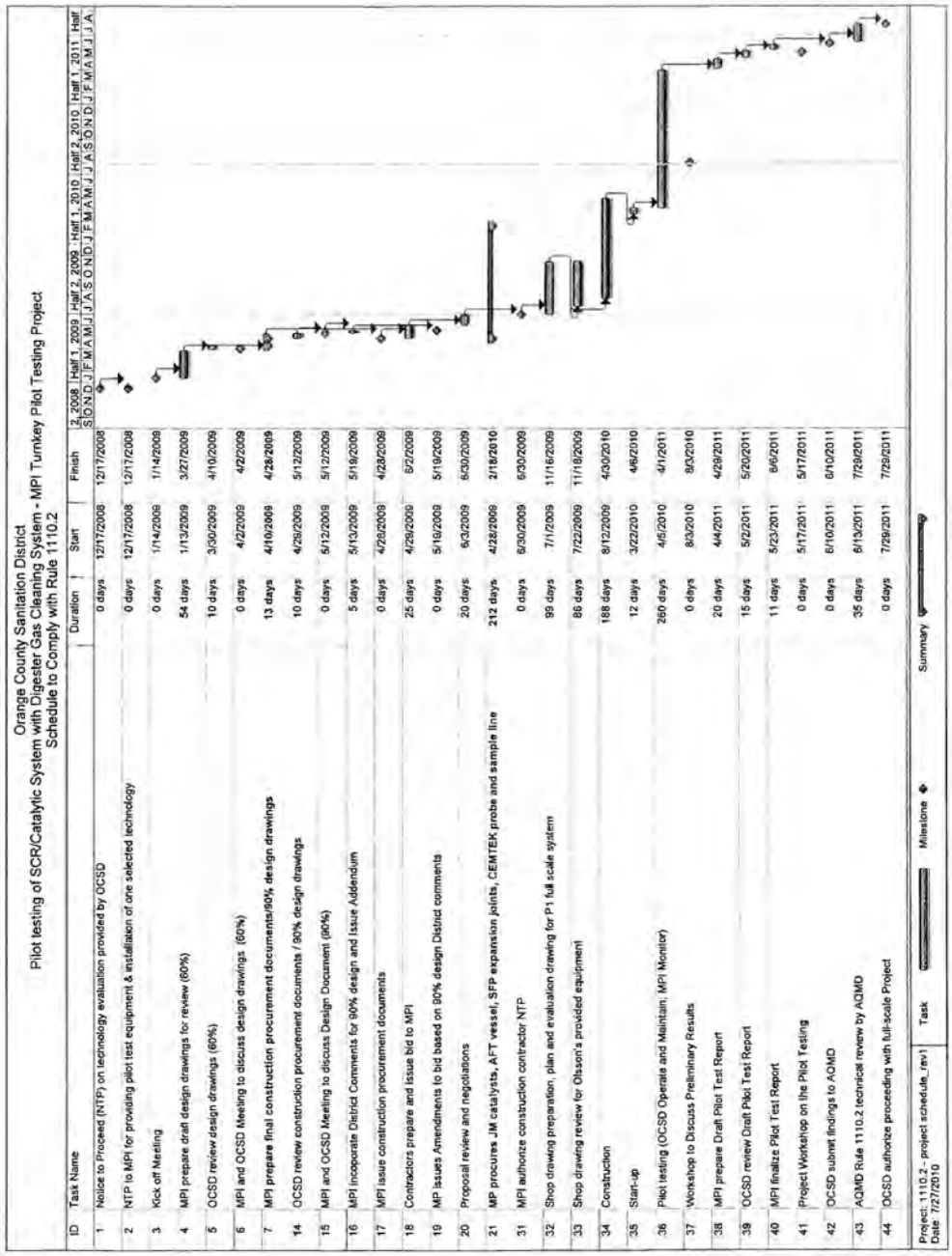
The projected cost for the pilot testing is $530,000 for the SCR/catalytic oxidizer and digester gas cleaning system and $2.4 million for construction and related expenses during the test. Equipment for full-scale installations on the remaining seven CGS engines would cost $31 million.

Status:

Engineering services for the J-79 Project are being provided by Malcolm Pirnie, Inc. (MPI). The design and construction of the pilot testing facilities has been completed. Olsson Construction provided installation services for the earlier catalytic oxidizer pilot test at Plant

2010-11 Project Description

2 and installed the pilot testing equipment at Plant 1. The construction began October 2009 and was completed in February 2010. Testing activities began in late March 2010 and continued through March 2011. Reports are being prepared by Malcolm-Pirnie, with draft reports due to SCAQMD for comment in June 2011.



Project Category:

Odor and Corrosion Control

Project Type: ☐ New ☒ Continuing

2010-11 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.

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.

2010-11 Project Description

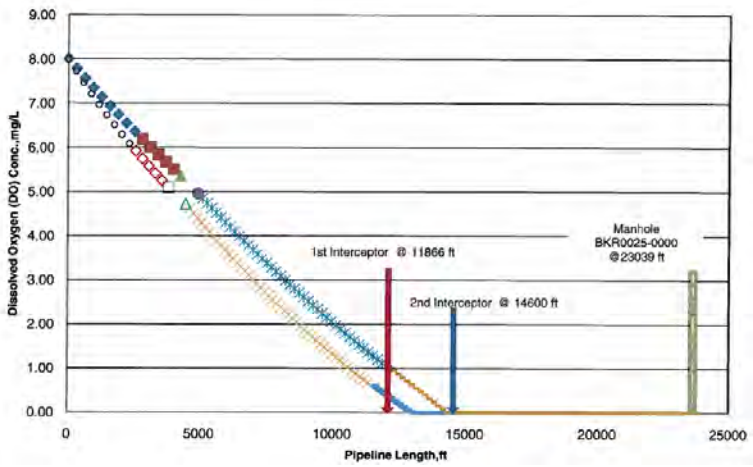
For odor control at certain pump stations, superoxygenation appeared to be technically feasible and potentially less expensive than alternative chemical treatments. These locations could be candidates for superoxygenation with relatively minor modifications to the existing sites.

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. In addition, preliminary cost assessments for superoxygenation use at the Rocky Point and Bitter Point lift stations were done; these sites had not been evaluated previously because they were under construction.

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 interceptor. 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

2010-11 Project Description

laterals in the Baker- Gisler interceptor. The life cycle cost of superoxygenation for Main Street was calculated to be slightly less than half the cost of ferrous chloride.



At Crystal Cove the annual operational cost of the system increased from the previous evaluation as a result of new data that was collected, but the capital cost of the system decreased as a result of revised cost information from the equipment manufacturer. The net results was a decrease in the life cycle cost for an installation at Crystal Cove. The superoxygenation system would treat odors in the downstream piping but would not treat odors in the pump wet well (as calcium nitrate does). The life cycle cost of superoxygenation for Crystal Cove was calculated to be slightly more than half the cost of calcium nitrate.

For the Rocky Point and Bitter Point assessments, assumptions had to be made about sulfide levels to be treated and the detention times available for treatment. As a result, the evaluations were performed for ranges of sulfide concentrations, pipe sizes, and detention times.

The life cycle cost results for both Rocky Point and Bitter Point showed that superoxygenation and ferrous chloride were comparable, whereas calcium nitrate was an order of magnitude more expensive.

Status:

Superoxygenation's use in sewer mains containing both force mains and gravity segments is restricted by a 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, little or no supersaturation is permissible. This prevents oxygen from being released and accumulating in the headspace.

Theory suggests that if both dissolved oxygen and calcium nitrate are available together, then sulfur-oxidizing bacteria preferentially will use the oxygen before the nitrate. This suggests the simultaneous addition of oxygen and chemicals to treat force mains (with

2010-11 Project Description

oxygen) followed by gravity sewers (with chemicals) might be a way to use superoxygenation in these combination trunk lines. Possibilities for testing this approach will be explored in 2011-12.

Project Category:

Process Alternatives or Improvement

Project Type: ☐ New ☒ Continuing

2010-11 Project Description

Project Title:

OpenCEL Process Evaluation

Contact: Jeff Brown, Engineering

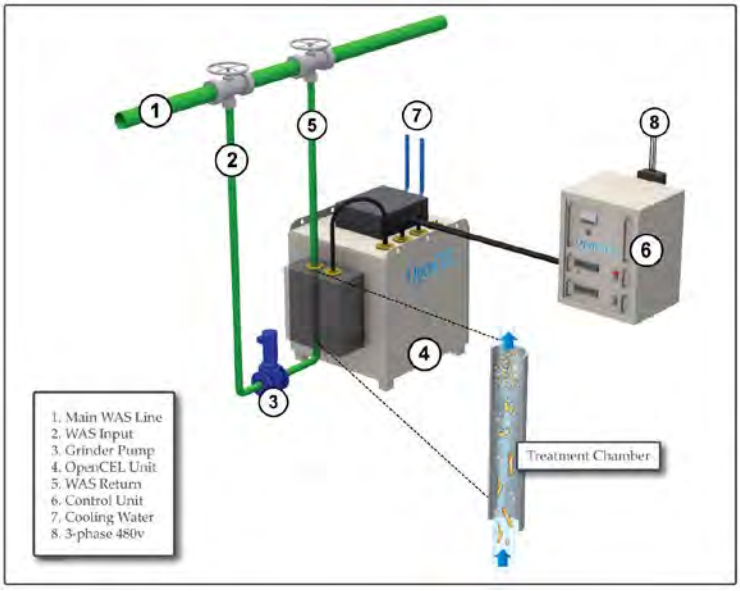
Purpose: Evaluate a process to improve digester efficiency and minimize residual solids

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.



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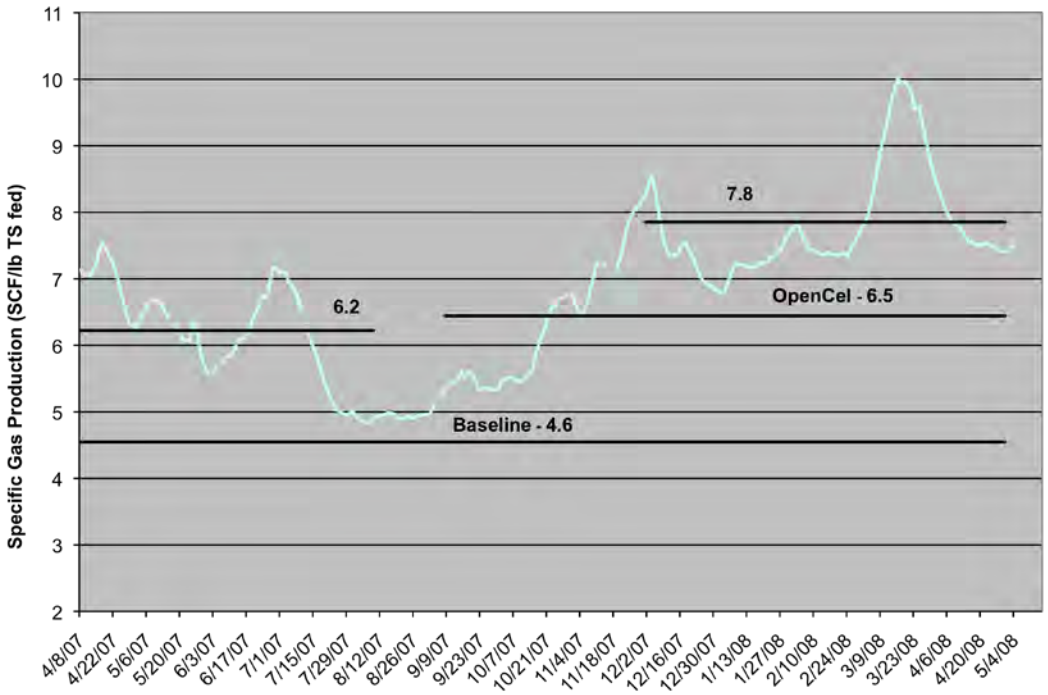
Results:

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.



Status:

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 one digester at Plant 1 has been developed. This program will compare digester 15's performance (e.g., biogas production and quality;

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VSR) with and without OpenCEL treatment. In addition, digester 16 without OpenCEL will be used as an experimental control so any changes in digester 15's performance can be correctly attributed to OpenCEL or other factors.

The first necessary step is 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 35-40% 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). These readings started being recorded in May 2011.

Establishing the digesters' baseline performance and completing the OpenCEL equipment installation will continue into Q1 2011-12. The OpenCEL performance test then will begin and is expected to continue throughout 2011-12.

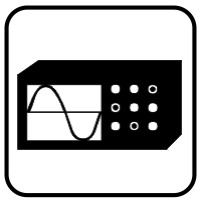
Project Type: ☐ New ☒ Continuing

2010-11 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 – 6,000 feet. Plant 1 would be preferred for an injection operation because the geology is less complex and has 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:

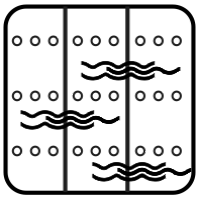
The TIRE project began full production in 2008, and OCSD continues to observe the operation, tracking the performance under varying densities and combinations of injected materials and the associated costs. The TIRE site currently processes 100% of the digested sludge generated at Terminal Island plus 25% of the biosolids generated at Hyperion (a total of about 200 wet TPD). The TIRE system cost approximately $8 million to engineer and construct. WERF estimates the capital costs for a deep well injection facility to manage up to 400 wet TPD to be less than $10 million.

Project Type: ☐ New ☒ Continuing

2010-11 Project Description

Project Title:

Process Modeling



Secondary Treatment

Process Related Special Project

Contact: Michelle Hetherington, Operations & Maintenance

Purpose: Establish biological and hydraulic models to optimize plant performance

Description:

Two types of computer models are involved in this project. For biological modeling, the Biowin program is being used. In addition to extensive sampling, calibration is required to ensure that modeled results are close to actual sample results. For hydraulic modeling, the EPA SWMM 5 model is being used together with custom-made Excel spreadsheet models.

Results:

OCSD owns a license for the Biowin program. A model has been developed for the Plant 1 activated sludge facility (AS1) and the new activated sludge facility (AS2) which will be in service in late 2011. Model calibration data was collected during the AS1 NDN process testing. The calibrated AS1 model has been used to evaluate, optimize, and predict process performance. For example, an idea of adding mixed liquor return gates to reduce effluent nitrates was modeled, and the recommendation was not to install the gates. Adding another mixer to Zone 4 also was evaluated, with the model predicting the mixer would reduce oxygen and effluent nitrates slightly but also increase the sludge yield. Further evaluation will be needed.

A model was developed for AS2, and calibration data were compared to design input data. The calibration data indicate slightly higher sludge yields then are predicted using design input data. Additional sample analysis and data will be collected for AS2 once it is operating.

Status:

OCSD staff began to model the Plant 1 trickling filters and Plant 2 oxygen plant. The Plant 2 model will be used as staff continue to work on optimizing the oxygen plant.

Project Type: ☒ New ☐ Continuing

2010-11 Project Description

Project Title:

Anaerobic Co-Digestion of Food Waste

Contact: Andre Miller, Engineering

Purpose: Evaluation of 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).

Project Type: ☒ New ☐ Continuing

2010-11 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. As discussed in the Background section, 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 select 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

2010-11 Project Description

(kinetics) as well as the full extent of the biodegrability of the waste streams and are a good supplement to the other reactor studies.

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 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

2010-11 Project Description

tasks. Biogas production, reduction in dewatered solids production, reduction in polymer/coagulant dose for dewatering, and operational stability as indicated by 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 are expected to take three months to complete, and the limited full-scale test is estimated to take nine months to complete.

Status:

The experimental work will start in FY 2011-12.

Project Category:

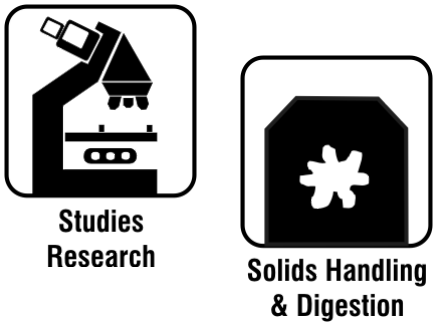
Emerging Contaminants, Ocean Monitoring, and General Topics

Project Type: ☐ New ☒ Continuing

2010-11 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 (over $11 million cumulatively 1999-2009) 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.

Results:

During 2010-11, research programs and results from the WET that were relevant to OCSD included the following.

2010-11 Project Description

Publications

Year	Title	Authors	Summary
2010	Pathogens and Indicators in United States Class B Biosolids: National and Historic Distributions. *J. Environ. Quality.* 39:2185-2190	Pepper, I.L., J.P. Brooks, R.G. Sinclair, P.L. Gurian, and C.P. Gerba. 2010.	This paper reports on the incidence of indicator organisms and pathogens found within Class B biosolids within 21 samplings from 18 wastewater treatment plants across the United States. This study suggests that pathogen levels of enteric viruses, Salmonella, and Ascaris ova in mesophilic anaerobically digested Class B biosolids are fairly low in the United States, and often meet Class A requirements. No viable Ascaris ova were detected, indicating Class A performance. However, this is more likely a reflection of the low incidence of infection in the population in the United States at the current time. Emerging pathogens such as Campylobacter and E. coli 0157:H7 were never detected, and shigella was only detected occasionally. In contrast, adenoviruses may be more commonly present in greater numbers than enteroviruses, suggesting that additional data on adenovirus may be useful in future risk assessments.
2010	Influence of Long-Term Land Application of Class B Biosolids on Soil Bacterial Diversity. *J. Appl. Microbiol*. 109:698-706.	Zerzghi, H., J.P. Brooks, C.P. Gerba, and I.L. Pepper.	This paper aims to evaluate the effect of long-term annual land applications of Class B biosolids on soil bacterial diversity at the University of Arizona Marana Agricultural Field Center, Tucson, Arizona. Following the final of 20 consecutive years of application of Class B biosolids in March 2005, followed by cotton growth from April to November 2005, surface soil samples (0–30 cm) were collected from control (unamended) and biosolids-amended plots. Biosolids-amended soils had a broad phylogenetic diversity comprising more than four major phyla: Proteobacteria (32%), Acidobacteria (21%), Actinobacteria (16%), Firmicutes (7%), and Bacteroidetes (6%) which were typical to bacterial diversity found in the unamended arid southwestern soils. Bacterial diversity either was enhanced or was not negatively impacted following 20 years of land application of Class B biosolids. This study illustrates that long-term land application of biosolids to arid southwestern desert soils has no deleterious effect on soil microbial diversity.
2010	Long-Term Effects of Land Application of Class B Biosolids on Soil Chemical Properties. *J. Res. Sci. Technol.* 7:51-61.	Zerzghi, H., C.P. Gerba, and I.L. Pepper	The objective of this study is to evaluate the influence of land application of Class B biosolids on the soil chemical properties by analysis of depth (0–150 cm) soil samples collected 9 months after the 20th annual land application. The study showed that land application of Class B biosolids had no significant long-term effect on soil pH and $CaCO_3$. However, land application significantly increased soil macro-nutrients (C, N and P). Soil nitrate values in plots that received biosolids or inorganic fertilizer amendments were high, indicating the potential for groundwater contamination. In addition, total and available soil P concentrations increased to values above those necessary for plant growth, but P values attenuated to background levels at a soil depth of 150 cm. Total metal concentrations attenuated rapidly with increasing soil depth

2010-11 Project Description

			and were generally similar to values found in control soils at a depth of 150 cm. Application of biosolids for nonfood agricultural crop production at this arid southwest site seems to be sustainable with respect to soil chemical entities.
2010	Long-Term Effects of Land Application of Class B Biosolids on the Soil Microbial Populations, Pathogens and Activity. *J. Environ. Qual.* 39:402-408.	Zerzghi, H., Gerba, C.P., Brooks, J.P., and Pepper, I.L	This study evaluated the influence of 20 annual land applications of Class B biosolids on the soil microbial community. Overall, the applications showed no long-term adverse effects, so this study documents that land application of biosolids at this particular site was sustainable throughout the 20-yr period with respect to soil microbial properties.

Final Reports: No relevant final reports during this reporting period.

Progress Reports

Year	Title	Authors	Progress Summary
2010	Fate of Endocrine Disruptors Following Long-Term Land Application of Class B Biosolids and Risks to Public Health	D. Quanrud, H. Zerzghi, C. Leung, D. Newman, C. Gerba, and I. Pepper	Biosolids contain trace levels of many organic wastewater contaminants, including natural and synthetic hormones, pharmaceuticals and personal care products (PPCPs), nonionic surfactants and their metabolites, flame retardants, and other consumer and industrial compounds. Results from this work support these conclusions: 1) Estrogenic activity and nonylphenol do not accumulate over time in biosolids-amended soils. 2. PBDEs do accumulate in soil following biosolids application; in this study, after 20 years the major PBDE congener concentrations in biosolids-amended surface soil at the highest loading rate (3x) were in all cases less than 100 parts per billion. 3) The health risk associated with exposure (inhalation, dermal) to PBDEs in biosolids-amended soil was found to be negligible in comparison to risks from other PBDE sources (e.g., house dust). A paper is currently being peer reviewed for publication.
2010	Sustainable Revegetation of Copper Mine Tailings Through Land Application of Biosolids	Ian Pepper, Huruy Zerzghi, Stuart Bengson, Ed Glenn	The University of Arizona was invited to monitor two copper mining tailing sites that were being amended with Class A biosolids with the goal of revegetating the sites. This research was conducted to determine if land application of dried biosolids to mine tailings would be effective in enhancing revegetation of the mine tailings. Estimation of shrub density Quickbird imagery showed that biosolids increased the plant cover on both plots compared to unamended tailings. However, Site 1, where biosolids were tilled into the soil, had only a third the plant cover of Site 2, where biosolids were applied to the soil surface but were not tilled in. Site 2 had higher moisture content in the top soil layer, which likely contributed to greater plant growth. Furthermore, nitrate levels at Site 1 were within the range that can inhibit the growth of native plants. Site 2 developed 30% shrub and tree cover, similar to undisturbed native soil; hence, this treatment can be judged to be successful in restoring native plant cover

2010-11 Project Description

			to tailings plots. A paper is currently being peer reviewed for publication.
2010	Survival of Infectious Prions During Wastewater Treatment	Syreeta Miles, Kazue Takizawa, Charles Gerba, and Ian Pepper	Infectious prions cause disease in both humans and animals. One potential route of infection of humans could be if prions survive wastewater treatment and end up in biosolids which are subsequently land applied. The study evaluated the survival of infectious prions in biosolids and during various wastewater treatments. 99.1% infectivity reduction of PrPSc infectivity was observed after 15 days at 37°C. A 2.43-$\log_{10}$ reduction in PrPSc infectivity was observed under a mesophilic (37°C) temperature after 15 days, and 3.41-$\log_{10}$ reduction was observed after 10 days at a thermophilic temperature (60°C). These data are significant since they indicate the infectivity of PrPSc will not survive conventional wastewater treatment and will not be a source of exposure to animals or humans following land application.
2010	Survival of Ascaris and Adenovirus in Biosolid Amended Soil	Ian Pepper, Channah Rock, David Williams, Huruy Zerzghi, Chuck Gerba	Ascaris eggs are the most resistant pathogens under the harsh conditions of sludge and wastewater treatment. The study focuses on the effects of temperature, moisture, and soil type on the development of Ascaris eggs. In two studies using Ascaris spiked, biosolids-amended Brazito sandy loam, it was found that moisture content played a more significant role in egg development than UV exposure or temperature. Common between both experiments was the complete drying of the biosolids-amended soil within a 24 hour period, indicating that moisture content is responsible for the decline of viability for this organism. Milestones: 1) January 2011 – June 2011 Initial survival experiments conducted, 2) July 2011 – August 2011 Survival in different soils conducted, and 3) September 2011 Final Report.
2011	Risk Assessment of Adenoviruses in Biosolids	Chuck Gerba, Ian Pepper, Channah Rock, Huruy Zerzghi	Limited data are available on the occurrence of infectious adenoviruses in biosolids, but the available data indicate that it may be the most abundant virus in Class B biosolids. The overall purpose of this project is to determine the incidence and concentration of infectious adenoviruses in Class B biosolids. Adenoviruses cause a wide range of illnesses including diarrhea and respiratory, eye, and throat infections. All previous risk assessments for land-applied biosolids have focused on enterovirus. However, this project will conduct a new risk assessment for adenovirus in Class B biosolids. Milestones: 1) June 2011 - Initiate first Class B biosolids collection and testing, and 2) December 2011 - Finish testing of all biosolids.

2010-11 Project Description

New Proposed Projects

Year	Title	Author(s)	Progress Summary
2010	Determination of the Greenhouse Gas Footprint for Land Application of Biosolids	Ian Pepper	Not available at this time.
2011	Evaluation of the Efficacy of Class A Pelletized Biosolids for the Growth of Cotton in Southern Arizona	Ian Pepper, Huruy Zerzghi	A field study will be initiated that utilizes Class A biosolids provided by Mannco Environmental Services, Inc. as a fertilizer source for the growth of cotton in Southern Arizona. The study will examine the efficacy of the biosolids for cotton production relative to traditional inorganic fossil fuel fertilizer. The efficacy of the biosolids will be evaluated based on: 1) Cotton lint yield (quantity and quality), and 2) Soil quality enhancement (carbon sequestration). It is anticipated that this will be a 3-year field study. Milestones and Goals: 1) Cotton was planted in May 2011, and soil and plant analyses will be conducted throughout the growing season, and 2) Crop yields will be determined by November 2011 following harvest.

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 direction of the research program.

2010-11 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 2010-11 related to marine topics and trace pollutants included the following.

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

  Contacts: Dean Pasko and George Robertson, Operations and Maintenance

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

  The Bight'08 Survey is 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 is directly involved in the first three components.

  Bight'08 builds on the information from previous Bight Studies and expands on the 2003 survey by including new participants, answering additional questions, and measuring more parameters or using novel methods. The inclusion of multiple participants, many of them new to regional monitoring, provides several benefits such as cooperative

interactions with different perspectives and interests. Including a combination of regulators and dischargers, ensure that an appropriate set of regional-scale management and scientific questions will be addressed by the study.

With the exception of microbiology, all field sampling work has been completed. A final report has been written for the ASBS component, and draft reports have been prepared for the Coastal Ecology and Rocky Intertidal elements. Water Quality and estuaries are completing data analysis work. Shoreline microbiology sampling is now taking place, having been delayed due to state budgetary issues.

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).

- 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, including providing data to determine compliance with discharge permit conditions and advancing the understanding of physical processes that affect dispersion of the District's wastewater plume. These studies have contributed significantly to our understanding of mixing and transport processes on the San Pedro shelf near the District's outfall. In particular, the District 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 District's wastewater discharge and for evaluating the contributions to near shore bacterial contamination.

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

  Contact: Jeff Brown, Engineering

  The goals of this large project is 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 can 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.

This study is being conducted in four phases. Phase 1 includes the selection of viable indicator TOrCs that represent a wide range of physicochemical properties followed by a comprehensive and critical review of currently available TOrC fate models. This comprehensive review provides the foundation for the second and third phases of the project.

During Phase 2, aqueous and biosolid samples from full-scale treatment processes of participating utilities are being analyzed to determine and quantify select TOrCs present in raw sewage, in treated wastewater effluents, and accumulated in biosolids. Treatment processes being evaluated include non- or partly- nitrifying activated sludge systems, nitrifying/denitrifying activated sludge systems, and biological phosphorus removal processes. These efforts are being augmented by controlled experiments at the laboratory- and pilot-scales to enable the further development and evaluation of observed relationships between operational parameters and TOrC removal. Additional laboratory-scale experiments will derive biotransformation rate constants that will be used in fate model calibration.

During Phases 3 and 4, the most viable fate model will be validated at full-scale during various process modifications, and the economic value of the project to WERF subscribers will be assessed. The performance and costs of modifying and operating a secondary process for a given target TOrC reduction will be compared with the known performance and costs of removing TOrC with tertiary and advanced processes, such as membrane filtration, ozonation, and chlorination.

OCSD currently is 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. In the future, OCSD also could become a test site for validating the fate model in Phase 3.

Project Type: ☐ New ☒ Continuing

2010-11 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.

2010-11 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, and/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.

2010-11 Project Description

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:

Task 1 has been completed and Task 2 is in progress.

Phase II Schedule

TASK 1: Sample and analysis for variability assessment (OCSD) - Sampling (July – September 2010) - Laboratory analysis	7/10 – 12/10

2010-11 Project Description

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

2011-12 Research Plan

Part 5

2011-12 Research Plan

Several major project milestones are planned during 2011-12 and are described below. These will reflect substantial progress on efforts relating to air emissions control, environmentally responsible energy production and operating practices, and 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. A three-year test officially started in June 2011.

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. After the baseline biogas production from a selected digester has been determined, the effectiveness of the OpenCEL treatment will be tested in full-scale use.

Processed food waste as an additional digester feed source: This will be investigated at laboratory scale and full scale. Food waste is highly digestible itself, but research also suggests that its presence in a mixed-feed digester may 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 could lead to full-scale installations, and additional evaluations may be undertaken for other locations. An additional topic of interest is the concurrent use of superoxygenation and chemicals to control odors in combined force main/gravity flow sewers.

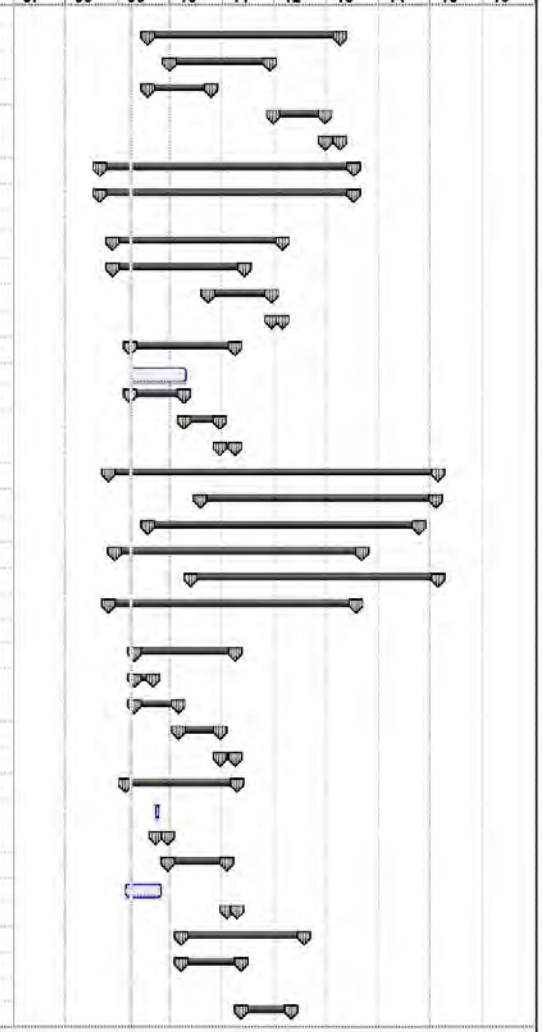
New projects: Improving the efficiency of core wastewater treatment activities is an on-going effort. One way to improve efficiency is to adopt new technologies that provide cost or efficiency advantages over existing practices. New projects in 2011-12 will include a look at alternatives to using iron salts for primary treatment coagulation and digester odor control and evaluations of nutrient recovery from liquid waste streams, supercritical fluid destruction of organic solids, and biotechnology-based conversion of sludge into plastic and industrially useful chemicals.

Part 6

Research Strategic Plan Schedule

OCSD Strategic Research Plan
5-year Project Scheduling

ID	Rank	Task Name
1		
2	1	Power Generation Project
3		Task 1: FOG Handling Study
10		Task 2: Fuel Cell Testing and Marketing
14		Task 3: Strategy for OCSD Vehicle Fleet and Renewable/Alternative Energy Sources
16		
21	2	Sludge Disposal (Deep Well Injection) Project
22		Task 1: Sludge Disposal via Deep Well Injection
28		
29	3	Enhanced Gas Production and Solids Treatment Project
30		Task 1: Evaluation of Sludge Conditioning Technologies & Dewatering Improvements
37		Task 2: Digester Mixing
43		
48	4	Environmental Footprint Project
49		Task 1: Investigate Green Technologies Applicable to OCSD
50		Task 2: Ecological and Carbon Equivalent Footprint
54		Task 3: Impacts of Climate Change on Plant Operations and Compliance Monitoring
60		
65	5	Organizational Cooperation and Outreach Project
66		Task 1: Website and Outreach Materials Development for the Board and Public
72		Task 2: Establish Regional Technology and Information Sharing Group
76		Task 3: Placeholder for Urgent Regulatory Analysis
78		Task 4: Develop Formal Program of Cooperation with Universities
82		Task 5 - Participate in Multi-agency Technology Review Group
84		
85	6	Process Modeling Project
86		Task 1: Develop Biowin Models for OCSD Plants
90		Task 2: Develop Hydraulic Modeling of Plants
94		Task 3: Liquid Stream Optimization
99		
104	7	Chemical Mixing Systems and Collection System Chemicals Evaluation Project
105		Task 1: Select Mixing Site
106		Task 2: Evaluate Mixing Alternatives
110		Task 3: Testing of Selected Mixing Technology
116		Task 4: Collection System Chemicals Evaluation
117		
122	8	Odor Analysis Project
123		Task 1: Identify Specific Odor Problems by Odor Panels and Chemical Analysis
127		Task 2: (moved to end)
128		Task 3: Determine non-H2S Compounds in Collection System

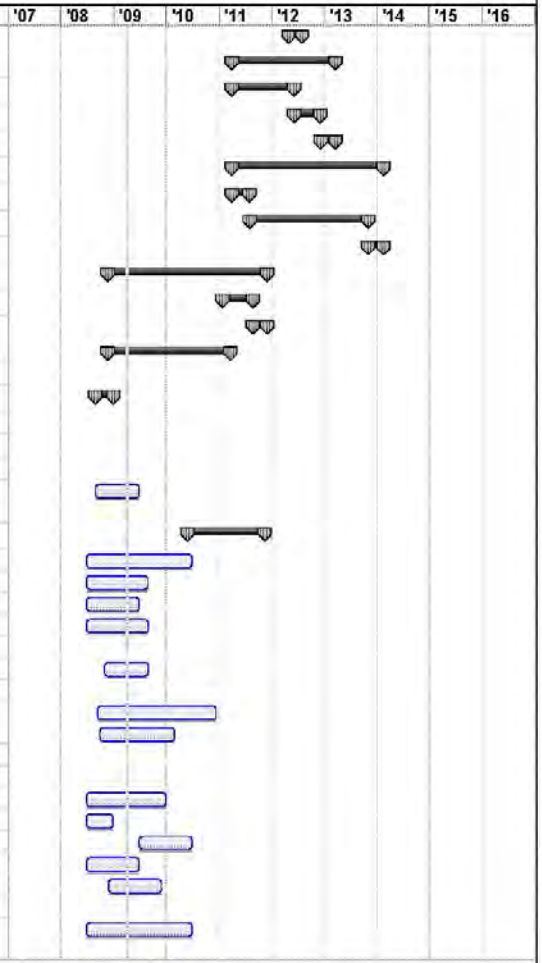


Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External MileTask
Split

Page 1

OCSD Strategic Research Plan
5-year Project Scheduling

ID	Rank	Task Name
132		
137	9	Odor Control Improvement Project
138		Task 1: Modifications of Biological/Chemical Scrubbers
146		Task 2: Optimization of Chemical Scrubbers
151		
156	10	WASAC Process Feasibility Study Project
157		Task 1: WASAC Process Evaluation
160		Task 2: Demonstration Testing
166		
171	11	Air Regulations (Combustion Sources) Project
172		Task 1: Evaluation of Regulated and Unregulated Particulate and Odorous Emissions from Combustion Sources
178		Task 2: Project Report
183		Task 3: J-79 Engine Emissions Control Catalyst Test (MPI)
188		
189		Superoxygenation Applications
191		
192		Cooperative Projects Not Included in Other Projects Above:
193		University of Arizona Water Quality Center (WQC)
194		WQC Biosolids Safety Studies
195		Water Environment Research Foundation (WERF) Support
196		WERF Cooperative Project: Model Development Linking Collection System Odor Generation and Corrosion
200		WERF Targeted Research (TCR): Pathogen Risk Assessment
201		WERF Targeted Research (TCR): Incident Response
202		WERF Targeted Research (TCR): Centrifuges & Pathogen Regrowth
203		WERF Epidemiological Study Advisory Committee
204		UC Irvine Urban Water Research Center (UWRC)
205		UWRC Projects TBD
206		So. Cal. Coastal Water Research Project (SCCWRP)
207		SCCWRP Endocrine Disruptor Study
208		SCCWRP So. Cal Bight Regional Study
209		American Water Works Assn. Research Foundation
210		WateReuse Foundation (WRF)
211		WRF: Identifying Health Effects Concerns of Water Reuse
212		WRF: Study of Advanced Oxidation Processes
213		WRF: Impacts of Nanoparticle Pollutants
214		WRF: Project Advisory Committee on UV Disinfection
215		WRF: Methods for Measuring Chemicals of Emerging Concern (CECs)
216		So. Cal. Assn. of Marine Invertebrate Taxonomist (SCAMIT)
217		SCAMIT: Developing On-line Tools for Ocean Organism Identification



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Orange County Sanitation District

We're here for you.

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