Orange County Sanitation District

Research Report 2009

2009
OCSD Research Report

Compiled by

Technical Services Administration and Research

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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 2008-09 were:

Operations and Maintenance

- Carla Dillon
- Michelle Hetherington
- Y. J. Shao

Engineering

- Jim Burror

Technical Services

- Jeff Armstrong
- Layne Baroldi
- Jeff Brown
- Charles McGee

Part 1

Introduction and Overview

Part 1

Introduction and Overview

This document is a report of OCSD research activities for fiscal year 2008-09. While it was compiled by the Technical Services Department, the various activities it describes were done in Technical Services, Engineering, and Operations and Maintenance.

This document brings together in one place summaries of research-related expenditures (Part 2), information about specific project accomplishments (Parts 3 and 4), and plans for relevant activities in the upcoming year (Part 5). It also presents for reference the research project schedule that was developed 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, odor and corrosion control, treatment process improvements, and emerging (trace) contaminants detection and removal. These included several cooperative projects with wastewater industry research organizations and with universities, arrangements which provided substantial leveraging of OCSD's funds.

A highlight of the year was the completion and adoption of a five-year operational research strategic plan. This was the culmination of an extensive review of the agency's current and future needs that included OCSD staff and internationally-known industry figures in developing a plan that will serve as a blueprint for identifying and prioritizing research efforts in the coming years.

Environmental stewardship figures prominently in the current research projects. For example, a climate change initiative was begun to determine and reduce the environmental footprint of OCSD's activities and to identify effective responses if climate changes affect our operations. Also, the fuel cell demonstration at Plant 1, a project with high public visibility and interest, is poised to finish construction and start operating in 2009-10. This public/private collaboration will use anaerobic digester gas in a fuel cell to produce electricity (for on-site use) and hydrogen (for fueling vehicles at a nearby fueling station). This fuel cell installation will use a renewable energy source and is expected to produce virtually no regulated air emissions. Superoxygenation for odor and corrosion control without using additional chemicals also continues to be evaluated as a means for reducing operating costs and environmental impacts.

New research projects will be undertaken consistent with the research strategic plan's recommendations. Preliminary work has started on evaluations of alternative digester feed streams (such as processed food waste) and process changes to increase digestion efficiency of waste activated sludge. The research program will continue to be proactive in identifying and evaluating opportunities for OCSD's activities to reduce costs, improve efficiency, and promote environmental protection.

Part 2

Research Financial Summary

Part 2

Research Financial Summary

During 2008-09, the budget for research totaled $2.62 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 projects that typically have been funded as individual line items in the CIP budget and in the future usually will be 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 50% 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 2008-09, 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). This category was 19% of the total research budget.

"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 are 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 630 (Environmental Lab and Ocean Monitoring). This category was 31% of the total research budget.

Figure 2-1b shows the distribution of actual expenditures for 2008-09. While the budget was $2.62 million, the expenditures totaled only $1.54 million. This is almost entirely due to the annual allocation ($1 million) appearing in the budget as a level amount over several years, whereas the expenditure schedule in the Research Strategic Plan is a typical S-curve with lower than average expenditures at the beginning as new projects are started and higher expenditures in later years. The actual expenditures for CIP Research are primarily (91%) for ongoing projects that are funded as CIP line items and so did not draw on the general allocation funds.

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. The largest fraction (35%) is used for organization memberships, with projects related to air quality forming the next largest fraction (28%). Progressively smaller fractions are devoted to categories such as odor and corrosion control, ocean monitoring activities, and process

alternatives. Details about the projects that are in each category are presented in Parts 3 and 4 of this report.

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 16:1 leveraging of its total $8.0 million cost, and the other projects as a group show 9:1 leveraging of their total $3.7 million cost. Overall, for a total cost of $0.9 million, OCSD benefits from projects budgeted at $11.7 million.

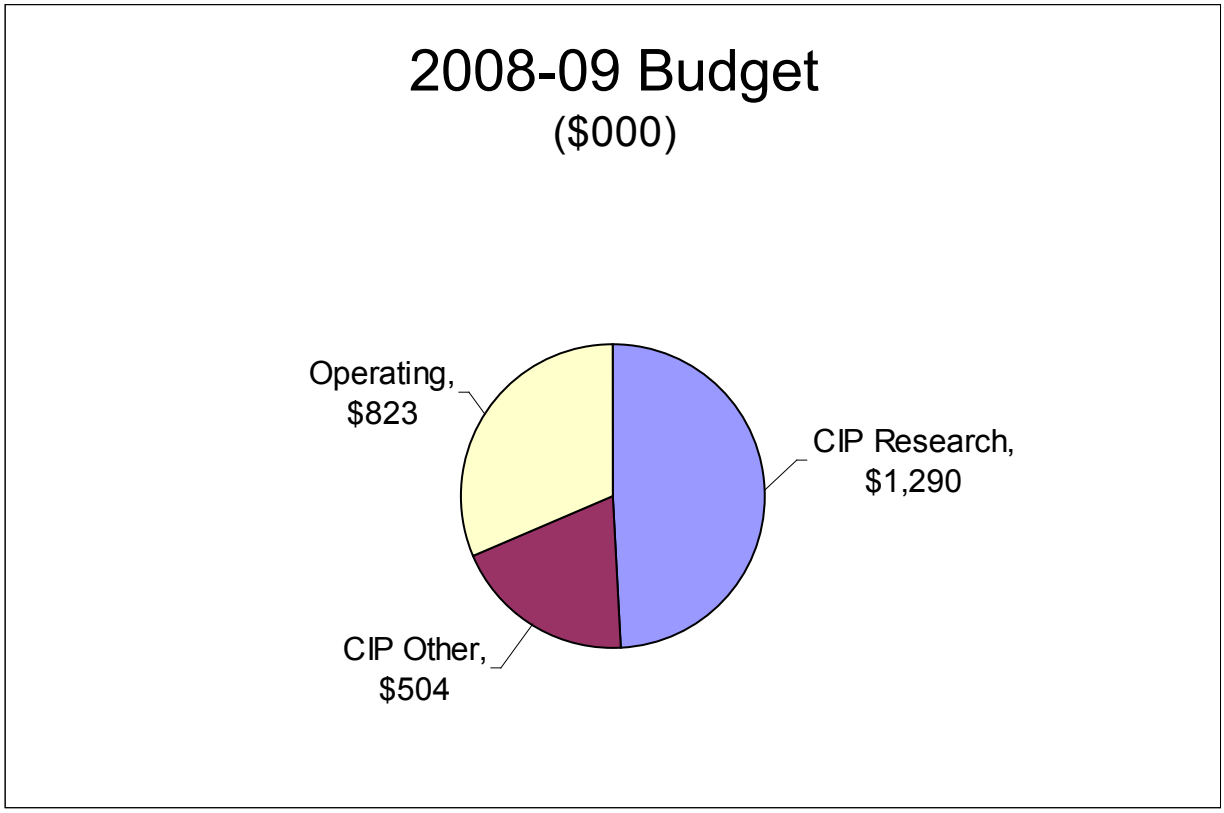


Figure 2-1a. Research Budget by Expenditure Type

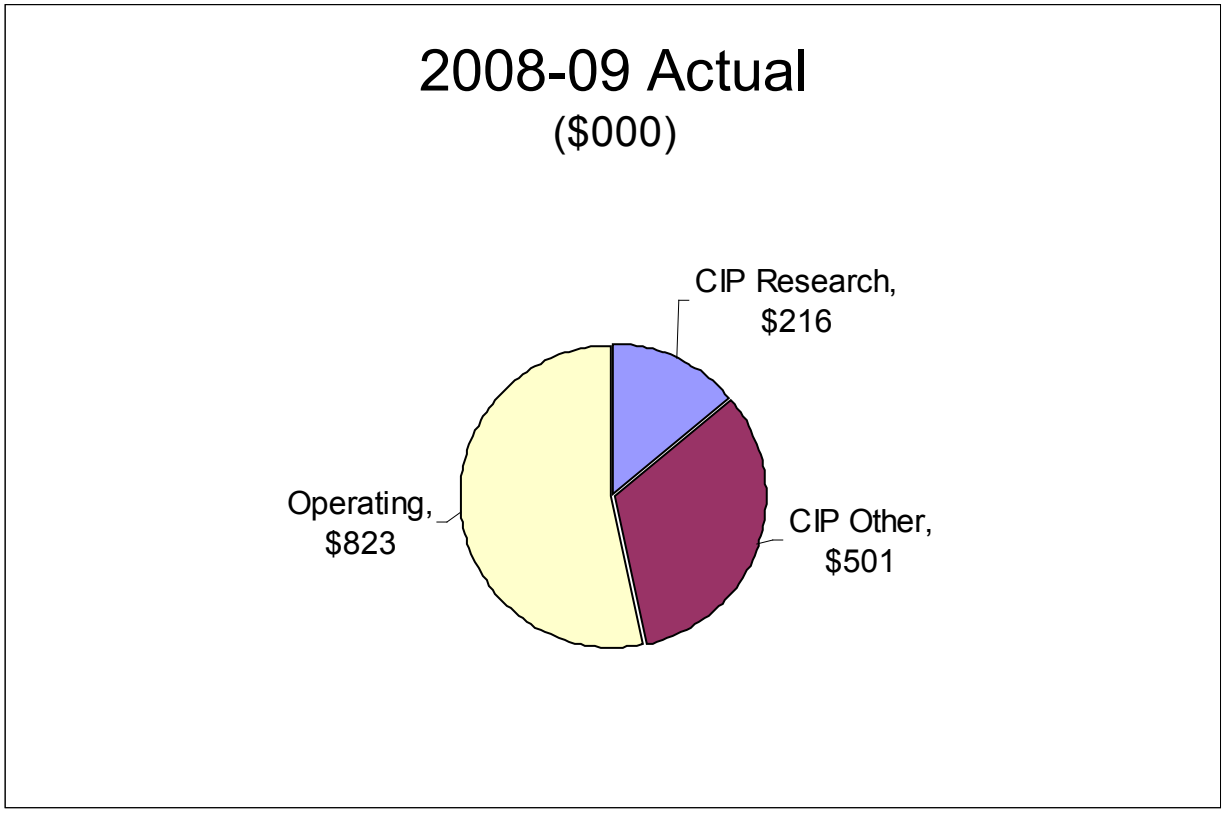


Figure 2-1b. Distribution of Research Expenditures by Expenditure Type

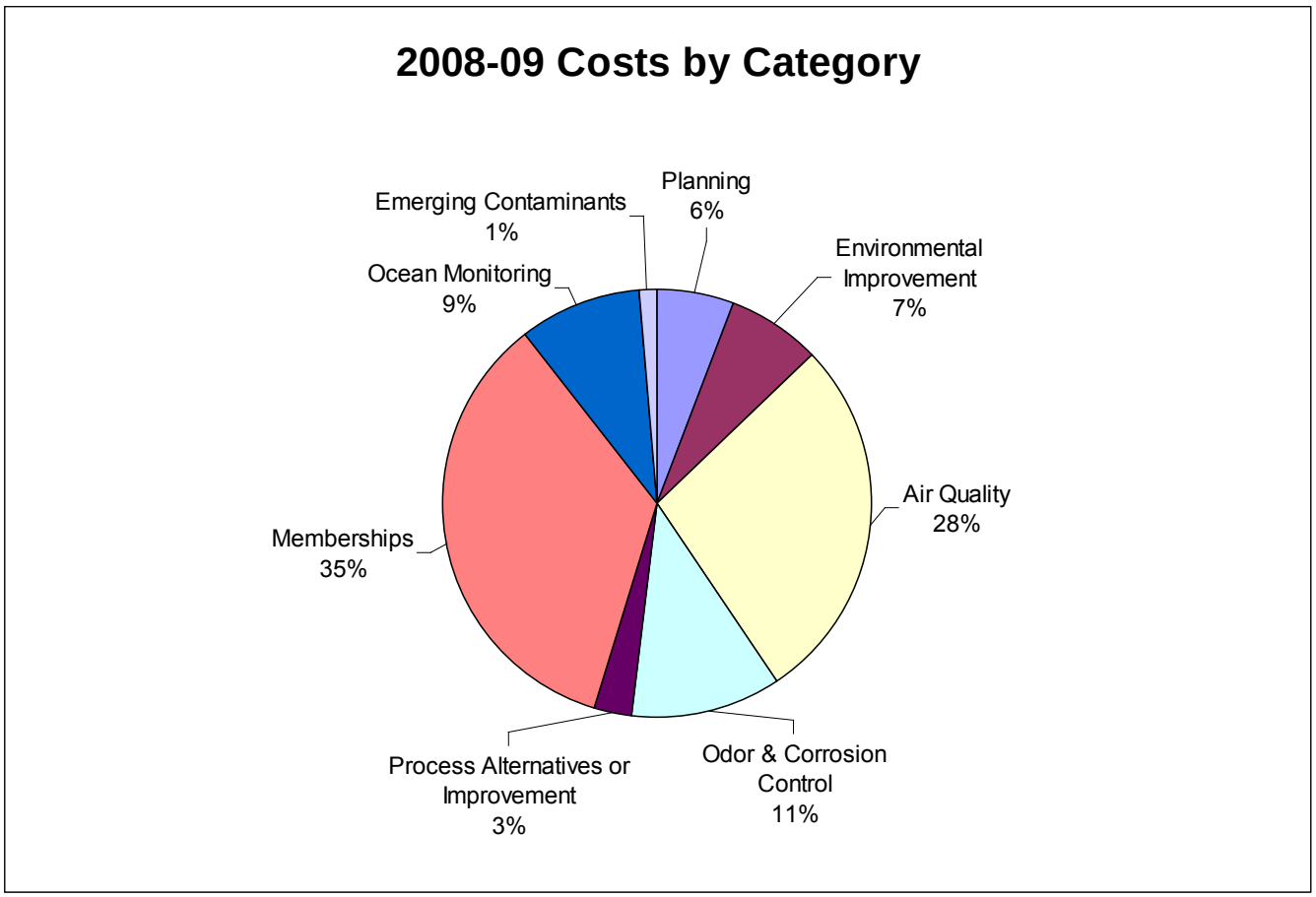


Figure 2-2. Actual Research Expenditures by Focus Category

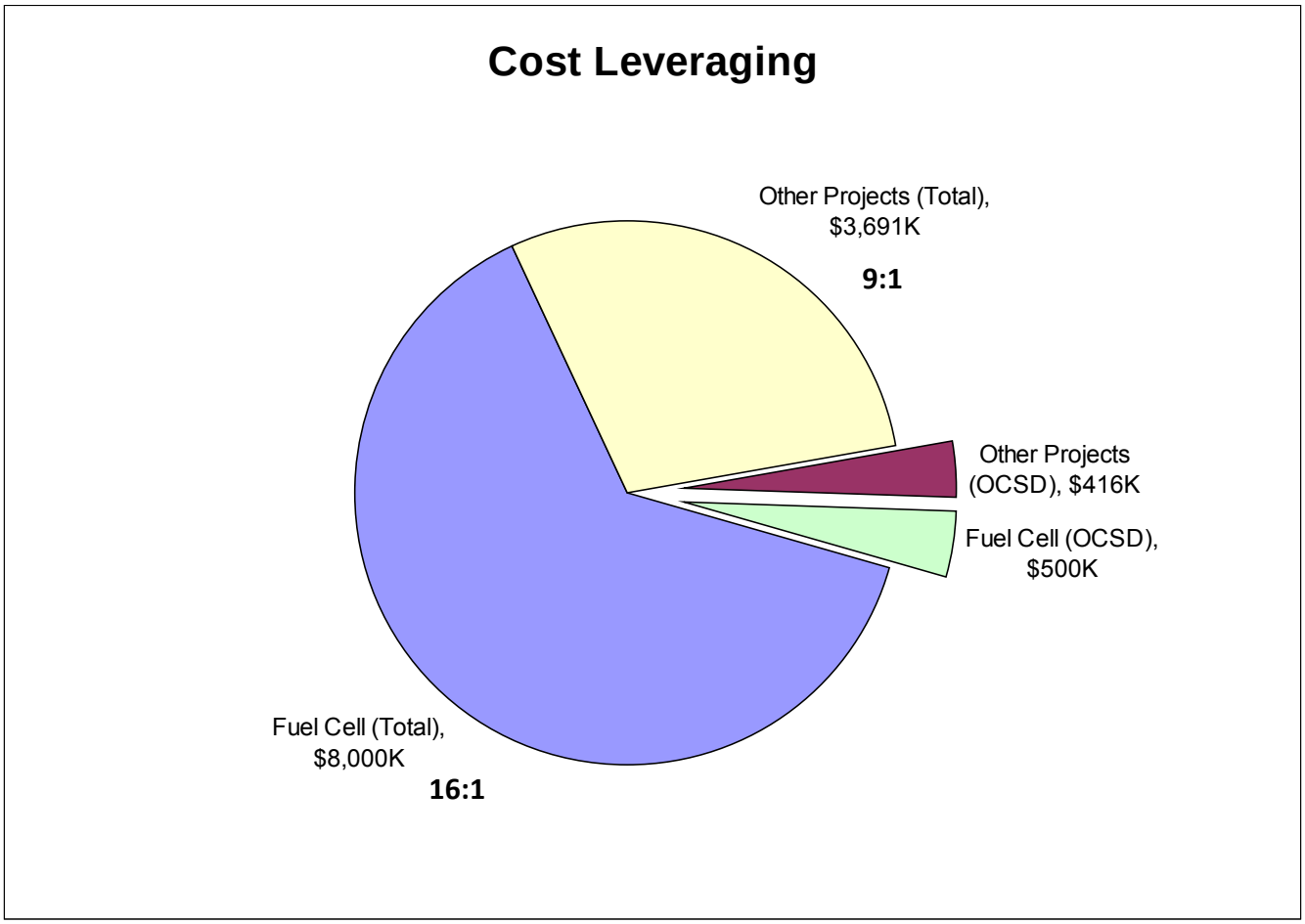


Figure 2-3. Cost Leveraging Achieved in Research Projects

Part 3

Summary of Projects and Memberships

OCSD Research Summary 2008-09: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2008-09	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2009-10)
Planning	Research Strategic Plan	$365,000	$310,000	---	---	Develop a multi-year strategic plan for OCSD's operational research efforts	A five-year plan was developed by OCSD staff and external experts and was accepted by the Board for implementation.	The Research Strategic Plan identifies the major operational research initiatives that will be pursued.
Environmental Improvement	Climate change initiative	To be determined	$35,000 (through Urban Water Research Center)	---	UC Irvine	Develop strategy for identifying and responding to climate change effects and regulations	The project will (1) determine OCSD's environmental footprint and identify ways to reduce it, and (2) identify climate change impacts on OCSD operations and necessary responses.	Finish developing repeatable process for calculating OCSD's environmental footprint; develop climate change strategy to reduce greenhouse gas emissions and implement relevant sustainable environmental initiatives
Environmental Improvement	Fuel cell demonstration	$500,000	$400,000	$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	Finish installation at Plant 1; start fuel cell operation
Air Quality	J-79 Central Generation engine emissions control	$9.1 million	$136,000	---	---	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. A reductive catalyst system is being installed and will be tested at P1.	Full-scale equipment installation will finish early in 2010, and testing will continue until mid-2010.

OCSD Research Summary 2008-09: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2008-09	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2009-10)
Odor & Corrosion Control	Superoxygenation for odor control	$850,000	$330,000	---	---	Investigate using dissolved oxygen rather than chemicals for controlling odors and corrosion in sewers and treatment plants.	Superoxygenation is not cost-effective within the treatment plants, but promising opportunities at collections system pump stations were identified.	Chemical tests and engineering analyses for specific pump stations will further investigate the potential for successfully using superoxygenation.
Odor & Corrosion Control	Minimizing collection system odors and corrosion	$50,000	---	$249,483	WERF (Water Environment Research Foundation)	Participate in collaborative project to reduce odors and corrosion through identifying effective approaches and through improving the accuracy of computer modeling.	The results will aid OCSD's odor control program with a better understanding of airflow dynamics, testing methods, decision tool application, and potential implementation of design features to minimize odors and corrosion.	To be determined.
Process Alternatives or Improvement	OpenCEL process for digestion improvement	To be determined	Negligible in 2008-09	---	---	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	Preliminary engineering analysis results will be refined, possibly leading to onsite tests of the OpenCEL process
Process Alternatives or Improvement	Deep well biosolids injection	To be determined	$50,000	---	---	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. A sample of OCSD's biosolids will be sent to the City's deep well injection site for processing and evaluation.

OCSD Research Summary 2008-09: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2008-09	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2009-10)
Process Alternatives or Improvement	Process modeling	To be determined	$40,000	---	---	Develop biological and hydraulic computer models to help optimize plant performance.	Biological modeling: a commercial program (Biowin) has been used by OCSD consultants on past capital improvement projects. OCSD now has this program in-house. After calibration, it will be a tool for optimizing plant processes. Hydraulic modeling: EPA and custom models were used in evaluating OOBS and EPSA design and performance at Plant 2.	Calibration data for biological modeling will be obtained through new sampling, from previous projects, and from a planned test of Plant 1 A.S. operation in nitrification mode. For hydraulic modeling, staff will assess the timing and appropriate resources for further model development.
Emerging Contaminants	Trace organic chemical removal during wastewater treatment	$20,000 + $20,000 (in-kind over 3 years)	Minimal	$500,000	WERF (Water Environment Research Foundation)	Determine the effects of wastewater treatment processes on various trace chemicals (pharmaceuticals, EDCs, PCPs)	Leverage 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	OCSD will provide technical expertise and review data; later we may become a test site
Emerging Contaminants	Evaluating analytical methods for certain trace contaminants in water	$36,000 (in-kind for lab analyses)	$12,000 (in-kind for lab analyses)	$784,000	WRF (Water Research Foundation)	Evaluate lab analysis methods for endocrine disrupting compounds (EDCs) and personal care products (PCPs)	Round-robin testing with other laboratories will help establish the best test methods for EDCs and PCPs and may improve current in-house methods	WRF will coordinate three rounds of testing with several laboratories over 12-15 months
Emerging Contaminants	Endocrine disruptor study	$135,000 over 3 years (ending 2008-09)	$10,000	$548,000	SCCWRP (So. Cal. Coastal Water Research Project)	Determine causes and extent of endocrine disruption effects in some coastal marine species	Greater understanding of effects from endocrine disrupting compounds (EDCs) and possible management actions required to prevent the effects	Reporting of already-completed sampling and analysis results; further activities not determined

OCSD Research Summary 2008-09: Projects

Category	Project Description	Total OCSD Project Cost or Budget	OCSD Cost 2008-09	Total Project Cost or Budget (if cost-shared)	Other Participating or Funding Organizations	Goals / Scope	Accomplishments / Benefits	Upcoming Work (2009-10)
Emerging Contaminants	Impacts of nanoparticles on water reclamation and sewage treatment	$15,000 (in-kind for lab analyses)	Minimal	$215,000	WateReuse Research Foundation; UC Irvine; Kennedy/Jenks	Evaluate effects of zinc and silver nanoparticles on specific water reclamation and sewage treatment processes.	Greater understanding of the importance of nanomaterial pollutants on activated sludge and media filtration processes.	OCSD will analyze 200 samples for zinc and silver concentrations during this study.
Ocean Monitoring	Southern California Bight Regional Study 2008	$125,000	---	$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	Continuing sample collection and analysis through 2010; reports issued over next three years
Ocean Monitoring	Online tools for organism identification	$15,000	$15,000	$300,000	SCAMIT (Southern California Association of Marine Invertebrate Taxonomists)	Participate in project to develop a database of ocean species relevant to OCSD's marine monitoring program	Database will provide a framework for linking images and ecological information to provide consistent species identifications throughout the Southern California marine monitoring community; work to date has focused on developing accepted descriptors for major species types.	Extend work on descriptors for major species types to minor species types; work on system for entering images into database

OCSD Research Summary 2008-09: Memberships

Organization	OCSD Funding	Benefits of Membership	Key Projects & Accomplishments
University of Arizona: Water Quality Center (WQC) [recently renamed the Water and Environmental Technology Center (WETC)]	$10,000	The WQC /WETC consists of an interdisciplinary group of research scientists working together to resolve water quality-related problems. The funding is supplied by 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 has focused on biosolids applications options and pathogen occurrence and transport. With the recent addition of Temple University to the Center, there will be an increased emphasis on endocrine disrupting chemicals in wastewater.
Southern California Coastal Water Research Project (SCCWRP)	$363,466	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. 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 w/ OCSD staff on multiple occasions to help develop the proposed receiving waters monitoring program included in our 2009 NPDES permit renewal application, significantly reducing our reliance on consultants. 2) SCCWRP and OCSD staff have worked together to facilitate meetings with the four major POTWs, State Water Quality Control Board staff to analyze data and review determinations of water quality compliance with California Ocean Plan standards. These will be used in developing a new simplified assessment method to be included in the California Ocean Plan.
Water Environment Research Foundation (WERF)	$87,630	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 member, OCSD has access to all research results at no additional cost.	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 implemented a "Program-Directed Research" initiative designed to focus on high-priority issues identified in consultation with WERF members. For example, in 2008 OCSD participated in a WERF Strategic Asset Management pilot effort by performing a gap analysis on how we manage our assets. The results indicated OCSD is at the forefront for implementing and using asset management techniques. WERF will be gathering additional information about our practices to help other agencies build their programs. OCSD also has participated for several years in a collaborative project to reduce odors and corrosion in collection systems through identifying effective odor control approaches and improving the accuracy of odor control computer models.

OCSD Research Summary 2008-09: 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 Foundation currently funds or co-funds several projects related to the following topics that are relevant for OCSD: 1) Analytical method development for TOrCs (trace organic chemicals). 2) Identification of surrogate or indicator TOrCs. 3) Risk analysis for public health and environmental health issues related to TOrCs. 4) Analysis of removal processes & mechanisms for selected TOrCs in wastewater (including membrane bioreactors) and water reclamation. 5) Analysis of mechanism of TOrCs removal using high energy free radical chemistry. 6) Psychology of public acceptance of reclaimed water for potable or indirect potable use. 7) New membranes and separation processes in water reclamation including desalination. 8) Legislative advocacy for water reclamation and desalination.
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 2008-09, OCSD's membership fee is being applied to a project to determine the environmental (carbon-equivalent) footprint of our treatment processes. This involves source testing of the greenhouse gas (GHG) air emissions from individual processes and modeling of the carbon-equivalent impacts of the treatment activities. The resulting computer model will allow OCSD staff to evaluate the GHG effects of possible operational changes.
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) Recovery of metal ions from membrane concentrates by dendrimer enhanced filtration: This project examines the feasibility of using a specific process to remove toxic metals from membrane filtration waste streams that complicate the disposal of those streams. 2) Source, fate, and transport of endocrine disruptors, pharmaceuticals, and personal care products: This project documents the occurrence of various trace contaminants on three California drinking water sources to assess the impact of wastewater on drinking water supplies. 3) High-efficiency hydrogen gas production using a microbial electrolysis cell: This project focuses on generating hydrogen gas from wastewater; if successful, this could be a cost-effective route to produce hydrogen and treat wastewater simultaneously. 4) Enzyme-enhanced membrane bioreactors to upgrade wastewater treatment for reuse: This project examines using membrane bioreactors and enzymes to enhance the removal of various trace compounds during wastewater treatment. 5) Development of rapid detection method of somatic coliphage as viral indicator of source water: This project is attempting to develop a test to detect water contamination by bacteria in four hours as an alternative to current tests that can take four days to provide results.

Part 4

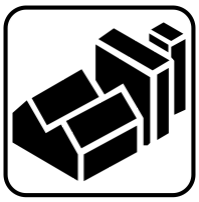
Detailed Project Information

Project Category:

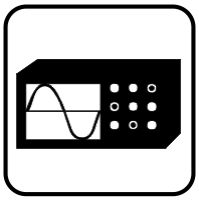
Planning

Project Title:

Research Program Strategic Plan



Strategic & Master Planning



Research & Development

Contact: Jeff Brown, Technical Services

Purpose: Produce a multi-year plan to guide operational research efforts

Description:

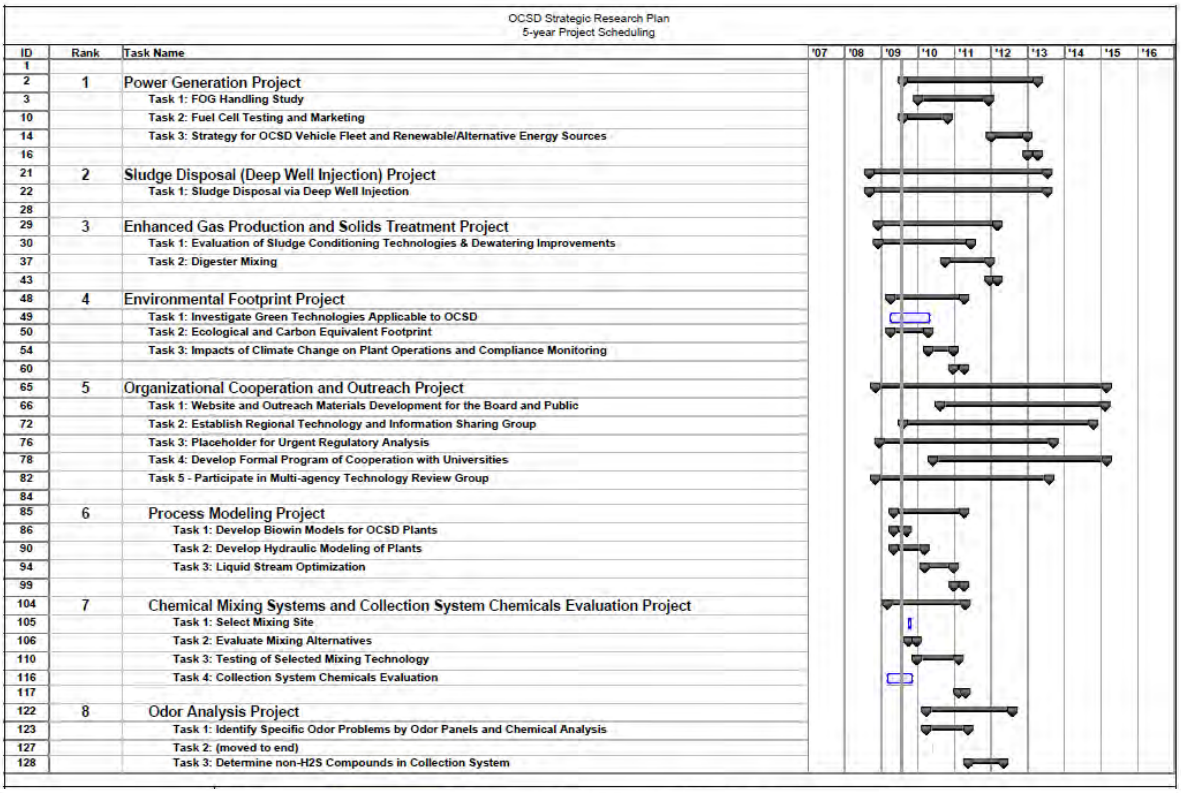
Research is an integral part of an organization's overall strategy to attain its goals. To have a coordinated proactive research program that meets OCSD's needs and addresses issues that are important for current and future operations, a Research Strategic Plan was developed to define the overall research direction and serve as a guide for the projects that will be undertaken over a five-year period. Its preparation involved both OCSD staff and an experienced outside consultant to ensure that the planning was comprehensive, yet was grounded in the realities of the agency's operations and future activities. The development process was designed to identify knowledge gaps in planned capital projects, regulatory directions that might require research input to address, opportunities for improved treatment approaches, and areas for valuable short-range and long-range investigations.

Results:

Thirty-six individual and small group interviews and three large workshops were held to develop a list of project areas that might be included in the final research plan. A structured ranking process, involving criteria such as a project's potential for cost savings, its public acceptability, and its environmental consequences, was used to prioritize the candidates. The top-rated eleven project areas formed the recommended 5-Year Research Strategic Plan. The topics range from improving anaerobic digester operation to determining the impacts of climate change on OCSD plant operations and regulatory compliance.

Status:

The final Plan was accepted by the OCSD Board of Directors and is being used as the blueprint for pursuing operational research and special projects throughout the agency.


OCSD Strategic Research Plan
5-year Project Scheduling
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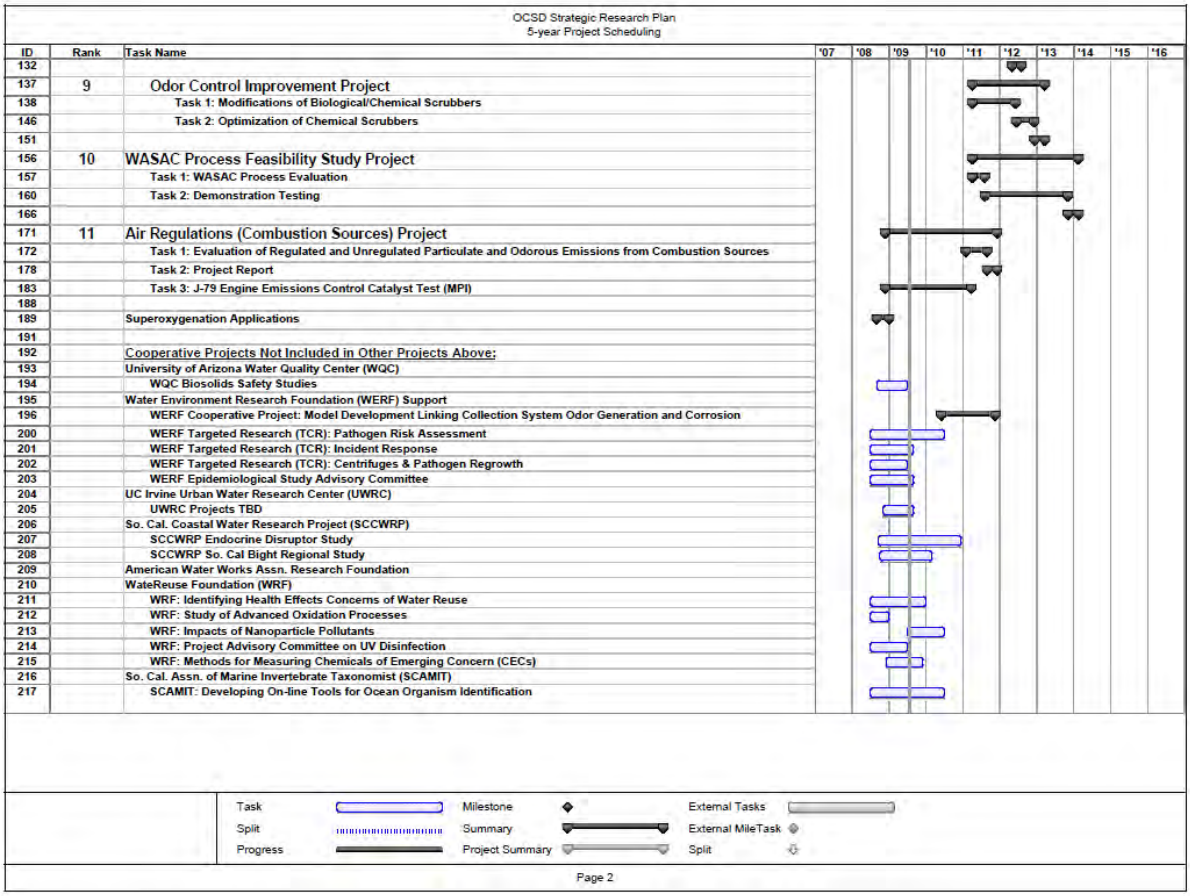
1
2 1 Power Generation Project
3 Task 1: FOG Handling Study
10 Task 2: Fuel Cell Testing and Marketing
14 Task 3: Strategy for OCSD Vehicle Fleet and Renewable/Alternative Energy Sources
16
21 2 Sludge Disposal (Deep Well Injection) Project
22 Task 1: Sludge Disposal via Deep Well Injection
28
29 3 Enhanced 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


OCSD Strategic Research Plan
5-year Project Scheduling
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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
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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)
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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
Task
Split
Progress
Milestone
Summary
Project Summary
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External MileTask
Split
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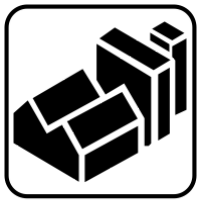
Project Category:

Environmental Improvement

Project Title:

Climate Change Initiative



Contact: Michele Farmer, Technical Services

Purpose: Develop an overall strategy for responding to climate change regulations and proactively adapting to the effects of climate change; this includes identifying and mitigating greenhouse gas (GHG) emissions and adapting to any climate change-related impacts to our facilities and operations.

Description:

The project will identify the responsibilities of various OCSD departments, the opportunities for collaboration with other organizations, and the process for keeping the climate change initiative (CCI) current. The possible benefits of the CCI include pollution reduction, cost savings, current and future regulatory compliance, and increased public confidence in OCSD.

Several interrelated projects and tasks will need to be accomplished. The key outcomes will include:

- A reasonable and repeatable methodology for determining the environmental footprint of both treatment plants.
- Outreach materials describing the environmentally sustainable initiatives that OCSD has already undertaken.
- Findings from research and studies to identify opportunities for cost-effectively reducing OCSD's environmental footprint and fully recycling our renewable energy resources.
- Identified key regulatory requirements and impacts to OCSD.
- Procedures to (a) identify risks to our facilities and operations resulting from climate change, (b) incorporate appropriate mitigations/adaptations, including capital improvements, to the respond to the risks of climate change, and (c) incorporate greenhouse gas emissions and other climate change impacts into our CEQA documents.

Results:

Notable CCI activities that were started or completed in 2008-09 include:

- OCSD submitted its first annual GHG emissions report in response to a mandatory compliance requirement [California's "Global Warming Solutions Act" (AB-32)].
- The Public Information office developed a brochure titled "The Science of Sustainability" that describes major sustainability achievements by OCSD.
- A cooperative project was begun with UC Irvine's Urban Water Research Center (UWRC) to calculate the methane-equivalent environmental footprint of OCSD's treatment processes and biosolids management practices. The procedures developed during this project will be combined with other procedures focusing on nonmethane emissions to determine the comprehensive environmental footprint of OCSD's activities.

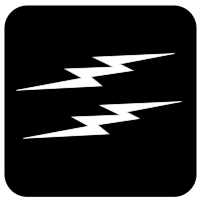
Status:

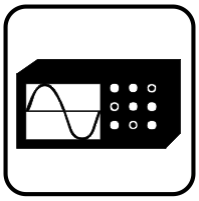
Work in the upcoming year will include:

- Developing an inclusive climate change strategy report as a tool to inform current and future policy decisions.
- Promoting a greater awareness of OCSD's sustainable initiatives inside and outside the agency.
- Reducing OCSD's environmental footprint through immediate greenhouse gas reduction measures when possible.
- Identifying strategies for implementing future sustainable initiatives.

Project Title:

Fuel Cell Demonstration for Energy and Hydrogen Production





Contact: John Linder, Engineering
Jeff Brown, Technical Services

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.

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 installing the utilities the equipment will need. The Board approved $500,000 for this project, which will include payments to APCI ($400,000) and OCSD administrative costs ($100,000).

Results: None; the system is not yet operational as of the end of 2008-09.

Status:

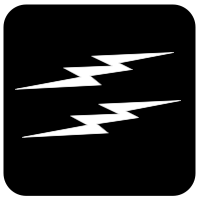
The original project schedule had the system fully operational in mid- 2009. However, delays in executing various legal agreements have extended the schedule about eight months. The system now is expected to be in operation early in 2010.

Project Category:

Air Quality

Project Title:

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



Contact: Dave MacDonald, Engineering
Jeff Brown, Technical Services

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 will be conducted on one CGS engine Plant 1. This selected post-combustion technology has been proven effective for controlling NOx, CO, and VOCs 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 also will be installed 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 will be 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 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 Fourier Transform Infrared Spectroscopy (FTIR) sampling to monitor for NOx, CO, and speciated VOCs including formaldehyde. There will be a three day FTIR test event during the start-up.
- 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 EPA Method 323 for formaldehyde.
- Perform daily/weekly monitoring of NO_x and CO performance at the inlet and two outlets of the two catalytic oxidizers using hand-held analyzers.
- Perform monthly source testing of VOCs using SCAQMD Method 25.1 and formaldehyde EPA Method 323 at the inlet and outlet of the catalytic oxidizer.

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

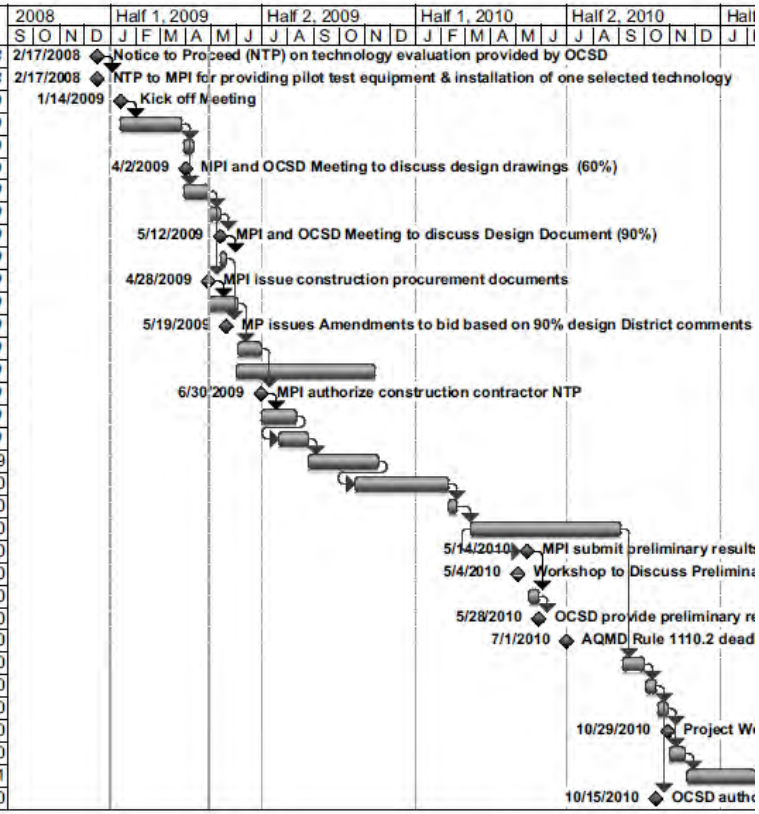
The projected cost for the pilot testing is $530,000 for the SCR/catalytic oxidizer and digester gas cleaning system and $2.4 million for construction and personnel expenses during the test. Equipment for full-scale installations on all eight CGS engines would cost $31 million.

Status:

Engineering services for the J-79 Project are being provided by Malcolm Pirnie, Inc. (MPI). The design of the pilot testing facilities has been completed. Olsson Construction provided contractor services for the earlier catalytic oxidizer pilot test at Plant 2 and will be retained to install the pilot testing equipment at Plant 1. The construction is scheduled to begin in October 2009, and the testing activities will take place from February through July, 2010.

Project No. J-79 - Central Generation System Engine Exhaust Emission Reduction Pilot Test for Air Quality Improvements

Task Name	Duration	Start	Finish
Notice to Proceed (NTP) on technology evaluation provided by OCSD	*0 days*	*Wed 12/17/08*	*Wed 12/17/08*
NTP to MPI for providing pilot test equipment & installation of one selected technolo	*0 days*	*Wed 12/17/08*	*Wed 12/17/08*
Kick off Meeting	*0 days*	*Wed 1/14/09*	*Wed 1/14/09*
MPI prepare draft design drawings for review (60%)	*54 days*	*Tue 1/13/09*	*Fri 3/27/09*
OCSD review design drawings (60%)	*10 days*	*Mon 3/30/09*	*Fri 4/10/09*
MPI and OCSD Meeting to discuss design drawings (60%)	*0 days*	*Thu 4/2/09*	*Thu 4/2/09*
MPI prepare final construction procurement documents/90% design drawings	*22 days*	*Mon 3/30/09*	*Tue 4/28/09*
OCSD review construction procurement documents / 90% design drawings	*10 days*	*Wed 4/29/09*	*Tue 5/12/09*
MPI and OCSD Meeting to discuss Design Document (90%)	*0 days*	*Tue 5/12/09*	*Tue 5/12/09*
MPI incoporate District Comments for 90% design and Issue Addendum	*5 days*	*Wed 5/13/09*	*Tue 5/19/09*
MPI issue construction procurement documents	*0 days*	*Tue 4/28/09*	*Tue 4/28/09*
Contractors prepare and issue bid to MPI	*25 days*	*Wed 4/29/09*	*Tue 6/2/09*
MP issues Amendments to bid based on 90% design District comments	*0 days*	*Tue 5/19/09*	*Tue 5/19/09*
Olsson Proposal review and negotiations	*20 days*	*Wed 6/3/09*	*Tue 6/30/09*
MP orders JM catalysts, AFT Vessels, & Flextronics Exp. Joints (including shop dwg	*120 days*	*Mon 6/1/09*	*Fri 11/13/09*
MPI authorize construction contractor NTP	*0 days*	*Tue 6/30/09*	*Tue 6/30/09*
Shop drawing preparation, plan and evaluation drawing for P1 full scale system	*30 days*	*Wed 7/1/09*	*Tue 8/11/09*
Shop drawing review for Olsson's provided equipment	*25 days*	*Wed 7/22/09*	*Tue 8/25/09*
Equipment ordering and fabrication completion	60 days	Wed 8/26/09	Tue 11/17/09
Construction	80 days	Wed 10/21/09	Tue 2/9/10
Start-up	8 days	Wed 2/10/10	Fri 2/19/10
Pilot testing (OCSD Operate and Maintain; MPI Monitor)	130 days	Mon 3/8/10	Fri 9/3/10
MPI submit preliminary results and technical memorandum to OCSD	0 days	Fri 5/14/10	Fri 5/14/10
Workshop to Discuss Preliminary Results for AQMD Submittal	0 days	Tue 5/4/10	Tue 5/4/10
OCSD review preliminary results	10 days	Mon 5/17/10	Fri 5/28/10
OCSD provide preliminary results to AQMD	0 days	Fri 5/28/10	Fri 5/28/10
AQMD Rule 1110.2 deadline to demonstrate achievable engine emission limits	0 days	Thu 7/1/10	Thu 7/1/10
MPI prepare Draft Pilot Test Report	20 days	Mon 9/6/10	Fri 10/1/10
OCSD review Draft Pilot Test Report	10 days	Mon 10/4/10	Fri 10/15/10
MPI finalize Pilot Test Report	10 days	Mon 10/18/10	Fri 10/29/10
Project Workshop on the Pilot Testing	0 days	Fri 10/29/10	Fri 10/29/10
OCSD submit findings to AQMD	15 days	Mon 11/1/10	Fri 11/19/10
AQMD Rule 1110.2 technical review by AQMD	60 days	Mon 11/22/10	Fri 2/11/11
OCSD authorize proceeding with full-scale Turnkey Project	0 days	Fri 10/15/10	Fri 10/15/10



Project Category:

Odor and Corrosion Control

Project Title:

Superoxygenation Process Evaluation

Contact: Jeff Brown, Technical Services

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:

A comprehensive engineering evaluation of the technical feasibility and cost implications of using superoxygenation at OCSD was performed. This found that superoxygenation would not be technically feasible for the headworks / primary clarifiers because there would not be enough contact time available for the added oxygen to react. For the activated sludge processes, using superoxygenation was found to be technically feasible but not cost effective.

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

Status:

Since this work was intended as a screening-level evaluation of superoxygenation's applicability in the collections system, additional work to characterize the odor levels and refine the technical and cost assumptions will be done to confirm the suitability of particular sites before proceeding to detailed design work and on-site equipment installations.

Project Title:

WERF: Minimization of Odors and Corrosion in Collection Systems

Contact: Carla Dillon, Operations & Maintenance

Purpose: Participate in a cooperative program to minimize odors and corrosion

Description:

The project started in 2005 and OCSD has been involved since its inception. It is a large-scale project to minimize odors and corrosion in collection systems. It seeks to determine available baseline data for odor and corrosion measurement, prevention, and control in collection systems, and to gather data on the advantages and disadvantages of each approach.

There are several activities in this effort.

- Developing references through an information literature search and utility surveys.
- Performing research to obtain missing data to fill any data gaps for current practices.
- Developing a Web-based collection system tool to help utility operators and designers research options and evaluate potential solutions for their collection system odor and corrosion concerns.

The project was conducted of two phases. The Phase 1 report was completed in 2007 and presented the results of a comprehensive literature review and assessment. It focused on the odor and corrosion approaches, strategies, challenges, and successes and failures as described in both open peer-reviewed and gray literature. The efforts was based upon information-sharing partnerships with municipal utilities, the academic community, and the profession, all on a global basis. Current literature on wastewater collection system odor and corrosion was identified and reviewed systematically, and each paper's essential information was documented electronically. The total number of references screened was 3,842, and the total number of papers included in the database was 412. A decision-making tool was also developed on the WERF website to assist users in identifying treatment options.

In 2009, the Collection System Ventilation Research activity completed Phase II of the project. The purpose of this work was to measure air ventilation within full-scale gravity collection system components, simultaneously measure parameters related to ventilation, use the field experimental results to evaluate current ventilation models, and develop a concept for an improved ventilation model.

Results:

Experiments were completed at four different locations within the Los Angeles (CA) and King County (WA) wastewater collection systems. The components included concrete gravity pipes ranging in diameter from 33 to 96 inches. Using a carbon monoxide pulse tracer method, the air velocity was measured within each pipe entering or exiting the components at vents using a standpipe and hotwire anemometer. The ambient wind speed, temperature, and relative humidity, headspace temperature and humidity, and wastewater flow and temperature were measured and logged continuously using data loggers. The field experiments resulted in a large database of measured ventilation and related parameters characterizing ventilation in full-scale gravity sewers. The field data were used as input to three current ventilation models to evaluate the models' accuracy compared to the measured field data. The strengths and weaknesses of each model were assessed. Finally, observations from the study were used to develop a concept for an improved ventilation model based on conservation of momentum equations in connected collection system components.

The Phase II project resulted in the following major conclusions:

- A method was developed in this project for inexpensively measuring collection system ventilation over a two-day period.
- Field testing was conducted to measure ventilation rates and compare to existing models. It was determined that many of the existing models inadequately predict ventilation. One model was identified that could be used as a screening tool with the understanding that the variability of ventilation in real collection systems may be much greater than the model-predicted variability.
- Ventilation within a gravity collection system segment may be influenced by forces upstream or downstream of the segment more so than forces within the segment.
- With the exception of the thermodynamic model, existing ventilation models are limited in that they do not consider influences on ventilation in terms of the fundamental physics. The thermodynamic model does so indirectly with an energy balance rather than directly with a force balance.

- A force balance model approach that could solve some of the limitations of the other models has been proposed. In order to implement the new model, a better characterization of the drag forces acting at the air–water interface is needed. The experimental approach used in this project could be adapted to obtain drag coefficients with minimal interference from other variables. A network model using the force balance approach as the software backbone would represent a significant improvement in the current state of the science.

Status:

OCSD participated in this project through literature reviews, consultation, and monetary support. The results of this study will aid OCSD with its odor control program through a better understanding of airflow dynamics, testing methods, application of decision tools, and potential implementation of design features to minimize odors.

Project Category:

Process Alternatives or Improvement

Project Title:

OpenCEL Process Evaluation

Contact: Jeff Brown, Technical Services

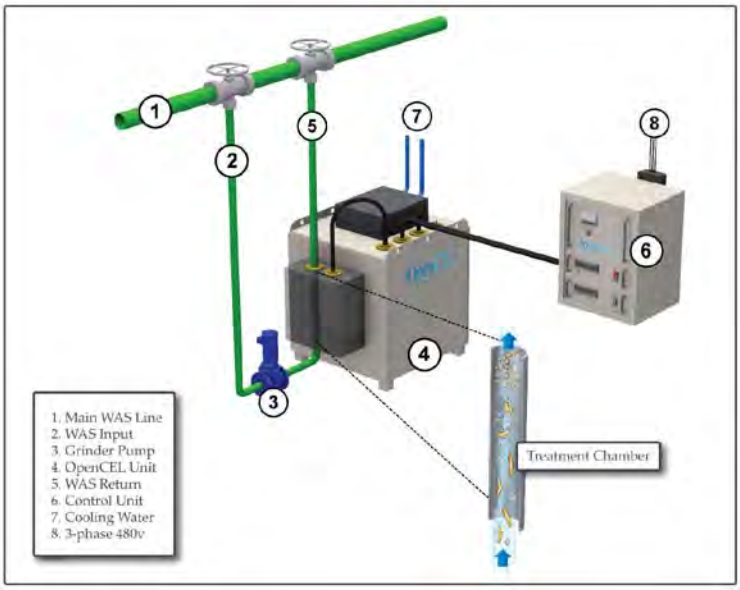
Purpose: Evaluate a process to improve digester efficiency and minimize residual solids

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.

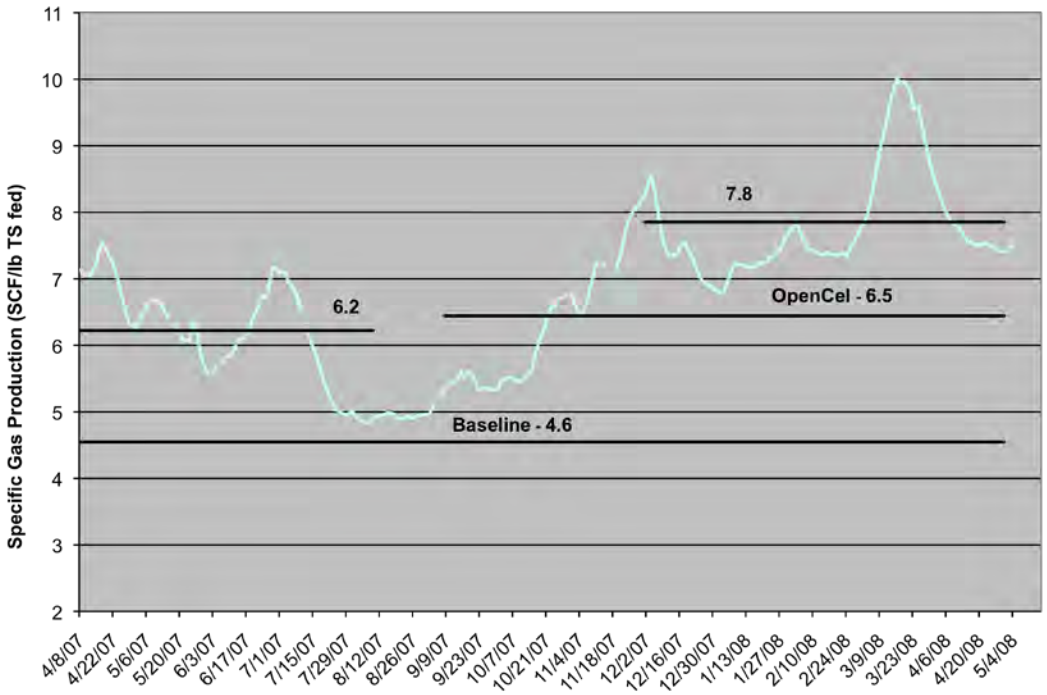
Breaching the cellular membrane is the rate-limiting step for anaerobic digestion of WAS. Various methods of digestion pretreatment have been shown effective at laboratory scale since the late 1970's, but scalability problems, excessive power requirements, and other factors generally have kept them from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



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:

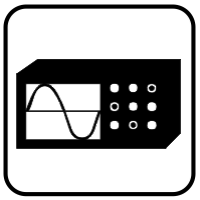
The first step in evaluating OpenCEL's possible applicability at OCSD was verifying the effect of the treatment on samples of OCSD WAS. Biological Methane Potential (BMP) tests on treated and untreated WAS were done by Arizona State University in April, 2009, and the results showed BMP increases after treatment that supported OpenCEL's expectations for successful performance. Subsequent preliminary cost analyses suggested that using OpenCEL could save OCSD on the order of $2-4 million/year at each plant (depending on the specific 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.

The next steps in the OpenCEL evaluation will involve verification of the expected cost savings and designing a program to demonstrate OpenCEL's performance at one of the treatment plants if that continues to appear justified.

Project Title:

Deep Well Injection of Biosolids

Solids Handling & Digestion



Research & Development

Contact: Michelle Hetherington, Operations & Maintenance

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 will inject 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 will be 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 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.

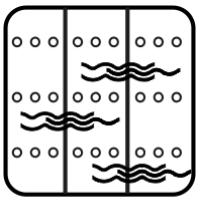
Status:

The TIRE project began full production in 2008, and OCSD continues to observe and learn from their operation. Staff visited Los Angeles' application at Terminal Island and have been

tracking the performance under varying densities and combinations of injected materials and the associated costs. The deep well injection system cost approximately $8 million to engineer and construct. OCSD will further evaluate options and potential applications in the next year.

Project Title:

Process Modeling



Contact: Carla Dillon, 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 will be 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 has been used together with custom-made Excel spreadsheet models.

Results:

The Biowin program has been procured and was used by OCSD consultants on several capital improvement projects in the past, but has not been used in-house. OCSD staff will obtain training on the software and hire a consultant to assist with planning, testing, and calibrating the model for all of the secondary treatment facilities.

Staff worked with a hydraulic consultant to evaluate the Plant 2 Ocean Outfall Booster Station (OOBS) and Effluent Pump Station Annex (EPSA), which pump treated effluent into the ocean, and the associated pipe/channel system.

Status:

In coordination with the design consultant, a test in nitrification mode is being planned for the Plant 1 activated sludge plant after its recent upgrades. Data obtained during this test will aid in calibrating the Biowin model for one mode of operation. Since OCSD has not previously used this model in-house, electronic data have not been provided to OCSD by consultants after completing testing and modeling projects.

Part of the effort in 2009-10 will include working with past OCSD consultants to obtain electronic data for the Biowin model used in various design efforts. The established model will be used as a planning and optimization tool by OCSD staff.

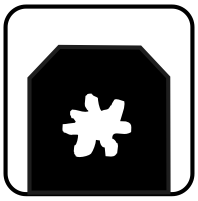
Also in 2009-10, staff will reassess the timing and resources available for expanded hydraulic modeling.

Project Category:

Emerging Contaminants, Ocean Monitoring, and General Topics

Project Title:

University of Arizona Water Quality Center (WQC)



Contact: Leyla Perez, Technical Services

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

Description:

OCSD is a supporter of the University of Arizona Water Quality Center (WQC), an official National Science Foundation Industry /University Cooperative Research Center (I/UCRC). The WQC consists of an interdisciplinary group of research scientists within the University who work together to resolve water quality-related problems. The WQC's funding is supplied by the National Science Foundation and a variety of companies and agencies that are interested in specific water quality issues. For its annual contribution of $10,000, OCSD gets access to the latest research results from the WQC and, as a voting member of the Industrial Membership Board, can influence the direction of the research program.

Results:

During 2008-09, research programs and results from the WQC that were relevant to OCSD included the following.

- Incidence of Pathogens and Indicators in Biosolids: This is the first nationwide study on pathogens in biosolids since the EPA Part 503 regulations went into effect and provides a comprehensive database on the occurrence of pathogens in Class B anaerobically digested biosolids. Nationwide data show that pathogen indicator (e.g., fecal coliform) concentrations in Class B biosolids are similar to concentrations found in the early 1990s, while *Salmonella* and enterovirus concentrations are now significantly lower. Overall, the data suggest that the Part 503 rule has resulted in reduced pathogen concentrations in biosolids.

- Sustainability of Land Application of Biosolids: Land application of Class B biosolids is one of OCSD's management options. However, due to public concern over potential hazards, the long-term sustainability of land application has been

questioned. The objective of this study was to evaluate the sustainability of biosolids land application. To do this, the WQC evaluated (1) the fate and transport of potential biological and chemical hazards within biosolids, and (2) the influence of long-term land application on the microbial and chemical properties of the soil. Direct risks to human health posed by pathogens in biosolids have been shown to be low. Risks from indirect exposure such as aerosolized pathogens or microbially contaminated ground water are also low. A long-term land application study showed enhanced microbial activity and no adverse toxicity effects on the soil microbial community. Long-term land application also increased soil macronutrients including carbon, nitrogen, and in particular, phosphorus. Available soil metal concentrations remained low over the 20-year land application period due to the low metal content of the biosolids and a high soil pH.

- Evaluation of Aging as a Class A Treatment Process: The WQC is in the early stages of a project to determine whether simply aging Class B biosolids could be an effective treatment process to produce Class A biosolids. If so, this could provide an additional biosolids management option for OCSD.

- Potential for Pathogens to be in Irrigation Return Flow Following Irrigation of Land Applied Fields: Preliminary data has shown the presence of low levels of fecal coliforms in irrigation water flowing along a furrow irrigation land applied field. This may affect OCSD's current management sites and their practices.

- Endocrine Disrupter and Estrogenic Activity in Soil Following 20 Years of Land Application: The results of this study could support the sustainability of long term biosolids land application on agricultural land. Researchers analyzed data on nonylphenol and estrogenic activity concentrations in soil core samples following 20 years of land application (the Marana Study). Estrogenic activity

was only detected in two samples, whereas nonylphenol was detected in many samples. Of significance is the fact that nonylphenol and certain industrial chemicals also were found in high concentrations in control (no biosolids) plots.

Status:

As a continuing member, OCSD maintains 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 WQC recently added Temple University as a participant; since Temple has a specialization in studies of endocrine disruptors in wastewater, this is likely to be an area of increased emphasis for the WQC.

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 2008-09 related to marine topics and trace pollutants included the following.

- Endocrine Disrupting Compounds (EDC): Estrogenic/feminizing activity in male fish collected near the OCSD outfall

  Contact: Jeff Armstrong, Technical Services

  The specific aims of this study were to determine the occurrence and prevalence of female characteristics in male fish in OCSD's monitoring area. A secondary purpose was to determine if the OCSD effluent has estrogenic activity in laboratory tests.

  All POTWs are experiencing this phenomenon at varying degrees, but few are actively investigating the source compounds. Identifying the occurrence and extent of the problem, and the subsequent identification of causative agents, are the first steps towards mitigation or management of the issue.

  This project was done in cooperation with UC Riverside and resulted in a doctoral dissertation and four technical publications. The project has been completed.

- Sea Grant EDC Study: Characterization of an Endocrine-Disrupted Condition Observed in Marine Fish of the San Pedro Shelf

  Contact: Jeff Armstrong, Technical Services

  This project, done in cooperation with CSU Long Beach, sought to use an analytical technique for protein identification called proteomics to discover new biomarkers and develop protein expression profiles that eventually can be used in environmental assessment as a screening tool. The goal will be to identify and classify the patterns of protein production following exposure to EDC chemicals and the potential impacts in wild marine fish in the urban ocean setting.

  This study is a first step toward developing specific biomarkers of environmental effects in the Southern California Bight and will point to potential specific endocrine disrupting chemicals and other causative chemicals in the local ocean environment.

  The completed project's results included:

  - New quantitative polymerase chain reaction (qPCR) assays enabling measurement of the expression of 8 genes
  - Eight new genes added to a microarray for use throughout Southern California
  - One master's degree thesis
  - Five professional meeting presentations
  - Two professional publications.

- Regional EDC Study: Endocrine Disruption in Coastal Flatfish (SCCWRP Cooperative Project)

  Contact: Jeff Armstrong, Technical Services

  This is a regional study through SCCWRP (Southern California Coastal Water Research Project) whose purpose was to determine whether EDC effects observed at the biochemical level (e.g., hormone/protein concentration, gene regulation) are expressed at the organism (histopathological effects) and population (sex ratio changes) levels. A secondary goal was to evaluate the cause(s) of the observed effects. This information will facilitate future studies and the development of appropriate management actions if necessary.

The sampling and analysis phase of the project has completed, and the project technical report is in preparation. The preliminary results have been reported at several professional meetings including the 2008 annual meeting of the American Association for the Advancement of Science (AAAS) and the 2008 annual meeting of the Society of Environmental Toxicology and Chemistry (SETAC). Future activities have not been determined.

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

  Contacts: George Robertson and Charles McGee, Technical Services

  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 about 60 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, and (6) Nutrient Overenrichment in Wetlands. OCSD is directly involved in the first three components.

  Bight'08 builds upon 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. Sixty organizations, including international and volunteer organizations, have agreed to participate. The inclusion of multiple participants, many of them new to regional monitoring, provides several benefits. Cooperative interactions among many organizations with different perspectives and interests, including a combination of regulators and dischargers, ensure that an appropriate set of regional-scale questions will be addressed by the study.

  All field sampling work has been completed for the Coastal Ecology component. The Water Quality component field sampling will be delayed until winter 2010 due to State budgetary issues. Future activities will include completing the sample analyses by June 2010 & issuing reports over the next three years.

  The approximate cost to OCSD in 2008-09 was $125,000, which included taxonomy and nutrient analyses. The total SCCWRP budget for the three components involving OCSD will be $500,000 to $750,000, and the total SCCWRP budget in Bight'08 for activities related to marine receiving waters is $1,095,000 plus in-kind services from various agencies.

- Ocean Current Measurement Program Analyses Of Inter- and Intra-Annual Variability In Coastal Currents

  Contact: George Robertson, Technical Services

  The purpose of this study is to provide an overview of the key findings of the ocean current measurement program conducted by OCSD since 1985.

  The ocean current measurement program has served multiple objectives, including providing data for determining compliance with permit conditions and advancing the understanding of physical processes that affect dispersion of the District's wastewater plume. These studies have contributed significantly to the present 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**.**

  The approximate cost to OCSD has been $135,000. A final report and fact sheet have been completed. Future activities will focus on incorporating information and conclusions into future coastal ocean current measurement projects.

- Ocean Currents Spatial Analysis: Mapping and Spatial Currents/ Strategic Process Study (MSC/SPS)

  Contact: George Robertson, Technical Services

  This project provides a summary for the year 2006-07 of the eight year Mapping and Spatial Currents/SPS (MSC/SPS) study. The MSC/SPS was designed to characterize the spatial and temporal variability of ocean currents in the near shore region surrounding the OCSD outfall.

  Since 1999, the District has acquired ocean current data over the near shore study region on a nearly monthly basis. Previous reports detailed the March 1999 through June 2005 observations and results. The 2008 report describes results observed during January 2006 through December 2007; yearly and previous seasonal statistics and analysis are modified and presented to include the 2006-07 data. The information and conclusions will be incorporated into future ocean current measurement activities.

- Online Tools for Taxonomic Analysis: Access Database for 5th Edition of SCAMIT Taxonomic Species Listing

  Contact: Dean Pasko, Technical Services

  This project supports the efforts of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) to develop the a database listing of species called *A Taxonomic Listing of Soft Bottom Macro- and Megainvertebrates from Infauna & Epibenthic Monitoring Programs in the Southern California Bight, Edition 5*. The database will become the framework through which taxonomic tools (such as images and taxonomic keys) and ecological resources (such as distribution data and sediment preferences) will be linked. This will facilitate the consistent application of species identifications throughout the Southern California marine monitoring community.

  Since June 2008, descriptive ontologies have been submitted, reviewed, and uploaded for all of the major taxa (e.g., Crustacea, Polychaeta, Echinodermata, Molluska). Ontologies are a listing of all the accepted terms to describe the contents of images submitted in support of the species listing and represent the first step toward uploading images into Morphbank (www.morphbank.net). Morphbank is a Web-based repository of biological images that will be linked directly to species listed in the SCAMIT Taxonomic Listing. Materials posted to Morphbank will be accessible to all SCAMIT members (which includes OCSD).

  The future activities will include creating ontologies for the remaining "minor" phyla and initiating a system for efficiently uploading images into Morphbank.

- Interlaboratory Comparison of Analytical Methods for Endocrine Disrupting Compounds (EDCs) and Pharmaceuticals and Personal Care Products (PPCPs) (Water Research Foundation Cooperative Project)

  Contacts: Kim Christensen and Sam Mobray, Technical Services

  This project evaluates analytical methods for EDCs and PPCPs using a round robin design involving multiple laboratories.

  OCSD's role will be to analyze 6 to 8 samples during three round-robin events over 12 to 15 months using its existing in-house methods for EDCs and PPCPs. Other laboratories will do the same. The project will compare the strengths and weaknesses of each method. It also will help to establish performance-based QA/QC criteria and guidelines to aid utilities in assessing the most appropriate methods to use.

- Impacts of Nanoparticle Pollutants on Water Reclamation and Sewage Treatment (WateReuse Research Foundation Cooperative Project)

  Contacts: Kim Christensen and Sam Mobray, Technical Services

  This is a WateReuse-funded cooperative project with UC Irvine and Kennedy Jenks Engineers to evaluate the impact of zinc and silver nanomaterials in two key water reclamation treatment processes, activated sludge and media filtration. through bench scale studies. Another goal that is relevant to OCSD is to determine if these nanoparticles have an impact on the treatability of sewage.

  The total project budget is $200,000 from WateReuse plus $15,000 from OCSD in in-kind support through sample analyses. Over a one-year period, the laboratory will analyze about 200 samples for nanomaterials (as total metals concentrations of zinc and silver) using ICPES and ICPMS methods.

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

  Contact: Sam Mowbray, Technical Services

  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.

  This project started late in 2008-09, so only project planning activities have been completed. OCSD currently is a minor participant in the larger WERF study, sharing data from previous internal studies and contributing about $40,000 in cash and in-kind expenses to the total $500,000 project cost.

  The future activities will include participating in project conferences and in reviewing data and reports. There also is a possibility that OCSD could become a test site for studying the removal of certain TOrCs in various treatment processes.

Part 5

2009-10 Research Plan

Part 5

2009-10 Research Plan

Several major project milestones are planned during 2009-10 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.)

Continuing Projects:

J-79 Central Generation engine emissions control: Several years of study and preliminary testing will culminate in a full-scale installation and validation testing of a gas cleaning system and a Selective Catalytic Reduction / catalytic oxidizer system on a Plant 1 engine to reduce the emissions of NO_x, CO, and volatile organic compounds as required by upcoming regulations. After equipment installation in early 2010, the testing will continue for about six months, and the results will be used to guide SCAQMD rule-making.

Fuel cell demonstration at Plant 1: Fuel cells provide perhaps the most environmentally benign method of generating electricity. The 300 kW OCSD installation will start with a renewable resource (digester gas), generate electricity for plant use and hydrogen for vehicle use, and emit 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. Once the equipment is installed and operating this year, a three-year test is planned.

Climate change initiative: This project is intended to reduce OCSD's environmental footprint and to respond to the possible impacts from climate changes that already may be occurring. For the first time, OCSD will have a repeatable and justifiable procedure for calculating the environmental footprint of its activities, and there will be a comprehensive strategy for reducing greenhouse gas emissions and implementing sustainable environment-friendly changes.

Process modeling and alternative technologies: Improving the efficiency of core wastewater treatment activities is an on-going effort.

- One way to do this is through computer process modeling, which can reveal changes in operating practices that will reduce costs and improve the quality of plant discharges. Both biological and hydraulic modeling will continue to be explored and refined by OCSD's process engineers.

- Another way to improve efficiency is to adopt new technologies that provide cost or efficiency advantages over existing practices.

- Superoxygenation for odor control in the collection system will continue to be investigated. Onsite sampling and preliminary design efforts are planned for selected pump stations, which could lead to full-scale installations.

- The OpenCEL process for digester improvement appears promising based on laboratory evaluations of the digestibility of OCSD's waste activated sludge and engineering economic projections of its benefits and costs. The next steps in 2009-10 will involve designing a test program to demonstrate OpenCEL's performance in full-scale use at one of our treatment plants.

New Project:

The following major new project is expected to begin in 2009-10.

Odor Analysis Project

Description:

To better understand process events that lead to off-site odor impacts, a study will take place to relate odors to specific chemicals and process performance. This project will include vapor-phase sampling of both treatment plants and throughout the collection system. Analyses will be performed to determine the odor and the chemical causing the odor. This information will enable an understanding of events that increase odors. It will also allow OCSD to make educated process modifications and to develop a long-term proactive sampling plan to prevent offensive odors. The project scope also includes developing improved models to correlate corrosion rates to vapor phase sulfide concentrations.

Goals for 2009-10:

The goals for this fiscal year include developing the project details including the task schedule and the budget. A contractor will be procured to assist in sampling. This work will begin in the collection system because odor control chemical prices have risen and it would be best to make any changes to the collection system dosing before conducting testing at the treatment plants.

An onsite olfactometer also is being installed, which is planned to be operational early in 2010. The original plan was to conduct 1-2 odor panels per month. If the number of panels is increased to support this project, the plans for staffing the panels may have to be revised.

Budget:

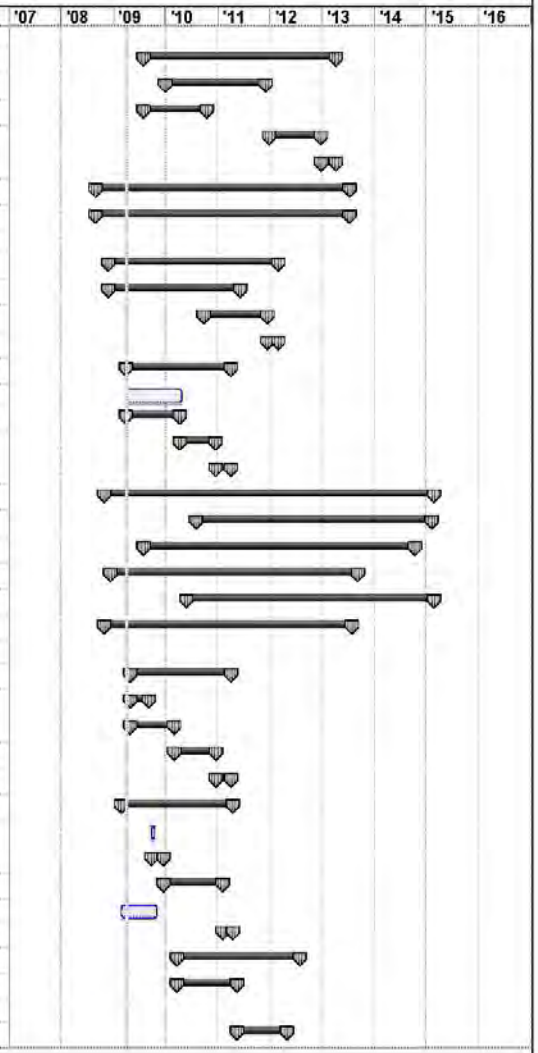
The overall budget for this multi-year project is $757,000, which includes allowances for substantial amounts of equipment and university consultant involvement if needed. During 2009-10, $85,000 is expected to be spent for contractor sampling support and laboratory analyses.

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



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Progress
Milestone
Summary
Project Summary
External Tasks
External MileTask
Split

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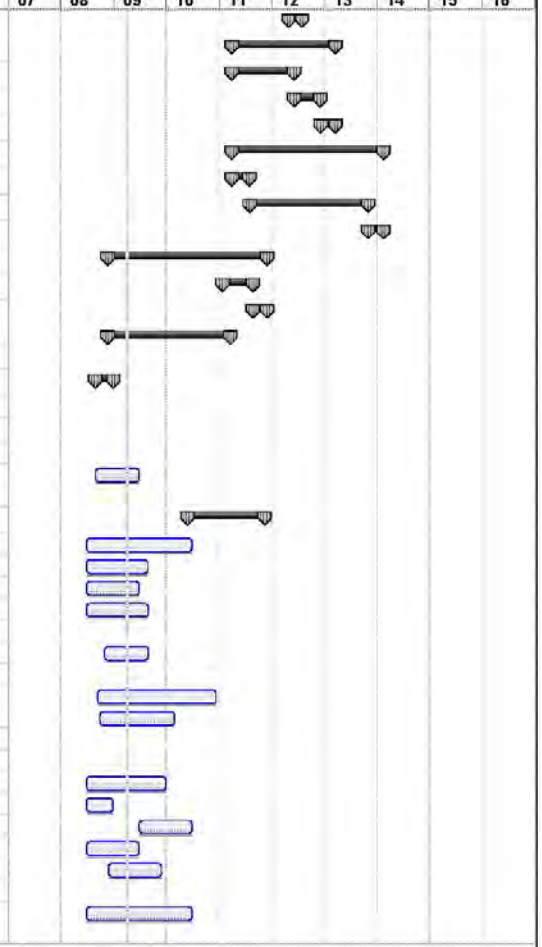
OCSD Strategic Research Plan
5-year Project Scheduling

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



Task
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Summary
Project Summary
External Tasks
External MileTask
Split

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OCSD 9/09