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SMUD Community Renewable Energy Deployment Final Report

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ABSTRACT

This report summarizes the completion of four renewable energy installations supported by California Energy Commission (CEC) grant number CEC Grant PIR-11-005, the US Department of Energy (DOE) Assistance Agreement, DE-EE0003070, and the Sacramento Municipal Utility District (SMUD) Community Renewable Energy Deployment (CRED) program.

The funding from the DOE, combined with funding from the CEC, supported the construction of a solar power system, biogas generation from waste systems, and anaerobic digestion systems at dairy facilities, all for electricity generation and delivery to SMUD's distribution system. In November 2014, the SMUD CRED projects won a State Leadership in Clean Energy Award.

The following overall goals of the program were achieved:

- Installing renewable energy facilities interconnected to SMUD's distribution grid.
- Contributing toward SMUD's Renewable Portfolio Standard (RPS) goal.
- Contributing to DOE's goal of accelerating renewable deployment.
- Reducing greenhouse gas (GHG) emissions through destruction of methane.
- Creating jobs and spurring of local economic activity.
- Demonstrating economically viable installations of technologies that are not yet widely commercially deployed.
- Demonstrating the alignment of economic incentives to achieve socially and environmentally desirable goals.
- Providing lessons learned for all participants (engineers, developers, public agencies, site hosts, interconnecting utility, contractors, financiers, permitting agencies, and the public).

The deployment of CRED projects shows that solar projects and anaerobic digesters can be successfully implemented under favorable economic conditions and business models and through collaborative partnerships. This work helps other communities learn how to assess, overcome barriers, utilize, and benefit from renewable resources for electricity generation in their region.

In addition to reducing GHG emissions, the projects also demonstrate that solar projects and anaerobic digesters can be readily implemented through collaborative partnerships. This work helps other communities learn how to assess, overcome barriers, utilize, and benefit from renewable resources for electricity generation in their region.

Keywords: community renewable energy deployment, solar, biogas, fats oils and greases (FOG), biodigester, dairy, methane

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This report summarizes the completion of four renewable energy installations supported by California Energy Commission (CEC) grant number CEC Grant PIR-11-005, the US Department of Energy (DOE) Assistance Agreement, DE-EE0003070, and the Sacramento Municipal Utility District (SMUD) Community Renewable Energy Deployment (CRED) program.

The DOE provided more than $5 million in funding for several SMUD Community Renewable Energy Deployment (CRED) projects. This funding, combined with $500,000 from the CEC, supported the construction of a solar power system, biogas generation from waste systems, and anaerobic digestion systems at dairy facilities, all for electricity generation and delivery to SMUD's distribution system. In November 2014, the SMUD CRED projects won a State Leadership in Clean Energy Award.

A summary of project characteristics is provided in Table 1-1.

Table 1-0-1: CRED Project Results Summary

Parameter	Simply Solar	SRCSD	New Hope Dairy	Van Warmerdam Dairy
Nominal Electric Capacity (kW)	1,498	1,000 - 3,000	450	600
Capacity Factor (%)	18	95	45	36
Annual Energy Production (MWh)	2,423	13,747	1,569	1,612
CO_2 equivalent Reduction (MT/yr)	1,842	10,616	2,697	7,839
LCOE (dollars/MWh) with tax credits and grants 2014 Nominal $	97.0	<100	140	78.5
kW = kilowatt gpd = gallons per day MWh = megawatt-hour CO_2 = carbon dioxide MT/yr = metric tons per year LCOE = levelized cost of energy				

The goal of the CRED program was to develop and demonstrate renewable energy technologies within SMUD's service territory. These technology installations were intended to bring several benefits to SMUD's customers and the local community:

- Generating renewable electricity locally to displace the use of fossil fuels, increase the distribution system's efficiency, and help to alleviate transmission constraints.
- Contributing to SMUD's and the state's RPS programs.
- Reducing GHG (chiefly, methane) emissions.
- Adding tax revenue for the county and extra revenue to farmers from lease payments.
- Creating jobs.
- Mitigating the problematic treatment and disposal of animal manure and food wastes.
- Turning problematic wastes into energy resources, reducing odor and flies.
- Providing farmers with facilities and equipment that improve dairy operations and reduce odors and flies.
- Co-producing value-added products such as fertilizers (solid and liquid).

These projects are an example of how small and distributed generation of renewable energy can be developed and deployed when appropriate business models and economic incentives are provided. SMUD believes that the successful deployment of these CRED projects can inspire others to develop similar projects in California, the United States, and elsewhere, bringing immediate benefits to communities.

This report includes the project description, approach, results, conclusions, and lessons learned for each of the four projects. Each project advanced science and technology to the benefit of California's ratepayers, despite challenges that were overcome during implementation.

These projects are helping SMUD meet its 2020 renewable energy goals and helping the Office of Energy Efficiency and Renewable Energy (EERE) meet its goal of accelerating market adoption of renewable energy technologies. Short-term economic benefits included job creation and use of US manufactured goods. Additional benefits included institutional capacity-building and advancement of the renewable energy industry in the Sacramento region, enabling project replication and higher efficiencies for future projects, based on lessons learned through the work completed here.

CHAPTER 1: Introduction

1.1 About the CRED Program

To help the Sacramento Municipal Utility District (SMUD) achieve its aggressive renewable energy goal, the US Department of Energy (DOE) provided more than $5 million in funding for several SMUD Community Renewable Energy Deployment (CRED) projects. This funding, combined with $500,000 from the California Energy Commission (CEC), helped to support the construction of a solar power system, a biogas enhancement facility at a regional wastewater treatment plant, and anaerobic digestion systems at two dairy facilities, all for electricity generation and delivery to SMUD's distribution system. The four CRED projects are the Simply Solar, Sacramento Regional County Sanitation District (SRCSD) Biogas Enhancement, New Hope Dairy Digester, and Van Warmerdam Dairy Digester projects.

1.2 CRED Objectives

The activities helped accelerate deployment and market penetration of the SMUD community's indigenous renewable resources, making use of otherwise overlooked resources. The biogas projects are used for combined heat and power (CHP) application. The environmental benefits of utilizing biogas for CHP are substantial, since this technological application concurrently prevents release of biogas to the atmosphere and displaces the need for an equivalent amount of fossil fuel, in addition to utilization of waste heat. These projects also help meet SMUD's 2020 renewable energy goal and the Office of Energy Efficiency and Renewable Energy's (EERE's) goal of accelerating market adoption of renewable energy technologies.

1.3 CRED Approach

The CRED project approach was to deploy and integrate renewable distributed generation into the system grid by proactively working with community, industrial, and regulatory partners. As the host utility, SMUD was able to address interconnection requirements and issues. In addition, SMUD leveraged working relationships with regulatory and permitting entities (e.g., California Air Resources Board, air quality boards, and the city and county of Sacramento). Through SMUD's power purchase agreements (PPAs) and feed-in-tariff (FIT) mechanisms and partnerships, implementation and deployment of renewable distributed generation was streamlined and accelerated relative to historic business models.

The following is a brief summary of the projects:

- Simply Solar: The Simply Solar project resulted in significant additional photovoltaic (PV) generation in SMUD territory, while also achieving community education goals and increasing public awareness about solar energy through three different solar configurations in a public park location. The project helps move the industry forward by addressing challenges of installing solar technology on brownfield landfill sites and in environmentally challenging conditions.

- SRCSD Biogas Enhancement: This project resulted in the implementation of grease and liquid food processing waste co-digestion at the SRCSD Elk Grove Wastewater Treatment Plant. Long-term benefits include the capacity for increased waste diversion from landfills, a decrease in associated transportation costs, and a significant increase in renewable energy generation from biogas.
- New Hope and Van Warmerdam Dairy Digesters: The implementation of the two dairy digester projects resulted in avoided carbon dioxide (CO_2) equivalent (CO_2e) emissions of 10,536 MT/yr and helped meet or exceed the California Air Resources Board (CARB) oxides of nitrogen (NO_x) requirements. These systems also mitigate odor, flies, and water contamination issues for the dairy facilities where they are installed.

The following sections of this report provide additional details for each project.

CHAPTER 2: Simply Solar

2.1 Project Description

Solar facilities were installed in the City of Sacramento's Sutter's Landing Regional Park. There are three solar configurations in the Sutter's Landing installation: a carport shade structure, dog park shade structures, and a ground-mount facility. All three facilities occupy the same general vicinity in the park. A general layout is provided on Figure 2-1.

Figure 2-1: Layout of Three Solar Photovoltaic Configurations at the Simply Solar Facility

2.1.1 Carport System

The carport system has a nameplate capacity of 371 kilowatts of direct current (kWdc), and it covers about 200 parking spots. The system uses the following equipment: Sharp 250W PV modules, SMA Sunny Central 500 kilowatt (kW) inverters, The New IEM switchgear, ABB transformers, Draker and Shark 100 Meter monitoring and reporting systems, and Capital Iron Works mounting structures.

2.1.2 Tree-Style Shade Structures

There are 10 tree-style shade structures installed in the dog run area of the park. These structures have an aggregate nameplate capacity of 35 kWdc. Equipment manufacturers are largely the same as those listed in Subsection 2.1.1.

2.1.3 Ground-Mount System

The ground-mount system has a nameplate capacity of 1,092 kWdc. This is the largest and most cost-effective of the three configurations on the site. It is a stationary structure with panels tilted at approximately 5 degrees for optimal sun exposure throughout the year.

2.1.4 Project Partners and Timeline

Project partners included Conergy and Washington Gas.

A general timeline is as follows:

Fall 2011: Engineering design began.

Spring 2012: SMUD completes competitive solicitation and awards project grant funds to Conergy.

Spring 2013: Sacramento City Council approves project California Environmental Quality Act (CEQA) document, landfill post-closure amendment, and lease agreement with Conergy.

Fall 2013: Grant Subrecipient Agreement completed.

Winter 2014: Sitework and construction begins.

Fall 2014: Work completed.

2.2 Project Implementation and Testing Goals

Goals included reducing greenhouse gas (GHG) emissions, demonstrating new applications of solar energy, and providing educational value for both the industry and the general public.

2.3 Project Outcomes

2.3.1 Solar Energy System Performance

The solar system installation is complete. The system is generating 2,423 megawatt-hours per year (MWh/yr). The installation is providing educational value for accelerating renewable energy deployment in new applications and reaching a broad public audience through its strategic location.

2.3.2 Greenhouse Gas Benefit Analysis

The electricity generated is equivalent to 1,842 MT of CO_2e per year.

2.3.3 Job Creation Analysis

During the design and construction of the project, many jobs were created and retained. For Conergy, there were approximately six people working on the project prior to and during construction. In addition, there were many subcontractors and suppliers involved with the project. Approximately 10 contractors were on-site, with a range of one to eight employees, over approximately 10 weeks of construction.

2.3.4 Project Economic Analysis

In 2012, Conergy's original project budget estimate was slightly in excess of $5.7 million dollars. The project experienced delays in construction because of a complex design process and a lengthy CEQA study and project approval phase. These delays increased some costs but also allowed the project to benefit from reduced solar panel and other equipment costs. After changes in the system design and equipment specifications from the original proposal, the preliminary budget was set in early October 2013 for the constructed system. The final project cost was $4,074,255. There were several partners and funding sources for this project, including DOE through a grant, CEC and SMUD through match and project funding, and Conergy. The CEC provided $125,000 in cost share, while the DOE CRED grant funded a $1,632,800 contribution toward the modules and a portion of the electrical installation. SMUD contributed $224,000 toward one of the project inverters and also provided project cost share and grant administration. Conergy covered $2,092,455 of the remaining costs, which were for racking, installation, a portion of the modules, and the balance of system for the project to be completed.

2.3.4.1 Levelized Cost of Energy

Using the above cost and performance data, the levelized cost of electricity (LCOE) using the revenue requirement approach was calculated for solar PV. The results of different LCOE cases and other assumptions such as taxes and other technical and financing assumptions are shown in Table 2-1.

The LCOE of generating electricity from solar PV depends primarily on capital and operating expenses.

- **Case 1.** This scenario assumes the capital cost = $4,469,662 million, operating expenses = $20/kW-yr (kilowatt-year), with no investment tax credit (ITC), no CO_2 payment, no grants, 60 percent debt ratio, cost of debt = 8 percent, debt term = 20 years, return on equity = 12.5 percent, and economic life = 20 years. The LCOE in this scenario is equal to 21.99 cents/kWh (kilowatt-hour) (nominal $2014).
- **Case 2.** This scenario assumes the capital cost = $4,469,662 million, operating expenses = $20/kW-yr, with no ITC, no CO_2 payment, no grants, 100 percent debt ratio, cost of debt = 8 percent, debt term = 20 years, no return on equity, and economic life = 20 years. The LCOE in this scenario is equal to 15.52 cents/kWh (nominal $2014).
- **Case 3.** This scenario assumes the capital cost = $4,469,662 million, 30 percent ITC, $10/MT CO_2 payment, grants from DOE and CEC = $1,825,328, total equity invested = ($4,469,662-$1,825,328) = $2,644,334, debt ratio = 60 percent, cost of debt = 8 percent, debt term = 20 years, return on equity = 12.5 percent, and economic life = 20 years. The LCOE in this scenario is equal to 5.25 cents/kWh (nominal $2014).
- **Case 4.** This scenario assumes the capital cost = $4,469,662 million, 30 percent ITC, $10/MT CO_2 payment, grants from DOE and CEC = $1,825,328, total equity invested = ($4,469,662-$1,825,328) = 2,644,334, equity = 100 percent, no cost of debt, no debt term, return on equity = 12.5 percent, and economic life = 20 years. The LCOE in this scenario is equal to 9.76 cents/kWh (nominal $2014). This Case 4 mimics the actual case for Conergy.

Table 2-1: Simply Solar LCOE Calculations

Cases	Case 1	Case 2	Case 3	Case 4
Technical Entries				
Total Facility Capital Cost ($)	$ 4,469,662	$ 4,469,662	$ 4,469,662	$ 4,469,662
Grants	$ -	$ -	$ 1,825,328	$ 1,825,328
Electric- base year				
Net Electrical Capacity (kWe)	1.5	1.5	1.5	1.5
Capacity Factor (%)	18	18	18	18
Carbon Offset (tons CO2e)				
Expenses-base year				
O&M ($/kW-yr)	20	20	20	20
Federal Tax Rate (%)	34	34	34	34
State Tax Rate (%)	6.65	6.65	6.65	6.65
Combined Tax Rate (%)	38.389	38.389	38.389	38.389
Investement Tax Credit (% of Total Capital Cost)	0	0	30	30
Income other than Energy				
Carbon Payment ($/tons)	0	0	10	10
Escalation/Inflation				
General Inflation (%/y)	2.8	2.8	2.8	2.8
Escalation-for all parameters (%/y)	2	2	2	2
Financing				
Debt Ratio (%)	60	100	60	0
Equity Ratio (%)	40	0	40	100
Interest Rate on Debt (%/y)	8	8	8	8
Life of loan or debt term (y)	20	20	20	20
Economic Life (y)	20	20	20	20
Return of Equity (%/y)	12.5	0	12.5	12.5
Cost of Money (%/y)	9.8	8	9.8	12.5
Depreciation Schedule	MACRS 5-YR	MACRS 5-YR	MACRS 5-YR	MACRS 5-YR
Current $ LCOE (cents/kWh) 2014	21.99	15.52	5.25	9.76
Constant $ LCOE ($/kWh) 2014	17.65	12.29	4.21	7.99

LCOE is particularly sensitive to capital cost, operating expense, capacity factor, return on equity, debt ratio, and price of carbon, which are illustrated in Figure 2-2. This figure shows the full LCOE as each parameter is varied over the indicative relative range, all other values held constant at their reference or base case values (in this case LCOE = 5.25 cents/kWh [nominal $2014] Case 3). If the debt ratio is 0 percent or 100 percent equity, LCOE = 9.76 cents/kWh (Case 4). As capacity factor increases, LCOE decreases and as price of carbon increases, LCOE decreases.

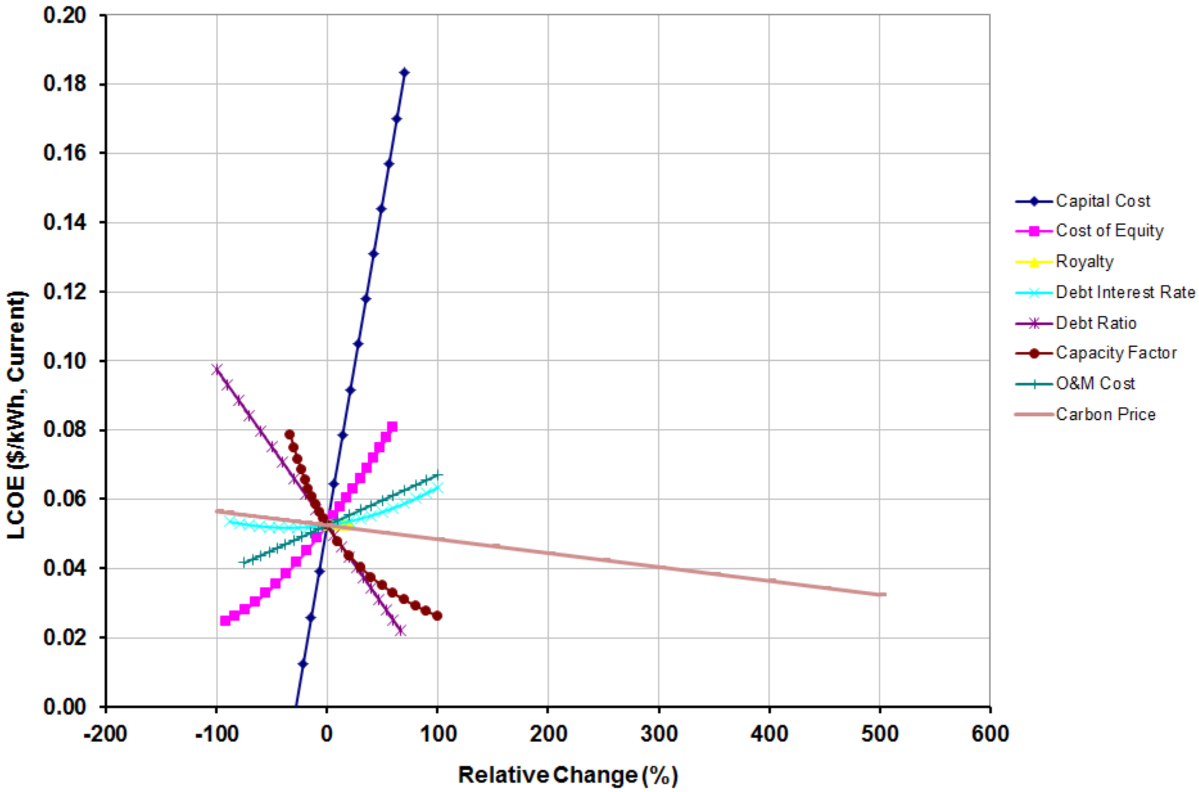

Figure 2-2: Sensitivity of LCOE (2014 Current $/kWh) to Technical and Financial Factors for PV Solar Field at Conergy PV Site

Figure 2-2 is based on the assumptions shown in Table 2-2.

Table 2-2: Input Assumptions for Simply Solar LCOE Calculations (2014 Nominal $)

Capital Cost = $ 4,469,662	Operating Expenses = $20/kW-yr	ITC = 30%
Price of Carbon = $ 10/MT	Debt Ratio = 0%	Grants Total = $1,825,328
Debt Term = 20 years	Cost of Equity = 12.50%/yr	Economic Life = 20 years
MACRS Depreciation = 5 years	General Inflation = 2.80%	Federal Tax Rate = 34%
State Tax Rate = 6.65 %	Net Plant Capacity = 1,500 kW	Capacity Factor = 18%

The significant drivers for economic sustainability of a large PV field deployment include the following:

- Reduction in capital cost.
- Reduction in operations and maintenance (O&M) cost.
- Increased carbon value.

2.4 Conclusions

The Simply Solar project advanced science and technology and overcame the following barriers:

- Achievements:
  - Solar structures were installed in three configurations: a carport shade structure, dog park shade structures, and a ground-mount facility at Sutter's Landing Regional Park in the City of Sacramento.
- Challenges:
  - Installing solar on a closed, pre-regulation landfill.
  - Working through CEQA issues (Swainson's hawk, Hackberry bush), which resulted in project downsizing and redesign.
  - The bankruptcy of a major equipment manufacturer, which eliminated grant funding for one of the inverters and required that a new funding source be found.
  - Contractor financing issues and parent company insolvency proceeding.
  - Tribal monitoring.
  - New city design requirement for explosionproof fittings.
  - Easement conflict with local residential development.
  - Hazardous waste disposal requirement for a portion of excavated soils.
- Lessons learned:
  - Additional project costs should be anticipated for solar PV projects sited on capped landfills, both for foundation design and other types of environmental mitigation.
  - Solar electricity generation can provide GHG emissions reductions and other associated benefits to the community.
  - Project delays are not necessarily always detrimental; in this case, they resulted in lower priced PV modules, as increased manufacturing achieves economies of scale.

In summary, the Simply Solar project successfully installed a PV facility with a 1.5 MW nameplate rating. The system is delivering electricity to SMUD (2,423 kWh/yr) at an LCOE of $97/MWh, and it is achieving 1,842 MT CO_2e per year GHG emissions reductions.

CHAPTER 3: Sacramento Regional County Sanitation District Biogas Enhancement

3.1 Project Description

A new process at the SRCSD wastewater treatment facility co-digests fats, oils, and grease (FOG) and food processing waste (FPW), such as off-specification soda pop, with sewage to generate biogas. During 2009, SRCSD and SMUD conducted a biogas enhancement pilot test to evaluate the feasibility of using FOG and FPW. This study confirmed that FOG and FPW used in the anaerobic digesters improved overall biogas production and would provide more electricity from the green energy source. Design and construction of the new biogas enhancement project (BEP) was completed in 2012, and the facility is currently operational. This project is projected to provide enough renewable energy to power between 1,000 and 3,000 homes, as well as eliminating GHG emissions and saving money for local businesses. These businesses might otherwise have paid a higher tipping fee to dispose of this waste, in a less GHG-efficient manner.

3.1.1 FOG Receiving System

The project consisted of designing and building a FOG receiving station sized to receive 42,000 gallons per day (gpd) of material. An aerial view of the facility can be seen on Figure 3-1.

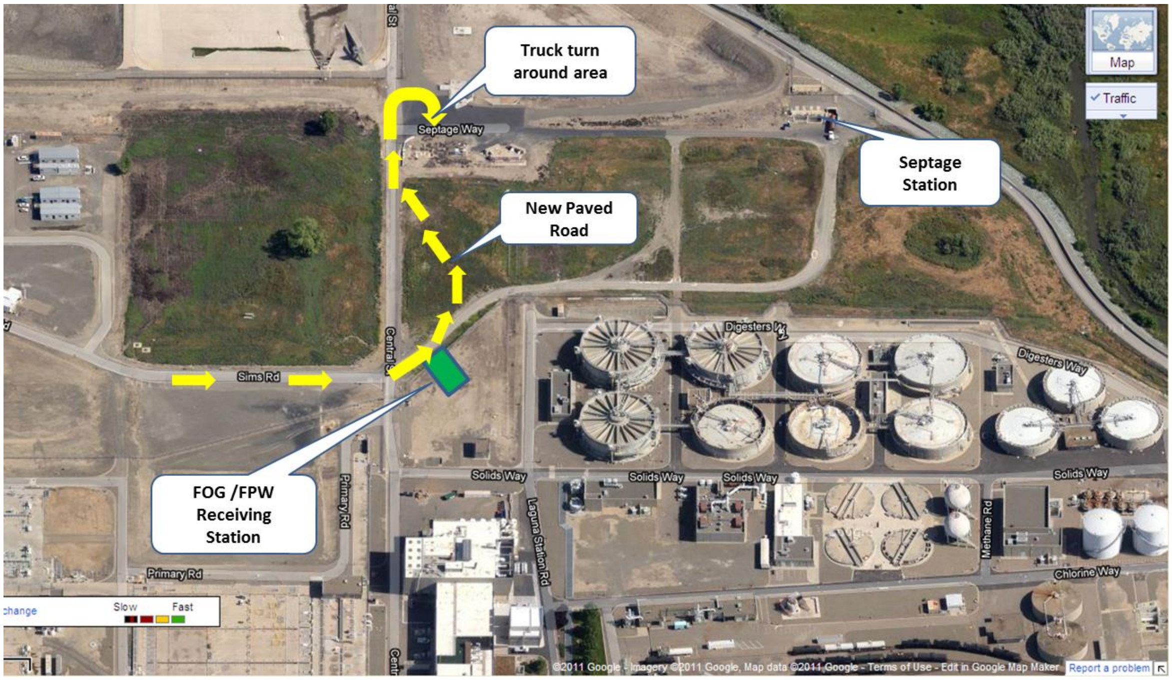

Figure 3-1: New Biogas Enhancement Project (BEP) Overview at Sacramento Regional County Sanitation District

The BEP is located at the Sacramento Regional Wastewater Treatment Plant (SRWTP). The BEP was designed to handle up to 42,000 gpd of feedstock material that includes FOG and FPW, such as soda pop waste. The estimated 42,000 gpd includes 30,000 gpd of FOG and 12,000 gpd of FPW materials. The BEP facility allows these materials to bypass the primary and secondary treatment processes at the SRWTP. The material is injected into the anaerobic digester to enhance the generation of biogas, which SMUD uses to produce renewable energy at the adjacent Carson Energy Cogeneration Plant.

The FOG receiving facility consists of two storage tanks, two off-loading stations, pumps, odor control, strainers, rock traps, grinders, flowmeters, and valves, along with two heated pipes from the offloading facility to the digesters. When the facility is not receiving FOG, the mixing mode is in effect, and FOG material is continuously mixed and chopped by the pumps and grinders. Each FOG tank has a variable frequency drive (VFD) pump that can vary the feed rate to the process downstream of the mixed sludge tanks.

A general layout is provided on Figure 3-2.

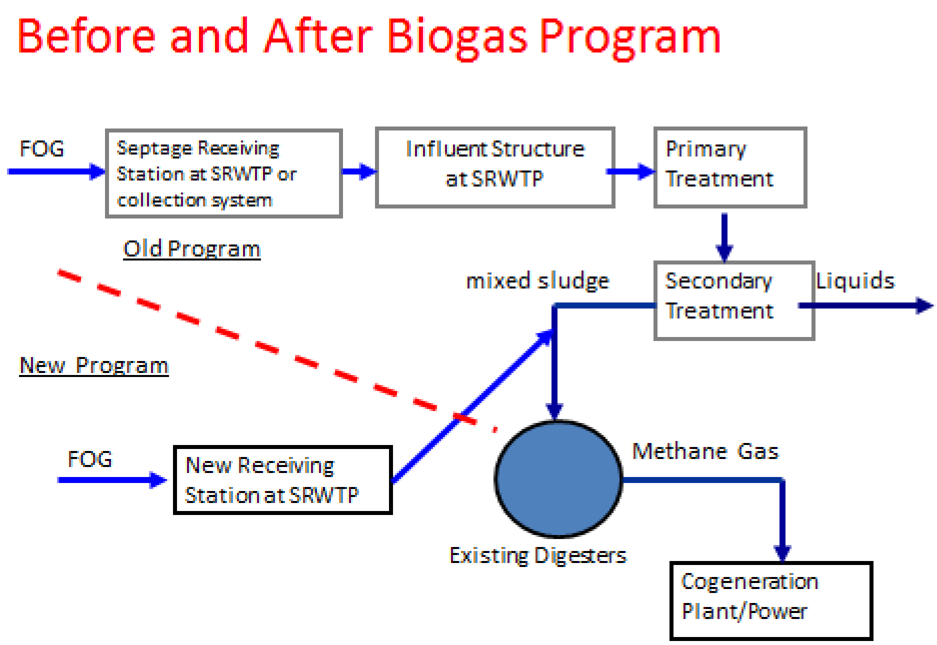

Figure 3-2: Layout of the SRCSD Biogas Enhancement Project

3.1.2 Project Partners and Timeline

Project partners included SRWTP, Carollo Engineers, Western Water Constructors (WWC), Kleinfelder Engineering, and Swabe.

The project timeline is summarized as follows:

- May 25, 2011: Design phase commenced.
- January 11, 2012: Project awarded to WWC.
- January 23, 2012: Construction phase commenced.
- December 31, 2012: Substantial completion achieved.
- January 31, 2013: Activation work commenced.
- June 12, 2013: Final project acceptance at SRCSD board meeting.
- July 2013: Initial operational phase (FOG only). Daily discharge averaging 4,500 gpd, resulting in 9 percent increase in biogas production.

3.2 Project Implementation and Testing Goals

The goal was shaped by the following feasibility studies that had been completed previously:

- SRWTP Biogas Enhancement Feasibility Study Phase I (January 2006).
- Phase II Technical Feasibility (May 2007).
- Phase III Economic Feasibility (August 2007).
- Pilot Study (January 2008–December 2009).
- FOG Receiving Facility Request for Proposal (RFP) (March 2011).

These prior studies had established that the BEP could leverage existing infrastructure at the SRWTP to provide a solution for problem waste streams such as FOG, while also providing new revenue streams for SRCSD, utilizing excess SRWTP plant capacity, reducing cost and emissions of FOG waste disposal, and providing renewable fuel to the adjacent Carson Energy Cogeneration Plant. In return, the Carson plant provides steam to the SRWTP to meet its heating needs. Beyond improving plant operations, the feasibility studies also indicated that the project could contribute to SMUD's renewable energy goals.

3.3 Project Outcomes

3.3.1 FOG Receiving System Performance

The SRCSD BEP was designed to handle up to 42,000 gpd of feedstock material that includes FOG and liquid FPWs, such as soda pop waste. The BEP began operational testing in January 2013 and became functional in June 2013. The system can reduce GHG emissions and can provide efficiency and operational benefits to the wastewater plant operators; however, SRCSD has experienced significant operational issues since the system was commissioned. In the first few months, FOG deliveries were limited to about 1,500 gpd to allow SRCSD an opportunity to gain operational experience, avoid digester upsets, resolve operational issues, and ensure system stability before gradually increasing feedstock deliveries.

The BEP operated from May 2013 to May 2014 using only the FOG feedstock. The BEP experienced valve and pump failures in May 2014 and has been out of service since that time. Upon inspection, it was determined that the internal linings of valves and pumps failed because of swelling and delaminating of the rubber sealing surfaces. SRCSD directed its design consultant to evaluate causes of failure and propose corrective measures. The evaluation included extensive research of similar facilities and visiting multiple BEPs in California and throughout the US to determine if other BEPs had experienced similar issues. O&M, as well as the characteristics of the FOG material, was highly variable, which presented challenges in developing suitable corrective measures.

SRCSD staff has identified a preferred alternative to resolve the operational issues and is preparing to make significant modifications and improvements to the BEP. Corrective actions are expected to take 6 months and will include a competitive bidding process and lead time for equipment, construction, and commissioning. Details of the operational problems and research into solutions are attached as Appendix B3.

Figure 3-3 shows an example of low-pressure sludge gas (LSG) flow, on a high feed day in July. It can be seen that total LSG production (in standard cubic feet per minute [scfm]) was higher than expected for this day. During the initial operational period, there was a general trend toward more biogas than expected during FOG feeding. FOG deliveries were, however, below peak design delivery rates during this period. Until more regular and substantial FOG and FPW feeds are received, it will likely be difficult to measure and confirm the ultimate increase in biogas production attributable to the BEP, as distinct from other contributing factors.

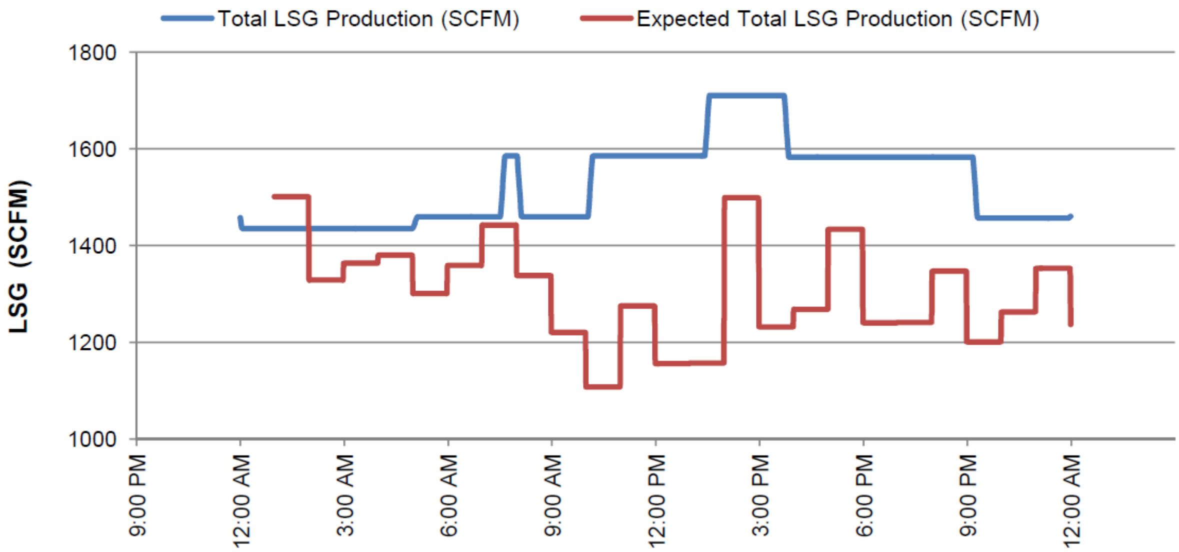

Figure 3-3: Low-Pressure Sludge Gas on High-Feed July Day at SRCSD Facility

The methane and energy content of the LSG was found to be stable.

SRCSD will continue to monitor its measuring methods and monitor the biogas production to better determine the amount of additional biogas that is being produced by the BEP. The production of biogas will increase as operational issues are resolved and system stability is ensured.

Pending implementation of proposed design changes, the project can contribute renewable energy toward SMUD's RPS goals and provide educational value for accelerating renewable energy deployment in new applications.

3.3.2 Greenhouse Gas Benefit Analysis

The electricity generated will be equivalent to 10,616 MT CO_2e per year.

3.3.3 Job Creation Analysis

During the design and construction of the project, many jobs were created and retained. Job creation includes employees of the SRWTP, Carollo Engineers, WWC, Kleinfelder Engineering, and Swabe.

3.3.4 Project Economic Analysis

The budget for this project was $3,520,000. The following funding was provided: $100,000 from CEC, plus $1,455,800 from DOE, for a total of $1,555,800.

3.3.4.1 Construction Costs

Budgeted construction costs were $2,263,897. The full amount was expended as of May 23, 2014.

3.3.4.2 Operational Costs

Typical operational costs for such a plant are about $60,000/yr.

3.3.4.3 Revenues

Revenue streams come from both tipping fees and avoided electricity.

With assumed average electricity cost of about $100/MWh, and annual electricity production of about 13,747 MWh, this gives electricity cost savings of $1,374,700.

Tipping fees may be an additional source of revenue, which have not been incorporated into this analysis, in order to give a conversative estimate of net benefits.

3.3.4.4 Levelized Cost of Energy

At assumed full scale operation of SRCSD FOG receiving station and using the above cost and performance data, the levelized cost of electricity (LCOE) was calculated. The results of different LCOE cases and other assumptions such as Net Electrical Capacity and other technical and financing assumptions are shown in Table 3-1 below.

The LCOE of generating electricity from anaerobic digestion of dairy wastes depends mainly on capital and operating expenses

Case 1 Using the capital cost = $ 3,194,500, Net Electrical Capacity = 3 MW, no grants, no taxes, 100 % debt ratio, economic life = 20 years, cost of debt = 5%, debt term = 10 years. The LCOE in this scenario is equal to 5.47 cents/kWh (nominal 2014).

Case 2 Using the capital cost = $ 3,194,500, Net Electrical Capacity = 1 MW, no grants, no taxes, 100 % debt ratio, economic life = 20 years, cost of debt = 5 %, debt term = 10 years. The LCOE in this scenario is equal to 16.42 cents/kWh (nominal 2014).

Case 3 With grants from DOE and CEC = $1,555,800, the capital cost is about $$1,638,700, Net Electrical Capacity = 1 MW, no taxes, no debt since the rest will be covered by SRCSD, Equity ratio = 100 %, economic life = 20 years. The LCOE in this scenario is 4.95cents/kWh (nominal 2014).

Case 4 With grants from DOE and CEC = $1,555,800, the capital cost is about $1,638,700, Net Electrical Capacity = 1 MW, no taxes, no debt since the rest will be covered by SRCSD Equity ratio = 100 %, economic life = 20 years. The LCOE in this scenario is 14.84 cents/kWh (nominal 2014).

Table 3-1. LCOE Cases for SRCSD

SRCSD				
Case:	Case 1	Case 2	Case 3	Case 4
Technical Entries			With grants = $1,555,800	With grants = $1,555,800
Total Facility Capital Cost ($)	$3,194,500	$3,194,500	$1,638,700	$1,638,700
Electrical and Biogas Fuel--base year				
Gross Electrical Capacity (kWe)	3,300	3,300	3,300	3,300
Net Electrical Capacity (kWe)	3,000	1,000	3,000	1,000
Capacity Factor (%)	95	95	95	95
Net Efficiency--Biogas to Electricity (%)	50	50	50	50
Methane Concentration in Biogas (% by volume)	60	60	60	60
Heat--base year				
Total heat production rate (kwth)	2,700	2,700	2,700	2,700
Aggregated fraction of heat recovered (%)	50	50	50	50
Recovered heat (kWth)	1,350	1,350	1,350	1,350
Overall CHP Efficiency--Gross (%)	77.5	77.5	77.5	77.5
Overall CHP Efficiency--Net(%)	72.5	72.5	72.5	72.5
Taxes				
Federal Tax Rate (%)	0	0	0	0
State Tax Rate (%)	0	0	0	0
Combined Tax Rate (%)	0	0	0	0
Escalation/Inflation				
General Inflation (%/y)	2.80	2.80	2.80	2.80
Escalation-- for all parameters (%/y)	2.80	2.80	2.80	2.80
Financing				
Debt Ratio (%)	100	100	0	0
Equity Ratio (%)	0	0	100	100
Interest Rate on Debt (%/y)	5	5	5	5
Life of loan or debt term (y)	10	10	10	10
Economic Life (y)	20	20	20	20
Cost of Equity (%/y)	5	5	5	5
Cost of Money (%/y)	5	5	5	5
Depreciation Schedule	MACRS 5-yr	MACRS 5-yr	MACRS 5-yr	MACRS 5-yr
Current $ LCOE ($/kWh) 2014	0.05472	0.16416	0.04945	0.14836
Constant $ LCOE ($/kWh) 2014	0.04227	0.12681	0.03820	0.11460

LCOE is particularly sensitive to capital cost, operating expense, capacity factor and net plant capacity. If the debt ratio is 0 percent or 100 percent equity, with at net plant capacity of 3,000 kW, LCOE = 4.94 cents/kWh [nominal $ 2014] Case 3).

The critical factors for economic sustainability of co-digestion facility at SRCSD includes:

- Reduction in capital cost.
- Reduction in operation and maintenance (O&M) cost.
- Plant Capacity

- Tipping Fees

3.4 Conclusions

The SRCSD BEP advanced science and technology and overcame the following barriers as follows:

- Achievements:
  - Completed 5 month design within budget.
  - Provided satisfactory connection point at which to feed FOG.
  - Used proactive approach to minimize change orders.
  - Met "Buy American" requirements.
  - Leveraged existing infrastructure at the SRWTP to provide an environmentally friendly disposal solution for problem waste streams such as FOG.
  - Utilized excess SRWTP plant capacity.
  - Reduced cost and emissions of FOG waste disposal.
  - Provided renewable fuel to the adjacent Carson Energy Cogeneration Plant.
- Challenges:
  - Tight schedule, expedited design.
  - Unclear specification of liquidated damages.
  - Short operational testing period (96 hours).
  - Significant effort of reporting for grant funding.
  - Late identification of pump component design flaw led to system outages.
- Lessons Learned:
  - Enforce accountability.
  - Work closely with responsible engineer for timely resolution of issues.

In summary, the SRCSD BEP successfully installed a FOG receiving facility capable of receiving 42,000 gpd. The system is capable of delivering up to 13,747 MWh/yr of electricity to SMUD, and achieving 10,616 MT CO_2e per year GHG emissions reductions.

CHAPTER 4:
New Hope Dairy Digester

A team led by California Bioenergy LLC (CalBio), through its special purpose company ABEC New Hope LLC, developed and demonstrated an anaerobic digester and engine-generator system at a 1,200 milk cow dairy farm, New Hope Dairy LLC, located west of Galt in the southern part of Sacramento County.

4.1 Project Description

New Hope uses a manure collection system to scrape manure from most stalls and deliver it to the complete stirred tank reactor (CSTR) digester that operates at mesophilic temperatures. The collected manure, along with some dilution water, is retained in the tank digester for 30 to 40 days. As the manure decomposes, biogas is produced and accumulates in the tank. The gas is then collected, cleaned, and sent to a 450 kW engine-generator.

4.1.1 Manure Collection System

New Hope Dairy installed a new automatic manure scraping system to collect manure from most of the stalls and deliver it to the anaerobic digesters. This system continuously scrapes the fresh manure from three free-stall barns into two slurry collection tanks with influent pumps.

4.1.2 Digester System

The tank digester (Figure 4-1) is a reinforced concrete structure 85 feet in diameter and 26 feet deep. This digester is heated using the water jacket and exhaust heat from a 2G CENERGY engine-generator.

In order to collect the produced biogas, the tank is equipped with a flexible double membrane roof. The outer cover is a protective cover that is held up through air inflation. The inner membrane can move freely between the top of the tank and the outer membrane, allowing for gas storage capacity. The effluent from the digester is pumped to a storage pond for solids separation and is afterward used for crop irrigation as a liquid fertilizer.

Figure 4-1: New Hope Tank Digester

4.1.3 Engine-Generator System

As shown on Figure 4-2, the engine-generator, made by 2G CENERGY using a MAN core engine, is a CHP package with a rated capacity of 450 kW; it utilizes a selective catalytic reduction (SCR) emissions control system.

Figure 4-2: New Hope 450 kW Engine-Generator

4.1.4 Project Partners and Timeline

CalBio, through its special purpose company ABEC New Hope LLC, is the developer of the New Hope Dairy Digester. MT-Energie, through its special purpose company RECM, LLC, completed the design in 2011; construction started in December 2012 and was completed in the first quarter of 2013. Commissioning was completed in the second and third quarters of 2013.

4.2 Project Implementation and Testing Goals

The main goal of this task was to implement the installation of an anaerobic digestion system at New Hope Dairy in Galt, California, which has over 1,200 dairy cows. The design strategy for the New Hope Dairy Digester included selecting an engine based on its suitability for biogas, its efficiency, and its emissions capabilities. The engine size was chosen to fit with the digester output to optimize power generation during peak hours.

4.3 Project Outcomes

4.3.1 CHP Engine Testing

The CHP engine-generator was subjected to yearlong continuous testing of its electrical output according to the biogas energy input as well as the thermal heat output and overall efficiency. The testing utilized the data collection system included as part of the engine-generator installation, which continuously collects the important engine and generator data, and results of influent and effluent lab analyses at several sampling times.

The overall efficiency of the CHP engine-generator is 67 percent, including both the electrical production and utilized thermal energy for digester heating. The available manure generates gas of consistent methane composition (55 percent average) and generates sufficient gas to produce 1,774,000 kWh/yr. The net load exported by the project is 1,570,926 kWh/yr, approximately 90 percent of the generated energy. These production levels are achieved at a 45 percent capacity factor; the generator operates twice per day as needed to burn the accumulated biogas, and the programming optimizes generation to occur as much as possible during hours when the SMUD rates are on-peak.

4.3.2 Greenhouse Gas Benefit Analysis

Actual and projected GHG benefits related to the system's ability to capture and combust methane emissions from the dairy manure were calculated using the Climate Action Reserve protocols. The estimated GHG credits for the actual 12 month period of operation considered were 2,697 MT of CO_2e per year.

4.3.3 Emissions Exhaust Analysis

Exhaust emissions from the engine-generator were tested in June 2013 while it was operating at 73 percent to 100 percent load, and the measured levels were compared to the allowable limits for the various pollutants. Air Science Technologies, Inc., conducted the testing, and the results are shown in Table 4-1.

Table 4-1: New Hope Generator Exhaust Emissions Testing Results

Pollutant	Emissions Limit	Results	Corrected to 15% O_2
CO (ppmvd)	329.6*	24.6**	8.1
NO_x (ppmvd)	24.1*	11.2**	3.7
VOC (ppmvd)	79.1*	13.0**	4.3
NH_3 (ppmvd)	10*	0.06**	0.020
PM (lb/day)	9.6	0.08	0.026
H_2S (ppmvd, fuel)	350	0.06	0.020

* at 15 percent O_2.
** at 3 percent O_2.

Notes:
CO = carbon monoxide
NO_x = oxides of nitrogen
VOC = volatile organic compound
NH_3 = ammonia
PM = particulate matter
H_2S = hydrogen sulfide
ppmvd = parts per million volumetric dry
lb/day = pounds per day

4.3.4 Job Creation Analysis and Impact to Local Economy

Job creation during construction and actual operation of the digester was determined. The calculation was based on the number of hours worked divided by 2,040 hours/year (full-time employee status). During construction, 6.1 full-time equivalent (FTE) jobs were created, and 0.86 FTE jobs were created for ongoing operations. Almost $230,000 was added to the local economy in terms of direct wages and additional indirect benefits of materials purchased.

4.3.5 Project Economic Analysis

Project financial and performance information were used as inputs to perform cash flow economic calculations and levelized cost analysis for the project.

4.3.5.1 Capital Costs

Capital costs to construct and commission the project amounted to $3.9 million. This figure includes design, procurement, and construction of the system; permitting; grid interconnection agreement; power and CO_2 purchasing agreement; financing costs; construction loan; commissioning; monitoring; developer fees; and other direct project costs. The total is exclusive of one-time costs related to training subcontractors on the use and deployment of the concrete slip-forming technology used to pour the CSTR tank digester.

DOE ($125,000), CEC ($250,000), and United States Department of Agriculture/Environmental Quality Incentives Program (USDA/EQIP) ($250,000) grants provided $1.177 million of the total cost. After achieving commercial operation, the project was successful in receiving an American Recovery and Reinvestment Act (ARRA) Treasury 1603 Grant in the amount of $1.24 million. The balance of the project cost was provided by CalBio and MT-Energie USA, Inc., as project equity and from a secured bank loan in the amount of approximately $400,000.

4.3.5.2 Operational Costs

As shown in Table 4-2, total fixed costs were determined to be $121,954, which included state property taxes, property insurance, administrative expenses, and a portion of the digester O&M expenses. The variable operating costs were determined to be $107,303, which included farmer feedstock and lease and O&M expenses related to the generator and digester. Based on an annual estimated energy production of 1,774 MWh, the annual operational cost is $0.1292 per kWh. The levered annual operational cost is $0.1247 per kWh.

Table 4-2: New Hope Operational Cost Estimate

Parameter	Value
Annual Total Fixed Costs ($)	121,954
Annual Variable Operating Costs ($)	107, 303
Annual Estimated Production (MWh)	1,774
Annual Operational Cost ($/kWh)	0.1292
Annual Interest Expense ($)	31,982
Levered Annual Operational Cost ($/kWh)	0.1247

4.3.5.3 Revenues

Based on the net energy production of 1,570,925 kWh/yr, and the average distribution of production by rate period (off-peak: 18.7 percent, on-peak: 40.4 percent, and super-peak: 40.9 percent), the annual average project revenue is expected to be $0.1414 per kWh, generating $222,116.38 per year in electricity sales.

4.3.5.4 Levelized Cost of Energy

The LCOE was calculated using the model developed by Black & Veatch[1] and often referenced by the CEC. The LCOE was calculated for the following four cases:

- **Case 1 (current economics).** Manure only, low capacity factor was assumed. This case assumes there is no 30 percent ITC, i.e., the ITC remains unavailable for biogas projects. Under this scenario, the LCOE = 41.2 cents per kWh (nominal 2014$).
- **Case 2 (economics of manure plus co-digestion).** Co-digestion of a farm friendly substrate that generates additional biogas sufficient to fully utilize the plant at a 95 percent capacity factor was assumed. This case assumes that the substrate generates a $10 per wet ton tipping fee, is 25 percent dry matter, and generates gas at 9,500 standard cubic feet (scf) of methane (CH_4) per dry matter ton. Similar to Case 1, it was assumed that the 30 percent ITC remains unavailable for biogas projects. The LCOE = 21.1 cents per kWh (nominal 2014$).
- **Case 3.** Same as Case 2, but it was assumed that the federal government adopts the Energy Policy Extension Act, or equivalent, and that the 30 percent ITC is reinstated for biogas projects to give them treatment similar to that of solar projects. The LCOE = 14.0 cents per kWh (nominal 2014$).
- **Case 4.** Same as Case 3, but it was assumed that the New Hope farmers would be willing to sell the fiber solids output of 112 tons per day x 8 percent dry matter or screw-pressed to 30,000 pounds per day at 70 percent dry matter. It was assumed that the project could net, after processing and drying costs, $10 per ton dry matter or $32,589 per year, approximately $90 per day. With this additional revenue, the LCOE = 12.8 cents per kWh (nominal 2014$).

Assuming higher prices of carbon offsets (in the regulatory and voluntary markets) lower O&M costs per kWh, and lower capital cost per MW, LCOEs around 10 cents per kWh or lower are possible. Possible higher market value of carbon offsets is likely the most viable economic factor to help in deployment of biomass-to-energy projects.

4.4 Conclusions

The overall project objective of implementing an anaerobic digestion system at New Hope Dairy was successfully achieved. Performance and financial conclusions of the first year of operation are summarized as follows:

- The CHP engine-generator operates with an overall (electrical and thermal) efficiency of 67 percent.

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[1] http://www.cpuc.ca.gov/NR/rdonlyres/69848D0B-9EA3-466B-8B8F-CE1E0EEF1894/0/PublicDRAFTLCOEModelCPUCSB1122.xlsx.

- The project currently operates at a capacity factor of 45 percent. The project exports a net energy production of 1,570,925 kWh to the grid (90 percent of the generated kWh) annually. Both can be increased by extending the operational period of the generator.
- During construction, 6.1 FTE jobs were created, and 0.86 FTE jobs were created for ongoing operations. Most of the job creation was realized during the construction phase. Almost $230,000 was added to the local economy.
- The generator emissions were lower than the allowable limits in all measured categories, demonstrating the effectiveness of the engine's SCR emissions control system installed in meeting stringent air emissions standards in California.
- The estimated GHG credits for the actual 12 month period of operation considered were 2,697 metric tons of CO_2e for the year.
- The project generates an estimated $222,116 in annual electricity sales.
- Using current project economics generates an LCOE of $0.412 per kWh, which could decrease to as little as $0.128 per kWh, assuming higher capacity factor, adoption of the Energy Policy Extension Act and extension of the 30 percent ITC, and sales of fiber solids and dry matter.

In addition to producing renewable energy, the facility also reduces significant GHG emissions by destroying methane. GHG benefits from the project are generated by the avoided methane emissions component. This benefit is unique to digester projects versus other renewables such as solar or wind.

Project revenues were maximized by optimizing generator production with SMUD peak rate periods. This is a critical strategy for the financial viability of the project. Of additional importance is the ability for biogas to regain tax parity with solar on the ITC. This has a significant impact on the LCOE. The performance of the system during the 12 month period of this review indicates that by optimizing the operations strategy, the New Hope Dairy Digester can produce high value, predictable, and reliable electricity at a competitive price.

CHAPTER 5:
Van Warmerdam Dairy Digester

The Van Warmerdam Dairy Digester is a covered lagoon anaerobic digester, which was installed on a 1,000 cow dairy farm near Galt, California, in 2012 to 2013. The project is privately developed, owned, and operated by Maas Energy Works, Inc., (MEW) with significant financial and development support from SMUD, which also purchases the power generated by the facility.

5.1 Project Description

The facility operates solely on manure collected from the Van Warmerdam Dairy. Biogas from the covered lagoon anaerobic digester is routed to a containerized internal combustion engine capable of generating 600 kW of electricity for delivery back onto the SMUD distribution grid.

5.1.1 Digester System

The digester is an earthen pond approximately 525 feet by 125 feet, with a total operational fluid volume of about 8,000,000 gallons. The pond is covered with a 80/1,000 inch high density polyethylene (HDPE) membrane to contain the biogas. The cover is designed to allow directional flow through the digester to ensure retention time; mixers in the digester improve biogas production. The digester operates at ambient temperatures and is supplemented by engine waste heat. The digester’s flexible cover enables biogas storage, allowing the engine to run during peak power periods when prices paid for electricity are highest and store gas when prices are lower. The effluent from the digester is used as a liquid fertilizer for crop irrigation. The biogas is conveyed underground to the engine-generator system.

A schematic of the engine-generator set depicting the filtration system, engine, generator, and heat recovery system is shown on Figure 5-1.

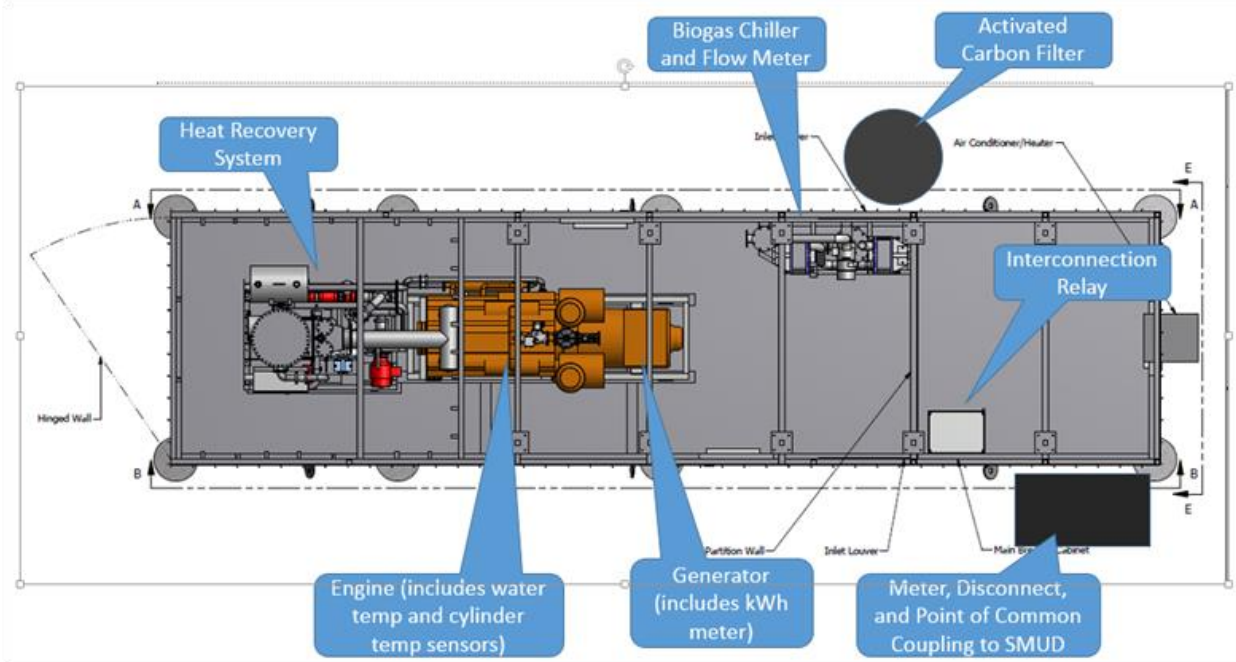

Figure 5-1: Van Warmerdarm Engine-Generator Set Schematic

5.1.2 Engine-Generator System

The project's power plant is a 600 kW engine-generator made by Martin Machinery. The engine is a Guascor SFGLD 560, 1,800 revolutions per minute (rpm), 12 cylinder internal combustion engine rated at over 900 horsepower and operating on biogas fuel from the co-located covered lagoon anaerobic manure digester. The engine is mated to a Stamford HCI 534F 600 kW synchronous generator, generating at 480 volts, which is connected to SMUD's distribution feeder via a 750 kilovolt-ampere interconnection transformer.

5.1.3 Heat Recovery System

The generator recovers heat from three sources. The engine block's jacket water is pumped out via the engine water pump. Additionally, the exhaust from the engine is routed through a series of parallel pipes where a heat exchanger extracts energy from the exhaust in the form of more hot water. Finally, the engine's intercooler loop coolant is pumped out to catch more hot water. Together, these three sources allow the system to recover hot water for a total well in excess of 40 percent of the engine's energy input. After collection, the hot water is transferred to a pipe-in-pipe heat exchanger where the heat is transferred to manure pumped from the covered lagoon. With its large volume, the lagoon can supply essentially unlimited cooling potential to the engine. The heated manure in the heat exchanger is then dumped back into the lagoon to increase the overall lagoon temperature and improve biogas production.

5.1.4 Project Partners and Timeline

The project owner is MEW. Martin Machinery supplied the engine-generator set and ancillary equipment. Environmental Fabrics, Inc., supplied and installed the lagoon cover. MEW coordinated a small number of local contractors and suppliers for additional services.

An earlier version of this project was previously attempted by a different developer whose contract with SMUD was terminated. For that reason, the project plan included an additional objective of rapid, reliable execution in order meet the summer 2013 sunset date for grant funds awarded to this effort. The grant agreement between MEW and SMUD was signed in December 2011, and permitting applications commenced in 2012. Construction began in January 2013, and the SMUD-approved commercial operations date was May 28, 2013. The total time from initial concept to commercial operations was 17.7 months.

5.2 Project Implementation and Testing Goals

The main goal of this task was to implement the installation of an advanced anaerobic digester system (AADS) at the Van Warmerdam Dairy. The effort will offset the use of grid energy the dairy requires and provide energy benefits and revenues through SMUD's FIT. This dairy farm has 1,100 lactating dairy cows and is located in Elk Gove, California.

The procedure used was a design-build-operate model headed by MEW. MEW designed the project using reliable technologies common to the digester industry, including a lean burn piston engine and covered lagoon digester. This approach promised the most amount of energy and economic benefit for the smallest capital investment in the shortest possible time with the highest degree of reliability. The overall approach to the project involved a simplified management structure at MEW, with only two main fixed-price, design-build contracts.

5.3 Project Outcomes

5.3.1 CHP Engine Performance

SMUD's monthly statements of power generation were used to create a record of net power delivered by the project. This information was broken down into off-peak, on-peak, and super-peak portions. MEW used its own ComAp InteliMonitor metering equipment to audit the SMUD monthly statements. Electrical consumption was calculated by subtracting the net power metered by SMUD from the gross power generation logged on the ComAp InteliMonitor; the difference was assumed to be site load.

The overall gross efficiency of the CHP engine-generator is 70.5 percent, including both the electrical production and utilized thermal energy for digester heating. The available manure generated gas of consistent methane composition (58.2 percent average) and 1,691,774 kWh during the first complete 12 months of operation. The net load exported by the project was approximately 1,612,294 kWh/yr, over 95 percent of the generated energy. These production levels are achieved at a 36 percent capacity factor. The generator is frequently started up/shut down to optimize generation to occur as much as possible during hours when the SMUD rates are on-peak.

5.3.2 Greenhouse Gas Benefit Analysis

GHG benefits were calculated using the Climate Action Reserve Livestock Protocol Tool Version 3.0 for avoided methane emissions. The estimated total annual GHG reduction was 7,839 metric tons of CO_2e.

5.3.3 Emissions Exhaust Analysis

Exhaust emissions from the engine-generator were tested on August 22, 2013, while it was operating at full load, and the measured levels were compared to the allowable limits for the various pollutants. MEW contracted a licensed third-party emissions tester to check for air permit compliance. The results of the testing are shown in Table 5-1.

Table 5-1: Van Warmerdam Exhaust Emissions Testing Results

Pollutant	Emissions Limit	Results
CO (ppmvd at 15% O_2)	236.2	34.5
NO_x (ppmvd at 15% O_2)	12	8.8
VOC (ppmvd at 15% O_2)	45.9	11.2
NH_3 (ppmvd at 15% O_2)	10	6.8

5.3.4 Job Creation Analysis

Project financial records were used to estimate total spending on manufactured equipment during construction and also to calculate hours of labor billed by MEW and other contractors. Estimates of operational purchases and labor were generated on the basis of expected O&M schedules. During construction, 8.2 FTE jobs were created, and 1.3 FTE jobs were created for ongoing operations.

5.3.5 Project Economic Analysis

Project financial and performance information were used as inputs to perform cash flow economic calculations and levelized cost analyses for the project.

5.3.5.1 Construction Costs

The initial budget for the project was set at $1,700,000. This amount does not include certain development, insurance, rent, and financing costs that were not eligible for inclusion in the SMUD project cost basis. The project was awarded a total of $880,852 in funding from SMUD, including $125,000 from the CEC and $755,852 from the DOE. In addition to these funds, the project secured a $900,000 construction loan from New Resource Bank. The project working capital and other funds were supplied out of company cash.

The total construction-related costs for this project amounted to $1,470,988, which includes lease agreement, interconnection and permitting, engineering, procurement, construction, grid connection, commissioning, labor, subcontractors, and other direct expenses. Inclusion of the non-SMUD-eligible costs brings the total project cost to slightly over $1,600,000, which is less than the initially budgeted amount.

5.3.5.2 Operational Costs

MEW staff tracked operational costs by summing the labor, rents, taxes, insurance, consumables, and other costs incurred during operations. In many cases, these costs had to be estimated since the project has not operated long enough to establish clear, steady-state operational cost trends. The annual operating costs totaled $166,974. Dividing by an estimated annual average production value of 1,800 MWh results in an annual operational cost per kWh of $0.0927. Costs are shown in Table 5-2.

Table 5-2: Van Warmerdam Operational Cost Estimate

Parameter	Value
Annual Total Operating Cost ($)	166,794
Annual Estimated Production (MWh)	1,800
Annual Operational Cost ($/kWh)	**0.0927**

5.3.5.3 Revenues

The project's electrical production revenue was estimated using historical production rates and estimated winter temperature impacts. For this calculation, total estimated power was set to 1,800 MWh. Revenues from electricity were calculated at the estimated levelized Power Purchase Agreement (PPA) price of $146.45/MWh on the basis of estimated seasonal and time of day power generation. The carbon revenue was estimated on the basis of a predicted market price of $9 per MT CO_2e. Total annual revenues were calculated as $317,610.

Without access to peak pricing, the effective PPA price received by the project would be significantly lower, and the project would not be economically feasible as designed.

5.3.5.4 Levelized Cost of Energy

Using the above cost and performance data, the LCOE using the revenue requirement approach was calculated for the Van Warmerdam Dairy Digester. The results of five different LCOE cases and other assumptions such as taxes and other technical and financing assumptions shown in Table 5-3 are described as follows:

- **Case 1.** This scenario assumes the capital cost = $1.8 million, operating expenses = $166,794, with no ITC, no CO_2 payment, no grants, 50 percent debt ratio, cost of debt = 6 percent, debt term = 10 years, return on equity = 15 percent, and economic life = 20 years. The LCOE in this scenario is equal to 25.59 cents/kWh (nominal $2014).
- **Case 2.** This scenario assumes the capital cost = $1.8 million, operating expenses = $166,794, with 30 percent ITC, with $9/MT CO_2 payment, no grants, 50 percent debt ratio, cost of debt = 6 percent, debt term = 10 years, return on equity = 15 percent, economic life = 20 years. The LCOE is equal to 19.28 cents/kWh (nominal $2014).
- **Case 3.** This scenario assumes 30 percent ITC, with $9/MT CO_2 payment, grants from DOE and CEC = $880,852, 50 percent debt ratio, cost of debt = 6 percent, debt term = 10 years, return on equity = 15 percent, economic life = 20 years. The LCOE is equal to 9.29 cents/kWh (nominal $2014).

- **Case 4.** This scenario mimics the real case for MEW with 30 percent ITC, \$9/MT CO_2 payment, grants from DOE and CEC = \$880,852, capital cost of \$919,148 (or about \$900,000), 94 percent debt ratio, cost of debt = 6 percent, debt term = 10 years, 6 percent equity contribution, return on equity = 15 percent, economic life = 20 years. The LCOE is equal to 7.85 cents/kWh (nominal \$2014). The levelized PPA price is equal to \$14.645, which is significantly higher than the LCOE in this scenario.
- **Case 5.** This scenario assumes 30 percent ITC, \$9/MT CO_2 payment, grants from DOE and CEC = \$880,852, 100 percent debt ratio, cost of debt = 6 percent, debt term = 10 years, return on equity = 15 percent, economic life = 20 years. The LCOE is equal to 7.67 cents/kWh (nominal \$2014).

Table 5-3: LCOE cases for Warmerdam Dairy Digester

Warmerdam Dairy Digester					
Case:	Case 1	Case 2	Case 3	Case 4	Case 5
Technical Entries			With grants = $880,852	With grants = $880,852	With grants = $880,852
Total Facility Capital Cost ($)	1,800,000	1,800,000	919,148	919,148	919,148
Electrical and Biogas Fuel--base year					
Gross Electrical Capacity (kWe)	600	600	600	600	600
Net Electrical Capacity (kWe)	570	570	570	570	570
Capacity Factor (%)	36	36	36	36	36
Net Efficiency--Biogas to Electricity (%)	38.9	38.9	38.9	38.9	38.9
Methane Concentration in Biogas (% by volume)	59.0	59.0	59.0	59.0	59.0
Heat--base year					
Total heat production rate (kWth)	865	865	865	865	865
Aggregate fraction of heat recovered (%)	50	50	50	50	50
Recovered heat (kWth)	433	433	433	433	433
Overall CHP Efficiency--Gross (%)	70.5	70.5	70.5	70.5	70.5
Overall CHP Efficiency--Net (%)	68.4	68.4	68.4	68.4	68.4
Carbon Offset (tons CO2e)	6,000	6,000	6,000	6,000	6,000
Expenses--base year					
Operating Expenses ($)	166,794	166,794	166,794	166,794	166,794
Taxes					
Federal Tax Rate (%)	34.00	34.00	34.00	34.00	34.00
State Tax Rate (%)	6.65	6.65	6.65	6.65	6.65
IvestmentTax Credit (% of Total Capital Cost)	0.000	0.300	0.300	0.300	0.300
Combined Tax Rate (%)	38.39	38.39	38.39	38.39	38.39
Income other than energy					
Carbon Payment ($/tons)	0	9	9	9	9
Sales price for solids ($/t)	0.00	0.00	0.00	0.00	0.00
Escalation/Inflation					
General Inflation (%/y)	2.50	2.50	2.50	2.50	2.50
Escalation--for all parameters (%/y)	2.50	2.50	2.50	2.50	2.50
Financing					
Debt ratio (%)	50.00	50.00	50.00	96.00	100.00
Equity ratio (%)	50.00	50.00	50.00	4.00	0.00
Interest Rate on Debt (%/y)	6.00	6.00	6.00	6.00	6.00
Life of loan or debt term (y)	10	10	10	10	10
Economic Life (y)	20	20	20	20	20
Cost of equity (%/y)	15.00	15.00	15.00	15.00	15.00

5.3.5.5. Sensitivity Analysis:

LCOE is particularly sensitive to capital cost, operating expenses, capacity factor, return on equity, and price of carbon. Sensitivity to these and other factors is illustrated on Figure 5-2, which shows the full LCOE as each parameter is varied over the indicative relative range and all other values held constant at their reference or basecase values (in this case LCOE = 19.28 cents/kWh [nominal $2014]). If capital cost is lowered by 50 percent (or with grants of about $900,000), LCOE is reduced to about 9 cents/kWh (nominal $2014) similar to the LCOE in Case 3 above. Lowering operating expenses by 50 percent reduces LCOE to 14 cents/kWh. Increasing the capacity factor by 50 percent reduces LCOE to about 13 cents/kWh. In addition, as the price of carbon increases, LCOE decreases.

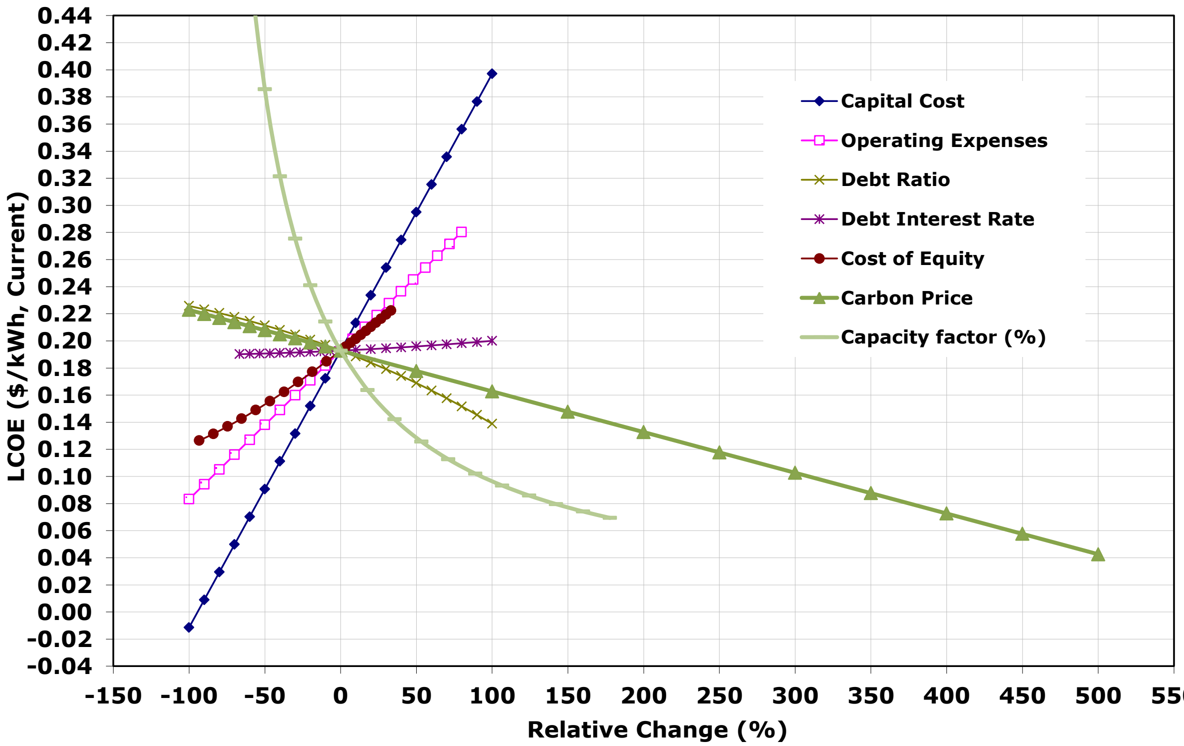

Figure 5-2: Van Warmerdam LCOE Sensitivity Analysis (2014 Nominal $/kWh) Assumptions as shown:

Capital cost = $1.8 Million	Operating expenses = $166,794/year	ITC = 30%
Price of Carbon = $9/MT	Debt ratio = 50%	Cost of debt = 6%/year
Debt term = 10 years	Return on equity = 15% /year	Economic life = 20 years
MACRS Depreciation = 5-year	General Inflation = 2.5%	Federal tax Rate = 34%
State Tax rate = 6.65%	Gross electrical capacity = 600 kW	Capacity Factor = 36%

5.3 Conclusions

The overall project objective of implementing an anaerobic digestion system at Van Warmerdam Dairy was successfully achieved. Performance and financial conclusions of the first full year of operation are summarized as follows:

- The overall gross efficiency of the CHP engine-generator is 70.5 percent including both the electrical production and utilized thermal energy for digester heating.
- The project operates at a capacity factor of 36 percent. The net load exported by the project was approximately 1,612,294 per year, over 95 percent of the generated energy.
- During construction, 8.2 FTE jobs were created, and 1.3 FTE jobs were created for ongoing operations. As with most renewable energy facilities, the project created most of its jobs during construction.
- Generator exhaust emissions were lower than the allowed limits in all measured categories. These results prove the effectiveness of the engine's lean burn control systems, as well as the effectiveness of the SCR emissions control system installed on the engine.
- The estimated total annual GHG reduction was 7,839 MT of CO_2e.
- The project generates an estimated $317,610 in annual electricity sales.
- Using current project economics generates an LCOE of 7.85 cents per kWh, which could decrease to as little as 7.67 cents per kWh assuming a higher debt ratio.

In addition to producing renewable energy, the facility also reduces significant GHG emissions by destroying methane. Nearly all of the GHG benefits from the project are generated by the avoided methane emissions component. This benefit is unique to digester projects compared to other renewables such as solar or wind.

The engine is oversized to allow the facility to generate most of its power during peak demand periods. Without access to peak pricing, the effective PPA price received by the project would be significantly lower, and the project would not be economically feasible as designed. The significant drivers for economic sustainability of covered lagoon digesters for widespread deployment include the following:

- Increased carbon value from methane destruction.
- Reduction in capital cost.
- Reduction in operating expenses.

Co-digestion can boost biogas production and increase revenues with minimal capital investment. Where feasible, this technique should be employed.

The project's overall financial approach was to reduce project cost and complexity as a means of reducing financial risk. The project achieved a low installation cost both in terms of capital expense and manpower expended. This structure enabled a simplified financial package whereby a single owner and a single bank, together with SMUD, financed the project. Many other projects require additional grants, loans, or investors, which slows down project development, increases costs, and reduces the likelihood of successful project replication.

CHAPTER 6: Conclusions and SMUD's Lessons Learned

During the implementation of the CRED grant, SMUD learned the following lessons:

- Obtaining financing for the projects was challenging and time-consuming.
- Grant funding was a two-edged sword. The grant funds were able to reduce the capital costs of the projects; however, the administrative requirements impacted the small developers.
- Project implementation, particularly acquiring necessary permits, took longer than expected.
- It was imperative to include SMUD's partners and affected customers in the grant implementation process.
- Flexibility was necessary to implement this multi-project effort. It was necessary to terminate a project, change a project, and/or change a developer.

When SMUD was awarded the grant for the CRED effort, it had planned five projects including the Garden Highway Foods Anaerobic Digestion project with RealEnergy as the developer. Soon after the grant was awarded, Garden Highway Foods decided not to participate in the project. RealEnergy started discussions to locate the project at the Sacramento Recycling Transfer Station. After prolonged discussions, RealEnergy could not secure this site. The SMUD team with DOE approval decided to terminate the project and was able to reallocate the DOE funding to the remaining four projects.

For the Van Warmerdam Dairy Digester project, SMUD contracted first with Innate Energy California, LLC (Innate). Unfortunately, Innate was not able to comply with the DOE's grant disbursement requirements and was not able to secure financing for the project. Because of these issues and the limited time left to implement the CRED, SMUD and Innate mutually decided to terminate the partnership and allow SMUD to find a substitute developer/partner to implement the Van Warmerdam Dairy Digester project. Through a competitive solicitation, MEW was selected to implement the project.

For the CRED solar project, SMUD initially intended to team with CalTrans and SolFocus to deploy the Sacramento Solar Highways effort. SMUD released a solicitation for a developer for the Solar Highways effort and did not receive an economically viable submittal. Because of this, SMUD terminated the Solar Highways project with DOE approval. SMUD then released a solicitation and teamed up with Conergy to develop the Simply Solar project.

In addition to overcoming the challenges described above, the following overall goals of the SMUD CRED program were still achieved:

- Installing renewable energy facilities interconnected to SMUD's distribution grid.
- Contributing toward SMUD's RPS goal.

- Contributing to DOE’s goal of accelerating renewable deployment.
- Reducing GHG emissions through destruction of methane.
- Creating jobs and spurring local economic activity.
- Demonstrating economically viable installations of technologies that are not yet widely commercially deployed.
- Demonstrating the alignment of economic incentives to achieve socially and environmentally desirable goals.
- Providing lessons learned for all participants (engineers, developers, public agencies, site hosts, interconnecting utility, contractors, financiers, permitting agencies, and the public).

In addition to reducing GHG emissions, the projects also demonstrate that solar projects and anaerobic digesters can be readily implemented through collaborative partnerships. This work helps other communities learn how to assess, overcome barriers, utilize, and benefit from renewable resources for electricity generation in their region.

GLOSSARY

Below is a summary of terms and definitions used in this report.

Term	Definition
AADS	Advanced Anaerobic Digester System
ARRA	American Recovery and Reinvestment Act
BEP	Biogas Enhancement Project
Biogas	Gaseous fuel, especially methane, produced by the fermentation of organic matter
CalBio	California Bioenergy LLC
CARB	California Air Resources Board
CCO	California Climate Offsets
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CH_4	Methane
CHP	Combined Heat and Power
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CRED	Community Renewable Energy Deployment
CSTR	Complete Stirred Tank Reactor
DOE	Department of Energy
EERE	Energy Efficiency and Renewable Energy
EQIP	Environmental Quality Incentives Program
FIT	Feed-in-Tariff
FOG	Fats, Oils, and Greases
FTE	Full-time Equivalent
FWP	Food Processing Waste

GHG	Greenhouse Gas Emissions
gpd	Gallons per Day
H_2S	Hydrogen Sulfide
HDPE	High Density Polyethylene
ITC	Investment Tax Credit
kW	Kilowatt
kWdc	Kilowatts of Direct Current
kWh	Kilowatt-hour
kW-yr	Kilowatt-year
lb/day	Pounds per Day
LCOE	Levelized Cost of Energy
LSG	Low-Pressure Sludge Gas
MACRS	Modified Accelerated Cost Recovery System
MEW	Maas Energy Works
MT/yr	Metric Tons per Year
MWh	Megawatt-hour
NH_3	Ammonia
NO_x	Oxides of Nitrogen
O&M	Operations and Maintenance
PM	Particulate Matter
PPA	Power Purchase Agreement
ppmvd	Parts per Million Volumetric Dry
RD&D	Research, Development, and Demonstration
RFP	Request for Proposal
RPS	Renewable Portfolio Standard
scf	Standard Cubic Feet
scfm	Standard Cubic Feet per Minute

SCR	Selective Catalytic Reduction
SMUD	Sacramento Municipal Utility District
SRCSD	Sacramento Regional County Sanitation District
SRWTP	Sacramento Regional Wastewater Treatment Plant
USDA	United States Department of Agriculture
VOC	Volatile Organic Compound
WWC	Western Water Constructors

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APPENDIX A:
Simply Solar Report

DRAFT FINAL REPORT

CRED GRANT
SUBRECIPIENT AGREEMENT NO. 4500074997
9/25/2014

Conergy | 3947 Lennane Dr., Suite 275 | Sacramento, CA 95821 | USA | Tel. 888.396.6611 | Fax 866.436.6114 | www.conergy.us | info@conergy.us

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CRED GRANT
SUBRECIPIENT AGREEMENT NO. 4500074997

Prepared for:
Kathleen Ave

Table of Contents

Exhibits:

Tables:

Figures:

Background

Conergy received funding from Sacramento Municipal Utility District (SMUD) for the Simply Solar project under the Community Renewable Energy Deployment (CRED) program. The project was installed in the City of Sacramento's Sutter's Landing Regional Park, and the duration of the project was fall 2011 to fall 2014.

Introduction

The original purpose of the Simply Solar project was to demonstrate multiple styles of solar electric generation in a unique location. Sutter's Landing Regional Park in the City of Sacramento is adjacent to a capped and closed landfill. The location is highly trafficked because of its recreational use; therefore, it has high outreach and education value for the general public.

Work included development of a vision for the City of Sacramento Sutter's Landing Park; engineering, procurement, and construction of the solar electric plant in that vision; and environmental studies and community outreach surrounding the solar installation activities.

One of the goals of the project was to address the challenges of installing solar on a capped and closed landfill that is settling as time progresses. One of the objectives was to identify foundations, mounting structures, and civil works that could be installed on this geotechnically unstable ground. Landfills are often considered as candidate sites for solar installations throughout the country. Brownfields are in some cases environmentally preferred over greenfields for development, and land costs tend to be low in landfill locations, increasing the cost effectiveness of the solar installation. Lessons learned from this project should be of significant benefit to municipalities interested in installing solar across the country.

Design and System Features

The original design was a ballasted nonpenetrating installation on the main landfill location. Because of the change in location, Conergy evaluated different installation types to see which was the most cost-effective and viable solution.

The original ballasted system design on a large portion of the landfill can be seen on Figure 1. This was planned to be a stationary ground-mounted installation that could be adjusted as the ground settled within the landfill. The ballasted racking system would not penetrate the ground, but instead would be weighted to anchor the system.

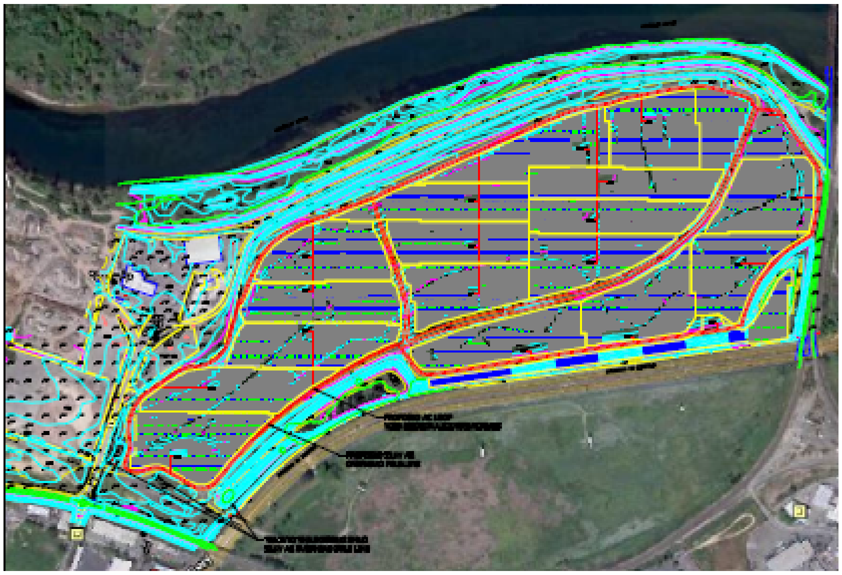

Figure 1. Original ballasted nonpenetrating design of solar array on landfill mound

During the development of the project, Sacramento officials were concerned that the weight of the ballast and the corresponding equipment would do irreparable damage to the asphalt, which is the cap for the landfill.

The installation location was changed to the asphalt area next to the dog park, the dog park, and the parking area across the main road. It was determined that the installation size could be maximized using a different type of installation in these new locations. Conergy, working with the city, determined that standard piles would not work for the new installation either, because of the construction debris that is contained within the landfill.

Standard piles cannot penetrate the soils in the new location without possible damage to the pile and the cap.

A third option involved using earth screws (Figure 2). Pullout tests were completed in front of city inspectors and independent lab officials. The information from the pullout tests was used to determine the dimensions of the earth screws, including the length and diameter. The earth screw locations would be pre-drilled, then the screw would be driven into the pilot hole, reducing risk of damage to the cap. This method limited the penetrations to smaller areas and made it possible to reseal the cap.

Figure 2. Earth screw foundation

The equipment installed and the method of installation vary slightly between the different installation types. There are three installation types: ground-mount, elevated structure, and solar trees. The ground-mounted installation on Figure 3 uses earth screws to anchor the racking into the ground. The earth screws did penetrate the landfill cap, but additional changes to the installation ensured resealing of the footings in order to ensure the integrity of the cap. The elevated structure with parking underneath and the solar trees/shade structures used large spread footings to support the racking system. These installations penetrated the cap as well but used a similar method for resealing the remaining cap and footings together.

To install the ground-mount installation, a small portion of the asphalt cap was removed, the screw was inserted, and then an asphalt patch was placed up against the screw and the existing asphalt cap to reseal each location. To install the elevated structure and shade structures, the asphalt cap was cut, the required concrete footings were poured, and then an asphalt patch was placed connecting the concrete footing and the existing asphalt cap to reseal the landfill cap.

In some locations, conduit was run, and this process penetrated the cap. The city required explosion-proof EYS conduit sealing fittings to be installation in any conduit where a penetration occurred in order to prevent the penetration of gases into the conduit. The fittings were placed in the conduit before and after equipment where a penetration occurred. This measure was taken to help restrict gases from passing through the conduit.

Since the landfill cap was penetrated, hazardous waste disposal was required for a portion of the excavated soils.

The final installation has three types of racking installations on the Sacramento facility totaling up to the 1.498 megawatt (MW) capacity. These installations include an elevated structure, shade structures, and a ground-mount facility. All three installations are in the same general vicinity in the park. Each of the systems uses 250 watt Sharp photovoltaic modules. Specifics regarding the quantity of equipment for each facility can be seen in Table 1.

Table 1. Design characteristics of the three system types

	System Size	**# Modules**
Elevated Structure	371 kW	1,484
Solar Trees	35 kW	140
Ground-Mount	1,092 kW	4,368
Total	**1,498 kW**	**5,992**
kW - kilowatt		

The three installations are located within walking distance of each other, next to the landfill mound. On Figure 3, the blue block to the right is the elevated array, the blue block to the left is the ground-mount installation, and the shade structures are in between the two.

Figure 3. Aerial image of the three solar photovoltaic systems

The elevated array structure/parking lot is the tallest installation visible at the park entrance. There are approximately 200 parking spots located under the canopy. Figure 4 below shows a plan view of the parking structure.

Figure 4. Photograph of the parking structure

The shade structures/solar trees are located within the dog park, as shown on Figure 5. There are 10 shade structures/trees located within the dog run area.

Figure 5. Photograph of the solar trees

The ground-mounted installation (Figure 6) is located to the far left of the road as visitors are entering the park. This portion of the installation comprises 4,368 modules. This system is a stationary installation with a tilt of 5 degrees for prime sun exposure.

Figure 6. Photograph of the ground-mounted system

Although the design and installation schedule were modified several times, many challenges were overcome during the installation. Currently, many visitors to the park enjoy the elevated parking structure and use the shade structures in the dog park.

Project Narrative

Conergy and its partners originally started discussing the potential installation with local members of the community and city representatives in 2010. The project was originally planned to be 20 MW. After many hours of discussions on the installation possibilities, a grant became available that would assist with the funding.

The majority of the installation was planned to be placed on top of the mound at the landfill on 28th Street in Sacramento. After several years of planning and discussion, it became apparent that the civil engineering of the structures would have to address the ground settling over time. This was one hurdle among many that had to be overcome. Additional hurdles included, but were not limited to, public opinion, local wildlife and endangered species, landfill closure verification, and environmental issues, all while trying to resolve the civil and structural issues of the site.

In order to overcome the site issues, Conergy with the City of Sacramento and the other parties adjusted the installation location. The main focus for the installation moved away from the mound, and the facility was instead installed on the local dog park, a smaller portion of the landfill, and a large parking area, all adjacent to the landfill mound. This design change is an example of creative solutions used to achieve the project's original goals. The original educational features were retained, and several types of installation options that are available with solar photovoltaics were demonstrated.

Activities Performed

Activities included facility design, environmental studies and permitting, contracting, interconnection studies, community oversight of the planning process, design changes, and procurement, construction, and cleanup work.

In original discussions in 2010, the solar facility was planned to be placed on the entire landfill, with a nameplate capacity of about 20 MW. Many changes occurred during the planning of the project that extended the development phase. These design changes also affected the contract signings and pushed the construction schedule later.

The environmental permitting phase included resolving issues involving the California Environmental Quality Act (CEQA), in particular working with several different species that are located on the site. One of these included the elderberry bush, which was observed in the southeast portion of the study area in the attached biological resources report prepared by Analytical Environmental Services. This threatened plant is the host to the valley elderberry longhorn beetle throughout its life cycle. In addition to the elderberry bush, there have been records of a burrowing owl species located within 5 miles of this location. The burrowing owl is a species of concern designated by the state of California. Another threatened species for California is the Swainson's hawk, which has been active in the area within the last 5 years. The habitat and feeding grounds were within 5 miles of the planned solar facility.

To mitigate the issues with the threatened and endangered species, Conergy adjusted the location of the facility as well as its size. The facility was moved from the landfill mound to the park location, and size was adjusted to a smaller facility to lessen the impact on wildlife.

Following discussions, property analysis, and cost/benefit analysis, it was established that Conergy could adopt a phased installation approach and start with a smaller project, primarily on the edge of the capped landfill, where the public could see the installation better from a public park.

After negotiations and public hearings, the property lease, interconnection permits, building permits, and Power Purchase Agreements were signed. The project was able to move forward largely because of the grant that assisted with project costs.

Originally, grant funding was intended to be used for electrical equipment installation. There were specific requirements for the funding; it was determined that the project would be required to use inverters by the manufacturer Satcon. During the development of the project, Satcon declared bankruptcy, so a new funding source had to be found to support the purchase of the new SMA inverters.

During the contract negotiations, financing was a prime focus for Conergy. Several financing partners reviewed the project. One major concern for the installation was the indemnity clause within the contract for the work completed on the landfill before Conergy's involvement. Ultimately, Conergy found a partner for the installation and investment in Washington Gas Energy Systems (WGES). WGES was able to develop a contracting mechanism despite the indemnity clause. At this point, Conergy had already made the decision to move the installation to the park facility and had already reduced the installation size.

In addition the financing hurdles, Conergy's parent company insolvency had a minor impact on the project schedule. Specific impacts included delays to the contract signing and delays to the equipment orders for a couple of months.

Before installation began, it had been determined that the local Native American tribe had rights to oversee the installation in case artifacts were located during the construction. This monitoring added costs to the installation; it also involved coordination efforts for a tribal representative to be present during any excavation during the construction. Jobs were also created through this monitoring activity, achieving the goals of the grant program to create jobs and stimulate the economy.

At the time of grant application, a ground installation had been planned. This was planned to be a ballasted, nonpenetrating ground installation that would not impact the landfill cap. During the progression of the project, the installation was adjusted to three different types of installations: an elevated array, shade structures, and a ground-mount installation. Because the location had changed, the racking for these installations was also evaluated to determine whether this nonpenetrating racking might also change. Conergy evaluated earth screws, which would penetrate the landfill cap; ballasted racking for the ground mount; as well as a piled installation. Additional information regarding the equipment used and the installation and evaluation is provided in the Design and System Features section.

Because of the location change, there was a minor easement conflict with a new residential development east of the medium voltage switchgear. To resolve the conflict, the city redirected the roadway to the developmen3t to provide adequate clearance for the solar equipment.

For each install type, the construction involved installing racking, inverters, and modules, as well as other balance of system equipment to complete the installation.

Final engineering was completed at the end of 2013, with construction beginning in January of 2014. The construction portion of the installation was completed in September 2014.

Several construction contractors were used during the installation, with Conergy overseeing construction on the jobsite. Approximately 10 subcontractors were on the site during construction. Work included earthwork, electrical installation, racking installation, and cleanup work. This was a significant contribution to the local economy; near-term jobs were created as intended by the CRED program.

At the time of this writing, an item still to be completed is educational signage for visitors of the park. This task is to be completed by the city Parks and Recreation department the first half of 2015.

Advancement of Science and Technology

This project resulted in the design of several types of solar photovoltaic systems that can be replicated at other landfill installations and parks across North America. As future equipment becomes available, these designs can be adapted for future locations. Nonpenetrating racking systems have also been created for landfill and brownfield locations. Applicability for a given site will depend upon the site's existing closure systems and topography.

Assessment of the Success of the Project

The original goal for the installation was to establish a photovoltaic system that could be placed on a landfill facility and minimally affect the closure system of the landfill and cap. Even though the installation location changed, this project was successful with the racking selected, for the portion of the project that is capped, under the ground-mount installation.

Conergy overcame the challenges of cost, endangered animals, and several other factors to successfully accomplish the original goal.

California's Economic Recovery

During the design and construction of the project, many jobs were created and retained. For Conergy, approximately six people were working on the project prior to and during the construction. This number includes employees for designing and engineering the project, project managers and site supervisors during construction, grant administrators, and office personnel.

Many subcontractors and suppliers were also involved with the project. Approximately 10 subcontractors were on-site, with a range of one to eight employees, over a span of 22 weeks during the construction of the project. In addition, jobs were sustained at the manufacturing facilities for all of the equipment used on-site.

How the Project Results Will Be Used

The energy produced will feed back into the local utility grid for the benefit of the community.

Because a solar facility of this scope is now accessible to the local community, educational goals will be achieved. Because the installation is in a public location, the community and younger generations can learn about alternative energy production and sustainability.

In addition, Conergy will be using lessons learned to develop other solar photovoltaic installations throughout the United States and Canada. Since Conergy is a global company with a team that works throughout North America, the knowledge gained from this project will benefit Conergy's other projects moving forward.

Projected Cost Reduction Impact and Other Benefits

There are many ways to offset some of every community's growing electrical usage with green methods that are already available. Solar electricity is one of those methods. The 1.498 MW solar photovoltaic system that was installed on the Sutter's Landing Regional Park in California is expected to produce approximately 2,423,050 kilowatt-hours of electricity each year. That is equivalent to the electricity used by approximately 230 homes.

The emissions reductions associated with the generation of electricity with solar photovoltaics is an important benefit of the project. According to the Environmental Protection Agency (EPA) Greenhouse Gas Equivalencies calculator,[1] a solar photovoltaic system of this size is expected to reduce greenhouse gas emissions into the atmosphere by approximately 1,842 tons per year. This amount is equivalent to reducing pollutants caused by driving a car approximately 3,978,135 miles per year.

Project Budget

In 2012, Conergy's original project budget estimate was slightly in excess of $5.7 million. The project experienced delays in construction because of a complex design process, a lengthy CEQA study, and a lengthy project approval phase. These delays increased some costs but also allowed the project to benefit from reduced solar panel and other equipment costs. After changes in the system design and equipment specifications from the original proposal, the preliminary budget was set in early October 2013 for the constructed system. The final project cost was $4,074,255. There were several partners and funding sources for this project, including a Department of Energy (DOE) grant, California Energy Commission (CEC) funding, SMUD matching and project funding, and Conergy. The CEC provided $125,000 in cost share (utilized for electrical equipment installation costs), while the DOE CRED grant funded a $1,632,800 contribution toward the modules and a portion of the electrical installation. SMUD contributed $224,000 toward one of the project inverters and also provided project cost share and grant administration. Conergy covered $2,092,455 of the remaining costs, which were for racking, installation, a portion of the modules, and the balance of system for the project.

Additional Potential Research, Developing, and Demonstration Projects

The CEC funding enabled this project to move forward, benefitting the community and the solar industry. This project provided lessons learned in areas including civil and structural design for unique landfill conditions, endangered species protection, tribal monitoring, hazardous waste disposal, and generation of renewable electricity.

There are many other potential projects for solar that might emerge from the conclusion of this project An additional research project involving a tracking installation on the site could have the potential to show the technology performance differences between a tracking facility and the fixed systems that are currently installed at the park. Some points of analysis could be the cost differences for the different types of installation, the energy production differences, and potential maintenance comparisons for costs and equipment repairs.

Project Outcomes/Results/Conclusions

The solar facility is currently producing electricity that is being fed directly into the utility grid for consumption by local residences and businesses. The project overcame schedule delays and unexpected cost increases, but the construction of the facility ultimately met planned timelines with minimal issues.

The mounting structure specified during the initial phases of the project ultimately met the criteria of the local permitting authorities. In addition, it did not disturb the landfill cap during construction.

References

1. EPA Greenhouse Gas Equivalency Calculator
   a. http://www.epa.gov/cleanenergy/energy-resources/calculator.html

2. Wikipedia Encyclopedia
   a. http://en.wikipedia.org/wiki/Solar_inverter

3. Biological Resources Report completed by Analytical Environmental Services
   a. Refer to the attached exhibits.

Exhibit 1

Equipment List

System Size

Ground Array	1,092 kW
Elevated Array	371 kW
Solar Trees	35 kW
	1,498 kW

Equipment List

	Quantity	Manufacturer	Model
Modules	5,992	Sharp	ND250QCS
String Combiners	22	Amtec Industries	Prom24-40-600V
Inverters	3	SMA	Sunny Central SC-500HE-US
AC Switchgear	1	The New IEM	
Transformers	1	ABB	100 kVA 480 Y/277
	1	ABB	500 kVA 480Y/277
Monitoring		Draker Monitor and Shark Meter 100	
Racking - Ground		Mounting Systems	
Racking - Elevated/Trees		Capitol Iron Works	

Exhibit 2

Biological Resources Report

BIOLOGICAL RESOURCES ASSESSMENT
CITY OF SACRAMENTO
28TH STREET SOLAR PHOTOVOLTAIC FARM

AUGUST 2011

PREPARED FOR:

City of Sacramento
Dept. of Parks and Recreation
915 I Street, Fifth Floor
Sacramento, CA 95814

PREPARED BY:

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TABLE OF CONTENTS

Biological Resources Assessment Technical Memorandum for the 28th Street Solar Photovoltaic Park Project

LIST OF FIGURES

LIST OF TABLES

ATTACHMENTS

PURPOSE

This Biological Resources Assessment (BRA) documents sensitive biological habitats and special status species that have the potential to occur on or be affected by the City of Sacramento's Sutter's Landing Park/ 28th Street Landfill Solar Photovoltaic Park Project (proposed project), located in the City of Sacramento, California (**Figure 1**). This BRA has been prepared on behalf of the City of Sacramento (City) and has been prepared for use in permit applications and environmental review conducted in accordance with the California Environmental Quality Act (CEQA).

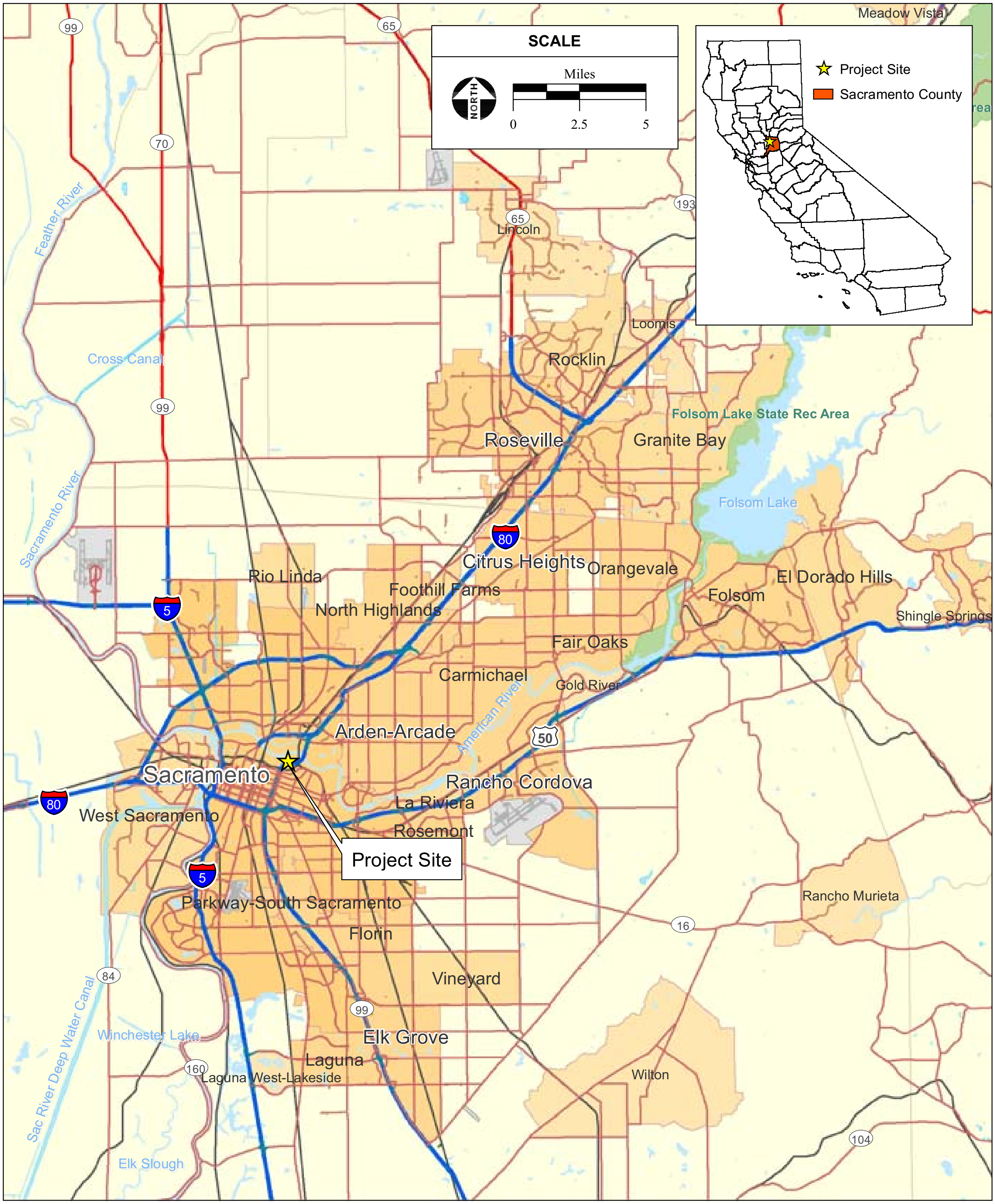
PROJECT LOCATION AND BACKGROUND

The approximately 180-acre study area is located within the Sutter's Landing Park/City of Sacramento's 28th Street Landfill on Assessor's Parcel Numbers 001-0170-018, 001-0170-021, and 001-0170-026, in the City of Sacramento, California. The study area is located at the northern end of 28th Street, in the northeast area of downtown Sacramento. The site is bordered by the American River to the north, Business Interstate 80 to the south, Southern Pacific Railroad tracks to the east, and industrial properties to the west.

The study area is located on Section 32 of Township 9 North, Range 5 East, of the Sacramento East, California, U.S. Geological Survey (USGS) 7.5-minute topographic quadrangle (quad), Mount Diablo Baseline and Meridian. The centroid of the study area is 38° 35' 12.5" North, 121° 77' 9.7" West. A topographic map and an aerial photograph of the study area are shown in **Figures 2** and **3**, respectively.

The study area is owned by the City and has historically been operated as the 28th Street Landfill until it was closed in 1997. The majority of the former 28th Street Landfill was used for the disposal of non-hazardous, inert residential, commercial, and industrial municipal solid wastes. The entire site was designated a park by the City Council in November 1995. The southwestern portion of the study area, which is currently partially developed as part of Sutter's Landing Park, was previously used as a burn dump as late as the 1950s (City of Sacramento, 2011). In 2004 the California Regional Water Quality Control Board adopted the Waste Discharge Requirements (Order Number R5-2004-0039) to prescribe the requirements for post-closure maintenance and monitoring of the closed landfill. The Landfill consists of 3 designated "waste management units" or WMU. The majority of the proposed project would involve activities on WMU A and WMU B, with some improvements on the WMU located on the west side of 28th Street. The third WMU is known as the Old Landfill, and is also subject to post-closure requirements. The facilities associated with the maintenance include gas monitoring wells, groundwater monitoring wells, and surface maintenance equipment during the summer to address settlement, mowing the grass for fire control, and drainage as the solid waste decomposes. The earliest post-closure maintenance requirement ends in 2027.

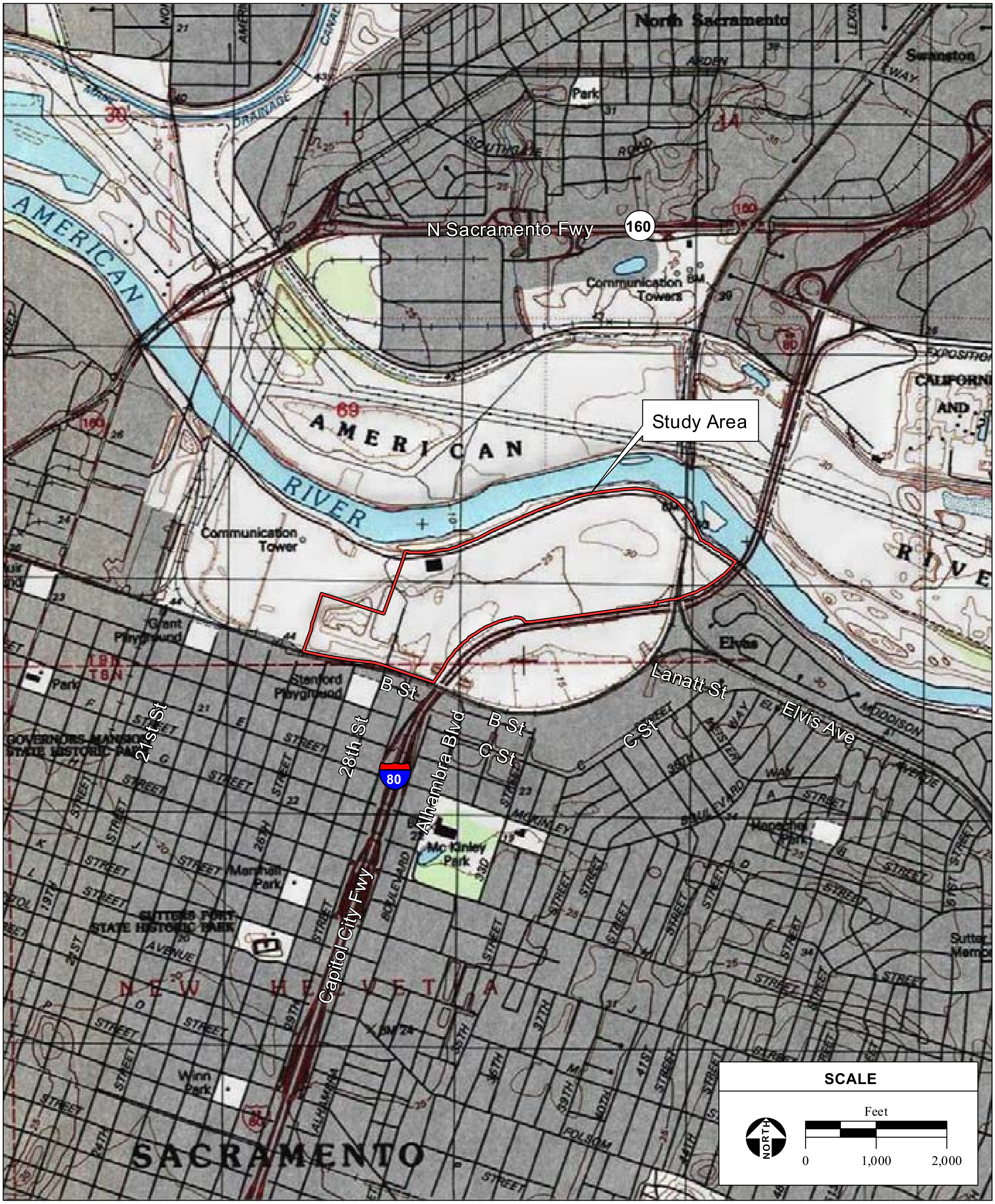
The land use designation for the study area in the 2030 General Plan is Parks and Recreation (City of Sacramento, 2009). The study area is zoned A-OS-PC (Agriculture-Open Space-Parkway Corridor). The PC designation reflects the study area's location within the American River Parkway Corridor, which is an overlay zone in the City Municipal Code (Chapter 17.160). Surrounding land uses, include recreational open space to the north, residential to the east, undeveloped lands zoned for residential uses to the



SOURCE: StreetMap North America, 2009; AES 2011

City of Sacramento 28th Street Solar Photovoltaic Farm BRA / 211526

Figure 1
Regional Location



SOURCE: "Sacramento East, CA" USGS 7.5 Minute Topographic Quadrange, T9N, R5E, Unsectioned Area of New Helvetia, Mt. Diablo Baseline & Meridian; AES, 2011

Figure 2
Site and Vicinity

SOURCE: NAIP Aerial Photograph, 6/21/2009; AES, 2011

Figure 3
Aerial Photograph

south, and industrial uses to the west. Recreational activities that occur onsite include a dog park, a skate park, parkway trail access to the American River bike trail, and related vehicle parking.

Current Maintenance Practices

An ongoing soils maintenance program occurs within the managed nonnative grassland. The majority of the program is done in the summer to prevent damage to the cap of the landfill. Every summer a visual survey of the landfill is conducted to locate where settlement has occurred and where water is not draining. The survey is usually conducted in May when the grass is cut and the surface of the landfill is more visible. A work plan and schematic of the landfill is developed showing the areas that settled or where erosion has occur within the last year. These areas are filled in using clean dirt, either from an existing stock pile on the site or from construction sites located within the City. Imported soils are tested for hazardous materials at a lab prior to use at the landfill.

The low areas are filled in and the soil is compacted using a water truck to moisten the soil and tracked in using a grader and other available equipment. The compaction ratio is approximately 800 to 1,000 pounds per cubic foot. This prevents water from perking through the landfill cover and into the garbage below, producing leachate. The compaction also prevents wildlife species from burrowing into the landfill cover. At the same time, the drainage ditches are graded and the areas along the gas collection pipelines and around the wells and probes located across the landfill surface are weeded.

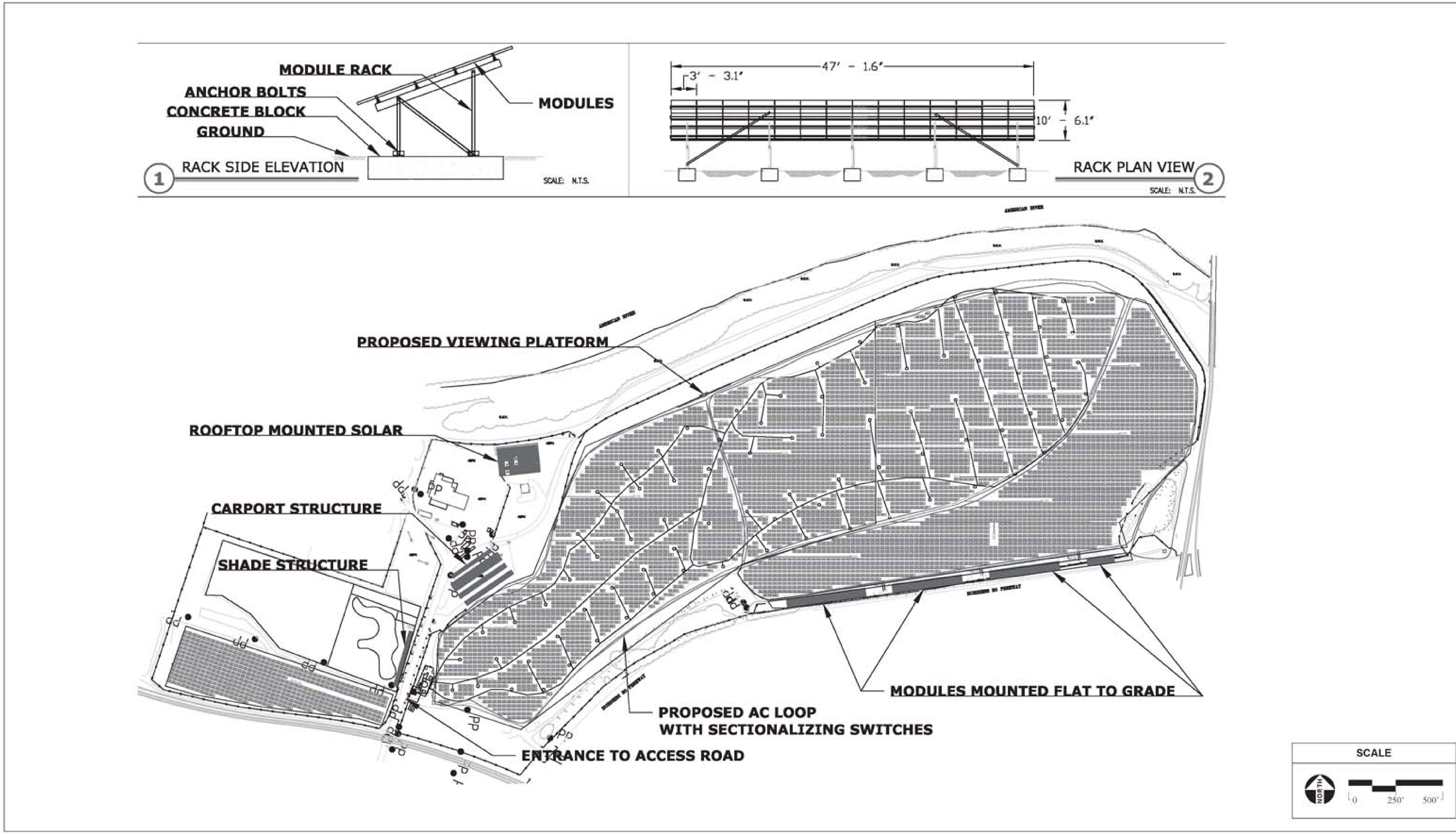
PROJECT DESCRIPTION

The City proposes to construct a photovoltaic solar park at the closed landfill and other areas of Sutter's Landing Park (**Figure 4**). The project site includes all areas where facility construction staging, construction, operation, and decommissioning would occur within the study area. The proposed project includes installation of solar modules within and adjacent to the closed landfill (i.e., within and adjacent to managed grasslands and methane collection systems), operation of the modules to produce and sell electricity, and removal of the solar installation at the conclusion of the lease term. Operation of the solar park by a solar operator would be pursuant to a lease agreement with the City.

Project Components

The solar facility would produce electricity through the installation and use of solar modules. Each solar module is approximately 5 feet high, 3 feet wide, and 1.8 inches deep. The proposed project includes the installation of approximately 83,000 modules on the landfill mound, 2,912 modules near Business Route 80, and additional solar modules on the project site to generate the desired level of electricity. Solar modules would be mounted on racks that would tilt each module approximately 20 degrees to face the south. Some panels would be mounted on shade structures on the developed portion of Sutter's Landing Park with the same tilt angle.

Each rack would hold 14 modules mounted next to each other with 0.5-inch spacing. The individual racks would be separated by approximately 1.5 feet. Taking into account that modules would be installed at a 20 degree angle, the distance between each row of modules would be approximately 9 feet. The modules closest to Business Route 80 would be approximately 40 feet from the right of way. The majority



SOURCE: Conergy, 8/2011; AES, 2011

Figure 4
Project Design

of the solar modules would be installed on the landfill "mound" east of 28th Street and a disturbed area located north of the railroad tracks. Other modules would be located on shade structures installed to support solar panels in other areas of the park, and along Business Route 80. A viewing tower and walkway would be constructed to oversee the solar facility. The overall area where solar modules are proposed to be installed consists of approximately 104 acres.

Electrical current generated by the solar modules would feed into approximately 20 onsite inverters to change the DC electrical current generated by the modules to AC current for delivery to the grid via the Sacramento Municipal Utilities District (SMUD) infrastructure. Each inverter is approximately 6 feet high, 11 feet long, and 3 feet deep. Each inverter is enclosed in a metal box to protect the equipment. Electrical lines required for the operation of the solar panels would be located in utility corridors on the ground surface. Electrical current generated at the project site would be routed to the SMUD sub-station located on the east side of 28th Street via existing overhead power lines.

No grading of the project site would occur in connection with the installations. Excavation would only be required for footers for the shade structures and panels located in areas with slope, including those along Business Route 80. Fill material would be imported for any excavations to avoid conflict with the landfill post-closure requirements.

Vehicular access to the solar panels would be primarily via existing asphalt and improved roadways within the project site. Some temporary roadway access may be required during installation.

All inverters, switchgear, and monitoring equipment would be located on a concrete pad with a sheet roof for protection from the elements.

Construction, Operation and Removal

Construction is estimated to begin in 2012. The construction process would take approximately 2 to 4 months, but may be completed in phases over a 3-year period. The proposed project would employ a minimum of 25 people at any given time during construction. Development of the project site would require delivery of materials to staging areas for the construction of racks, which would be completed on the project site, delivery of the solar modules, construction of shade structures, installation of the racks and solar modules, and completion of electrical connections to the SMUD substation. Solar modules would be delivered in semi-trucks and trailers and offloaded at the project site for delivery to the installation location. Most of the work required during installation involves construction of racks, installation of the ballast, movement and placement of modules to the rack, and electrical wiring of the modules. Once installed, the solar modules would produce approximately 20 megawatts of electricity at full build out. Operation of the solar park requires annual inspection, maintenance, repair of the facilities, and periodic cleaning of panels, which involves several employees. At the end of the lease, the operator would remove all solar-related facilities from the project site. Panels would be removed by truck. The Sutter's Landing Park/28th Street Landfill portion of the project site would be returned to its prior condition.

REGULATORY

Federal

Federal Endangered Species Act

The U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) implement the federal Endangered Species Act (FESA) of 1973 (16 USC Section 1531 et seq.). Under the FESA, threatened and endangered species on the federal list and their habitats (50 CFR Subsection 17.11, 17.12) are protected from "take" (i.e., activities that harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect) as well as any attempt to engage in any such conduct, unless a Section 10 permit is granted to an individual or a Section 7 consultation and a Biological Opinion with incidental take provisions are rendered from the lead federal agency. Pursuant to the requirements of the FESA, an agency reviewing a proposed project within its jurisdiction must determine whether any federally listed species may be present within the project site and vicinity and determine whether the proposed project will have a potentially significant impact upon such species. Under the FESA, habitat loss is considered to be an impact to the species. In addition, the agency is required to determine whether the project is likely to jeopardize the continued existence of any species proposed to be listed under the FESA or result in the destruction or adverse modification of critical habitat proposed to be designated for such species (16 USC Section 1536[3], [4]). Therefore, project-related impacts to these species, or their habitats, would be considered significant and require mitigation.

Under the FESA, critical habitat may be designated by the Secretary of the Interior for any listed species. The term "critical habitat" for a threatened or endangered species refers to the following: specific areas within the geographical range of the species at the time it is listed that contain suitable habitat for the species, which may require special management considerations or protection; and specific areas outside the geographical range of the species at the time it is listed that contain suitable habitat for the species and is determined to be essential for the conservation of the species. Under Section 7 of the FESA, all federal agencies (including the USFWS and NMFS) are required to ensure that any action they authorize, fund, or carry out will not likely jeopardize the continued existence of a listed species or modify their critical habitat.

Migratory Bird Treaty Act

Most bird species, especially those that are breeding, migrating, or of limited distribution, are protected under federal and/or state regulations. Under the Migratory Bird Treaty Act (MBTA) of 1918 (16 USC Subsection 703-712), migratory bird species, their nests, and their eggs are protected from injury or death, and any project-related disturbances during the nesting cycle. As such, project-related disturbances must be reduced or eliminated during the nesting cycle.

Wetlands and Waters of the U.S.

The U.S. Army Corps of Engineers (USACE) has primary federal responsibility for administering regulations that concern waters of the U.S. (including wetlands), under Section 404 of the Clean Water Act (CWA). Section 404 of the CWA regulates the discharge of dredged or fill material into waters of the U.S. The USACE requires that a permit be obtained if a project proposes the placement of structures within, over, or under navigable waters and/or discharging dredged or fill material into waters below the ordinary high water mark (OHWM). The USACE has established a series of nationwide permits (NWP) that authorize certain activities in waters of the U.S.

In addition, a Section 401 Water Quality Certification Permit is required to comply with CWA Sections 301, 302, 303, 306, and 307 and is regulated by the Regional Water Quality Control Board (RWQCB). Anyone that proposes to conduct a project that may result in a discharge to U.S. surface waters and/or waters of the state including wetlands (all types) year round and seasonal streams, lakes, and all other surface waters would require a federal permit. At a minimum, any beneficial uses lost must be replaced by a mitigation project of at least equal function, value, and area. Waste Discharge Requirement permits are required pursuant to California Water Code Section 13260 for any persons discharging or proposing to discharge waste, including dredge/fill, that could affect the quality of the waters of the state.

State

California Endangered Species Act

The California Endangered Species Act (CESA) prohibits the take of state-listed threatened and endangered species. Under the CESA, state agencies are required to consult with the California Department of Fish and Game (CDFG) when preparing CEQA documents. Under the CESA, the CDFG is responsible for maintaining a list of rare, threatened, and endangered species designated under state law (California Fish and Game Code 2070-2079). The CDFG also maintains lists of species of concern and fully protected species. Species of concern are those taxa that are considered sensitive and this list serves as a "watch list." Pursuant to the requirements of the CESA, agencies reviewing proposed projects within their jurisdictions must determine whether any state-listed species have the potential to occur within a project site and if the proposed project would have any significant impacts upon such species. Project-related impacts to species on the CESA's rare, threatened, and endangered list would be considered significant and require mitigation. The CDFG can authorize take if an incidental take permit is issued by the Secretary of the Interior or Commerce in compliance with the FESA, or if the director of the CDFG issues a permit under Section 2080 in those cases where it is demonstrated that the impacts are minimized and mitigated.

California Fish and Game Code Sections 1600-1616

Under Sections 1600-1616, the CDFG regulates activities that would alter the flow, bed, channel, or bank of streams and lakes. It derives this jurisdiction under the CESA because the CDFG is responsible for the protection of fish or wildlife resources and their habitats (including wetlands). The CDFG provides comments on USACE Section 404 and 401 permits under the Fish and Wildlife Coordination Act, last amended in 1995. The CDFG is authorized under the California Fish and Game Code Sections 1600-1616 to develop mitigation measures and to enter into Lake or Streambed Alteration Agreements with applicants whose proposed projects would obstruct the flow of, or alter the bed, channel, or bank of a river or stream in which there is a fish or wildlife resource, including intermittent and ephemeral streams and wetlands.

Local

2030 General Plan: Environmental Resources Element

The following goal and policies from the 2030 General Plan, adopted March 3, 2009 and last amended November 30, 2010, address biological resources and guide the location, design, and quality of development to protect important biological resources including wildlife habitat, open space corridors, and ecosystems (City of Sacramento, 2009).

Goal ER 2.1: Natural and Open Space Protection. Protect and enhance open space, natural areas, and significant wildlife and vegetation in the City as integral parts of a sustainable environment within a larger regional ecosystem.

Policies:

- **ER 2.1.1 Resource Preservation**. The City shall encourage new development to preserve on-site natural elements that contribute to the community's native plant and wildlife species value and to its aesthetic character. (RDR/MPSP)
- **ER 2.1.2 Conservation of Open Space**. The City shall continue to preserve, protect, and provide access to designated open space areas along the American and Sacramento rivers, floodways, and undevelopable floodplains. (MPSP/IGC)
- **ER 2.1.4 Retain Habitat Areas**. The City shall retain plant and wildlife habitat areas where there are known sensitive resources (e.g., sensitive habitats, special status, threatened, endangered, candidate species, and species of concern). Particular attention shall be focused on retaining habitat areas that are contiguous with other existing natural areas and/or wildlife movement corridors. (RDR/IGC)
- **ER 2.1.5 Riparian Habitat Integrity**. The City shall preserve the ecological integrity of creek corridors, canals, and drainage ditches that support riparian resources by preserving native plants and, to the extent feasible, removing invasive nonnative plants. If not feasible, adverse impacts on riparian habitat shall be mitigated by the preservation and/or restoration of this habitat at a 1:1 ratio, in perpetuity. (RDR/IGC)
- **ER 2.1.7 Annual Grasslands**. The City shall preserve and protect grasslands and vernal pools that provide habitat for rare and endangered species. If not feasible, the mitigation of all adverse impacts on annual grasslands shall comply with state and federal regulations protecting foraging habitat for those species known to utilize this habitat. (RDR/IGC)
- **ER 2.1.10 Habitat Assessments**. The City shall consider the potential impact on sensitive plants for each project requiring discretionary approval and shall require preconstruction surveys and/or habitat assessments for sensitive plant and wildlife species. If the preconstruction survey and/or habitat assessment determines that suitable habitat for sensitive plant and/or wildlife species is present, then either (1) protocol-level or industry-recognized (if no protocol has been established) surveys shall be conducted; or (2) presence of the species shall be assumed to occur in suitable habitat on the project site. Survey Reports shall be prepared and submitted to the City and the CDFG or the USFWS (depending on the species) for further consultation and development of avoidance and/or mitigation measures consistent with state and federal law. (RDR)

- **ER 2.1.11 Agency Coordination**. The City shall coordinate with state and federal resource agencies (e.g., CDFG, USACE, and USFWS) to protect areas containing rare or endangered species of plants and animals. (IGC)

METHODOLOGY

Analytical Environmental Services (AES) obtained information for the study area from the following sources: a USFWS (2011) list, updated April 29, 2010, of federally listed species with the potential to occur on or be affected by projects on the Sacramento East quad; a California Native Plant Society (CNPS; 2011) inventory, dated April 25, 2011, of special status species known to occur on the Sacramento East quad and 8 surrounding quads (Taylor Monument, Rio Linda, Citrus Heights, Sacramento West, Carmichael, Clarksburg, Florin, and Elk Grove); a California Natural Diversity DataBase (CNDDB) query, dated April 2, 2011, of special status species known to occur on the Sacramento East quad and 8 surrounding quads (CDFG, 2003); and CNDDB records of special status species documented within 5 miles of the study area. The USFWS, CNDDB, and CNPS lists are provided in **Attachment 1**.

Standard references used for the biology and taxonomy of plants include: Abrams (1951, 1960), CNPS (2011), CDFG (2003, 2009), Hickman, ed. (1993), Mason (1957), Munz (1959), and Sawyer and Keeler-Wolf (1995). Standard references used for the biology and taxonomy of wildlife include: Cornell Lab of Ornithology (2011), Ehrlich et al. (1988), Jennings and Hayes (1994), Peterson (1990), Sibley (2003), and Stebbins (2003).

FIELD SURVEY AND ANALYSIS

AES biologists Kelly Bayne, M.S. and Laura Burris conducted a biological survey on May 27, 2011. The biological survey consisted of conducting a botanical inventory, evaluating biological communities, documenting potential habitat for special status species with the potential to occur within the study area, and conducting an informal delineation of waters of the U.S. Plants and wildlife observed within the study area are identified in **Attachment 2**.

A table summarizing the regionally occurring special status species identified on the USFWS, the CNPS, and the CNDDB lists is provided as **Attachment 3**. The table provides a rationale as to whether the species have the potential to occur within the study area. Presence of the species or their habitat was evaluated during the May 27, 2011 biological survey. Species without the potential to occur in the vicinity of the study area are not discussed further in this report.

ENVIRONMENTAL SETTING

Soil Types

The study area is comprised 3 soil types (NRCS, 2009). A soils map of the study area is provided in **Figure 5**. **Table 1** summarizes the soil types by map unit symbols, percentages mapped within the study area, and identifies the landforms for the soil types that are considered hydric (NRCS, 2010).

SOURCE: NAIP Aerial Photograph, 6/21/2009; AES, 2011

Figure 5
Soils Map

TABLE 1
SOIL TYPES WITHIN THE STUDY AREA

Soil Type	Map Unit Symbol	Hydric Soil	Hydric Landform Indicator	Percentage of Study Area
Columbia Sandy Loam, Drained, 0 to 2 Percent Slopes	117	Yes	Floodplains	37
Columbia-Urban Land Complex, Drained, 0 to 2 Percent Slopes	124	Yes	Floodplains/ Natural Levees	3
Dumps	136	No	N/A	60
			Total	**100**

NRCS, 2009; 2010.

Habitat Types

Terrestrial habitat types within the study area include: managed nonnative grassland, elderberry savanna, cottonwood forest, and ruderal/developed areas. Aquatic habitat types within the study area include: ephemeral drainage ditch and concrete-lined detention basin. Terrestrial habitat types are discussed in detail below. Aquatic habitat types are discussed further under the *Potential Waters of the U.S.* section. Representative photographs of the habitat types within the study area are shown in **Figures 6a** and **6b**. A habitat map is provided in **Figure 7**. **Table 2** summarizes the acreages of habitat types within the study area.

TABLE 2
HABITAT TYPES BY ACREAGES WITHIN THE STUDY AREA

Habitat Type	Acreage
Terrestrial	
Managed Nonnative Grassland	125.33
Elderberry Savanna	4.76
Cottonwood Forest	1.02
Ruderal/Developed	47.83
Aquatic	
Ephemeral Drainage Ditch	0.03
Concrete-Lined Detention Basin	0.72
Total	**179.69**

[1]GIS calculations may not reflect exact acreage of study area due to rounding.

AES, 2011

PHOTO 1: View west of nonnative grassland and elderberry shrub less than one inches diameter at ground level on the west side of the study area.

PHOTO 2: View east of mowed nonnative grassland on southwest side of study area.

PHOTO 3: View southeast of elderberry savanna on the east side of the study area.

PHOTO 4: View east of cottonwood forest on the southeast side of the study area.

SOURCE: AES, 2011

Figure 6a
Site Photographs

PHOTO 5: View northeast of nonnative grassland within the northeast side of the study area. The American River is located outside of the north side of the study area.

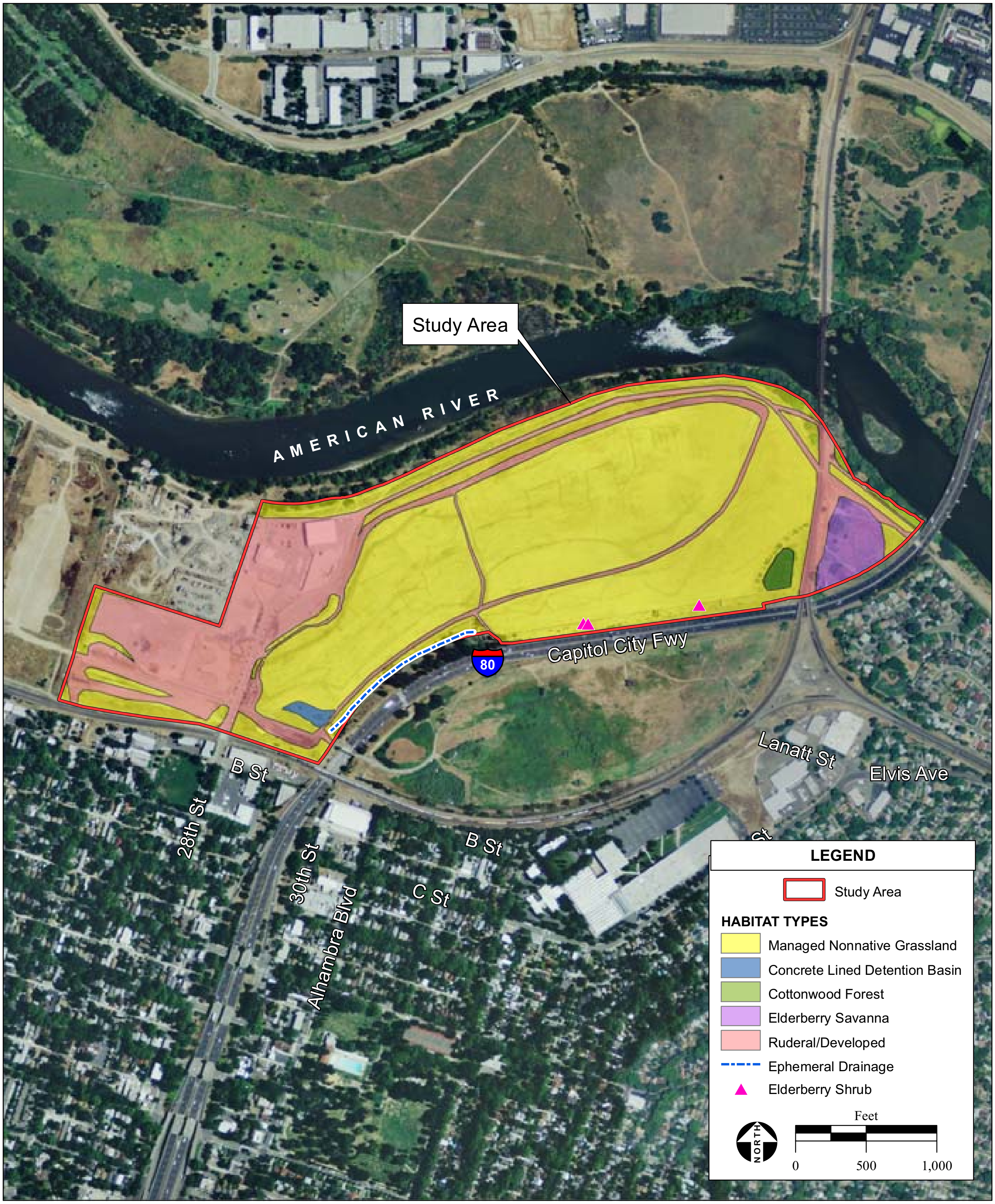
PHOTO 6: View southwest of ephemeral drainage ditch on the southwest side of the study area.

PHOTO 7: View southeast of concrete lined detention basin on the southwest side of the study area.

PHOTO 8: View of elderberry shrub on the south side of the study area.

SOURCE: AES, 2011

Figure 6b
Site Photographs



SOURCE: NAIP Aerial Photograph, 6/21/2009; AES, 2011

Figure 7
Habitat Map

Managed Nonnative Grassland

Managed nonnative grassland (nonnative grassland) occurs throughout the majority of the study area (**Figure 6a**: **Photographs 1** and **2**; **Figure 6b**: **Photograph 5**). The nonnative grassland is compacted on an annual basis as required by the 28th Street Landfill post-closure requirements and is regularly mowed[1] (Strauss, pers. comm., 2011). As identified within the description of current maintenance practices (page 5), burrowing rodents are actively controlled in the landfill closure area through maintenance activities associated with annual compaction and vegetation mowing. As a result of these activities, no burrows were observed within the managed nonnative grassland. Pipes are located throughout the nonnative grassland to collect methane gas and other gasses as a result of the breakdown of organic matter within the 28th Street Landfill. Dominant vegetation observed within the nonnative grassland included: wild oat (*Avena fatua*), hyssop loosestrife (*Lythrum hyssopifolia*), ripgut grass (*Bromus diandrus*), soft chess (*Bromus hordeaceus*), Zorro fescue (*Vulpia myuros*), plantain (*Plantago coronopus*), field hedge parsley (*Torilis arvensis*), foxtail barley (*Hordeum murinum*), and field bindweed (*Convolvulus arvensis*). Two elderberry (*Sambucus mexicanus*) shrubs with stems less than one-inch diameter at ground level (dgl) were observed growing in containers surrounding pipe valves within the western portion of the nonnative grassland, and several shrubs with stems greater than one-inch dgl were observed in isolated locations in the southern portion of the nonnative grassland. The locations of shrubs with stems greater than one-inch dgl are shown in **Figure 7**. These shrubs are discussed further under the *Special Status Wildlife* section.

Elderberry Savanna

Elderberry savanna occurs within the southeast portion of the study area, east of the railroad tracks (**Figure 6a**: **Photograph 3**). Elderberry shrubs are the dominant overstory species observed within this habitat type. Other overstory vegetation observed within this habitat type includes: willow (*Salix* sp.), box elder (*Acer negundo*), and Oregon ash (*Fraxinus latifolia*). Dominant understory vegetation observed within this habitat type includes: Himalayan blackberry, milk thistle (*Silybum marianum*), common sow thistle (*Sonchus oleraceus*), field hedge parsley, and wild grape (*Vitis californica*).

Cottonwood Forest

Cottonwood forest occurs within the southeast portion of the study area (**Figure 6a**: **Photograph 4**). The cottonwood forest occurs in a low area that appears to have been historically used as a detention basin. Fremont cottonwoods (*Populus fremontii*) are the dominant overstory species observed within this habitat type. Other overstory vegetation observed within this habitat type includes: box elder, Oregon ash, interior live oak (*Quercus wislizenii*), valley oak (*Quercus lobata*), and Northern California black walnut (*Juglans hindsii*). Understory vegetation associated with this habitat type is comprised primarily of upland species including: oat, soft chess, hedgehog dogtail (*Cynosurus echinatus*), Italian thistle (*Carduus pycnocephalus*), ripgut grass, field hedge parsley, and foxtail barley.

Ruderal/Developed

Ruderal/developed areas occur throughout the study area. These areas include the railroad tracks, paved and graded roads, road shoulders,and Sutter's Landing Park, which includes paved parking lots,

[1] At the time of the May 27, 2011 biological survey, several areas of the managed nonnative grassland had been recently mowed.

buildings, ornamental landscaping, and dog and skate parks. Dominant vegetation observed within the ruderal area of this habitat type includes: field bindweed, wild oat, and prickly lettuce (*Lactuca serriola*).

Potential Waters of the U.S.

Ephemeral Drainage Ditch

An approximately one-foot wide ephemeral drainage ditch occurs adjacent to a graded service road along the southwestern boundary of the study area (**Figure 6b**: **Photograph 6**). The ephemeral drainage ditch drains runoff from a eucalyptus grove located outside the southern boundary of the study area following precipitation events. The ephemeral drainage ditch drains southwestward and exits the southwestern boundary of the study area. No water was observed within the ephemeral drainage ditch during the May 27, 2011 biological survey of the study area. Vegetation associated with this feature is comprised primarily of upland species including: wild oat, ripgut grass, and Italian thistle.

Concrete-Lined Detention Basin

A concrete-lined detention basin occurs on the southwest portion of the study area (**Figure 6b**: **Photograph 7**). The concrete-lined detention basin is a manmade feature used to hold water received from runoff from the surrounding nonnative grassland and ruderal/developed areas following precipitation events. The basin appears to hold water until it evaporates. Water was observed during the May 27, 2011 biological survey of the study area. This feature lacks vegetation. This feature is not considered potential waters of the U.S. because it is manmade, lacks hydric vegetation and soils, and is an isolated feature that lacks connectivity to a potential waters of the U.S.

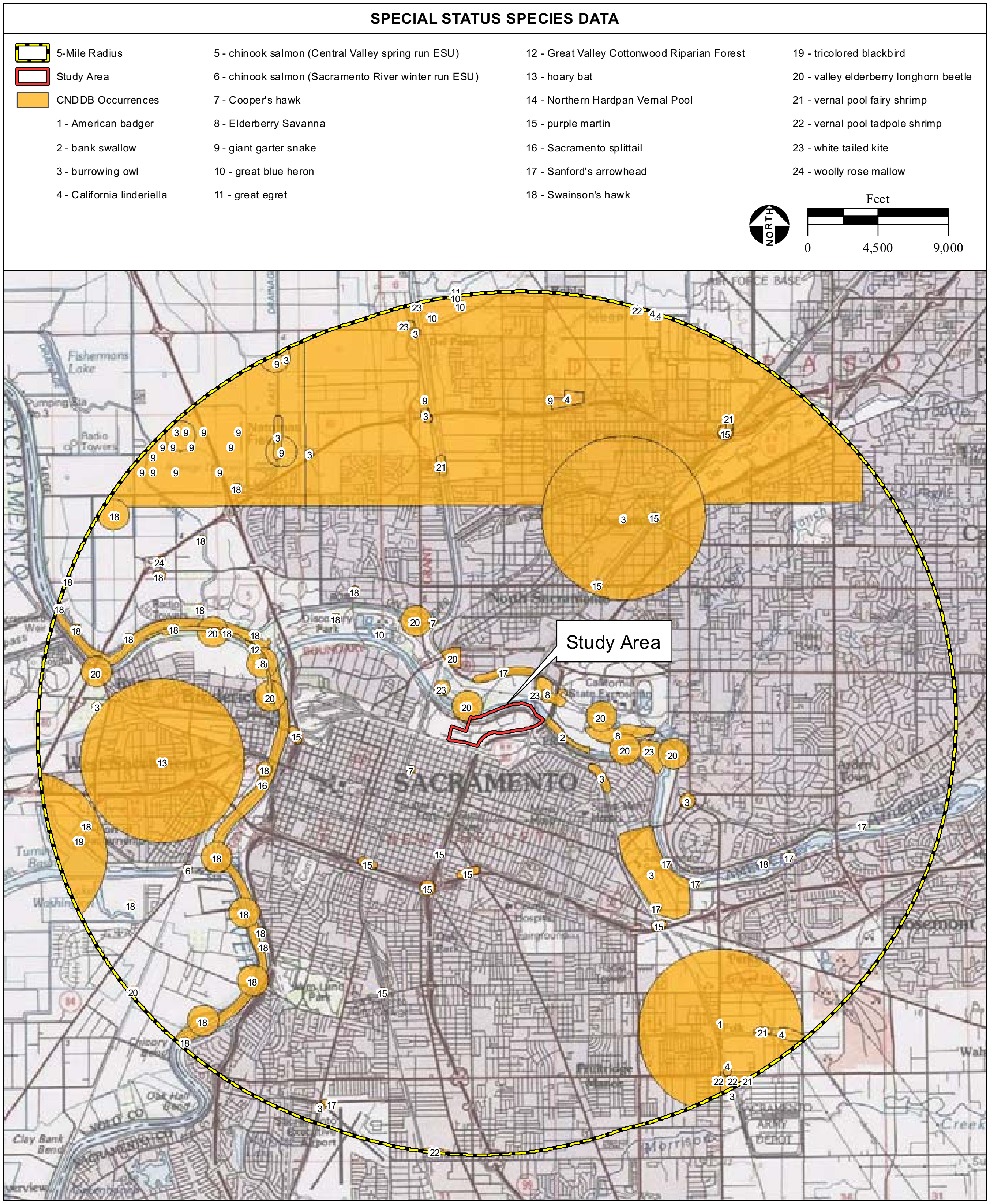
SPECIAL STATUS SPECIES

For the purposes of this assessment, special status has been defined to include those species that are:

- Listed as endangered or threatened under the FESA (or formally proposed for, or candidates for, listing);
- Listed as endangered or threatened under the CESA (or proposed for listing);
- Designated as endangered or rare, pursuant to California Fish and Game Code (§1901);
- Designated as fully protected, pursuant to California Fish and Game Code (§3511, §4700, or §5050);
- Designated as species of concern to the CDFG; or,
- Defined as rare or endangered under CEQA.

Attachment 3 provides a summary of regionally occurring special status species obtained from the USFWS, CNDDB, and CNPS lists and evaluates whether the species have the potential to occur within the study area based on habitat types observed during the May 27, 2011 biological survey. Species without the potential to occur within the study area are not discussed further. Special status species with the potential to occur within the study area are discussed in detail below, including distances from the study area to reported CNDDB occurrences (CDFG, 2003; 2011). A CNDDB map of special status species documented within a 5-mile radius of the study area is provided in **Figure 8**. A critical habitat map in the vicinity of the study area is provided in **Figure 9**. The study area does not occur within critical habitat for any federally listed species.

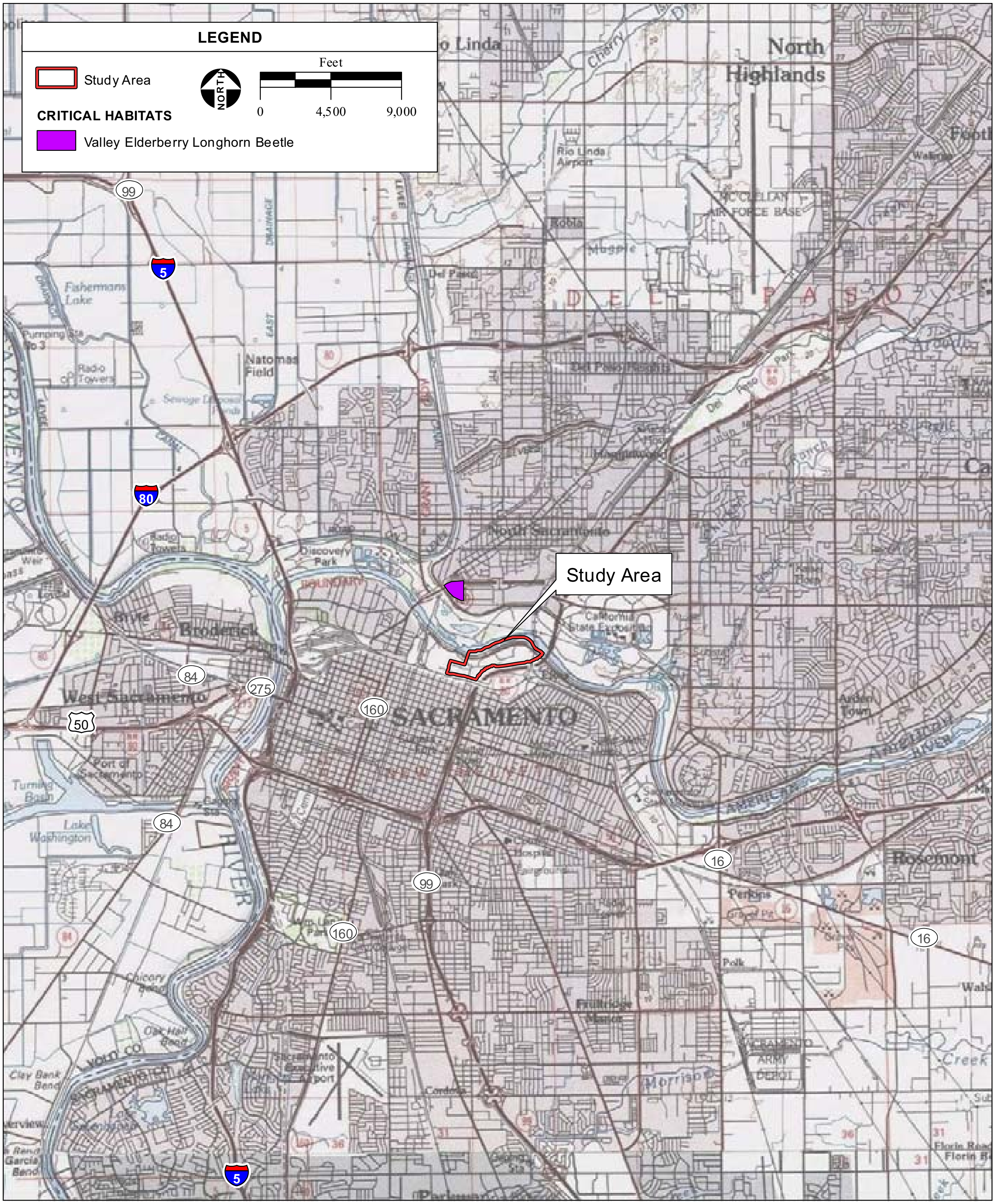
SPECIAL STATUS SPECIES DATA



SOURCE: California Natural Diversity Database, 4/2011; "Sacramento East, CA" USGS 7.5 Minute Topographic Quadrange, T9N, R5E,Unsectioned Area of New Helvetia, Mt. Diable Baseline & Meridian; AES, 2011

City of Sacramento 28th Street Solar Photovoltaic Farm BRA / 211526 ■

Figure 8
CNDDB 5-Mile Radius



SOURCE: USFWS Critical Habitat Survey of Sacramento County, Federally listed 1980; "Sacramento East, CA" USGS 7.5 Minute Topographic Quadrange, T9N, R5E, Unsectioned Area of New Helvetia, Mt. Diablo Baseline & Meridian; AES, 2011

Figure 9
Critical Habitats

Special Status Plants

Dwarf Downingia (Downingia pusilla)

Federal Status – None
State Status – None
Other – CNPS 2

Dwarf downingia is an annual herb found in valley and foothill grassland and vernal pools from 0 to 1,476 feet. Blooming period is from March through May. Dwarf downingia is known from Fresno, Merced, Napa, Placer, Sacramento, San Joaquin, Solano, Sonoma, Stanislaus, Tehama, and Yuba counties (CNPS, 2011).

There are no CNDDB occurrences for this species within 5 miles of the study area. The nonnative grassland within the study area provides potential habitat for dwarf downingia. The May 27, 2011 biological survey was conducted within the evident and identifiable period for dwarf downingia. Dwarf downingia was not observed in the study area. This species does not occur in the study area.

Northern California Black Walnut (Juglans hindsii)

Federal Status – None
State Status – None
Other – CNPS 1B

Northern California black walnut is a deciduous tree found in riparian forest and woodland from 0 to 1,444 feet. Blooming period is April through May. Northern California black walnut is known from Contra Costa, Lake, Napa, Sacramento, Solano, and Yolo counties (CNPS, 2011).

There are no CNDDB occurrences for this species within 5 miles of the study area. Isolated Northern California black walnut trees were observed within the cottonwood forest of the study area. The general locations of the Northern California black walnut trees have been recorded in the CNDDB database (CDFG, 2003). Northern California black walnut occurs in the study area.

Ahart's Dwarf Rush (Juncus leiospermus var. ahartii)

Federal Status – None
State – None
Other – CNPS 1B

Ahart's dwarf rush is an annual herb found in valley and foothill grasslands on mesic substrates from 98 to 981 feet. Blooming period is from March through May. This species is known from Butte, Calaveras, Placer, Sacramento, Tehama, and Yuba counties (CNPS, 2011).

There are no CNDDB occurrences for this species within 5 miles of the study area. The nonnative grassland within the study area provides potential habitat for Ahart's dwarf rush. The May 27, 2011 biological survey was conducted within the evident and identifiable period for Ahart's dwarf rush. Ahart's dwarf rush was not observed in the study area. This species does not occur in the study area.

Heckard's Pepper-Grass (Lepidium latipes var. heckardii)

Federal Status – None
State Status – None
Other – CNPS List 1B

Heckard's pepper-grass is an annual herb found in alkaline flats of valley and foothill grassland from 6.6 to 656 feet. Blooming period is from March to May. This species is known from Glenn, Solano, and Yolo counties (CNPS, 2011).

There are no CNDDB records for this species within 5 miles of the study area. The nonnative grassland within the study area provides potential habitat for Heckard's pepper-grass. The May 27, 2011 biological survey was conducted within the evident and identifiable period for Heckard's pepper-grass. Heckard's pepper-grass was not observed within the study area. This species does not occur within the study area.

Special Status Wildlife

Valley Elderberry Longhorn Beetle (Desmocerus californicus dimorphus; VELB)

Federal Status – Threatened
State Status – None

VELB is completely dependent on its host plant, the elderberry (*Sambucus* sp.) shrub during its entire life cycle throughout California's Central Valley (USFWS, 2008). VELB larvae live within the soft pith of the elderberry where they feed for one to 2 years. Adults emerge from pupation from the wood of elderberry shrubs during the spring as the plant begins to flower. The adults feed on the elderberry foliage up until they mate. Females lay their eggs in the crevices of elderberry bark. Upon hatching, the larvae tunnel into shrub stems and feed there. VELB typically utilize stems that are greater than one inch dgl (USFWS, 2008).

There are 11 CNDDB records for this species within 5 miles of the study area. The nearest CNDDB record (occurrence Number: 9) is from 1984 and abuts the northwestern boundary of the study area. The record states that adult VELB were observed on elderberry shrubs in riparian vegetation along the American River. Two elderberry shrubs with stems less than one-inch dgl were observed growing in containers surrounding pipe valves within the western portion of the nonnative grassland (**Figure 6a**: **Photograph 1**). The USFWS does not consider elderberry shrubs with stems less than one-inch dgl as VELB habitat. Elderberry shrubs comprised of stems with at least one inch dgl were observed in the elderberry savanna within the southeastern portion of the study area (**Figure 6a**; **Photograph 3**) and in a few isolated locations in the nonnative grassland within the southern portion of the study area (**Figure 6b**; **Photograph 8**). The host plant for this species occurs within the study area.

Burrowing Owl (Athene cunicularia)

Federal Status – None
State Status – Species of Concern

Burrowing owls occur in suitable habitat throughout California, except in northwestern coastal forests and on high mountains. Suitable habitat consists of open grasslands, especially prairie, plains, savanna, and in open areas including vacant lots and spoils piles near human habitat. Nesting and roosting occurs in burrows dug by mammals (such as California ground squirrels [*Spermophilus beecheyi*]), but may also occur in pipes, culverts, and nest boxes. Occupied nests can be identified by the lining of feathers, pellets, debris, and grass. Burrowing owls search for prey on the ground or on low perches such as fence posts or dirt mounds. Burrowing owls are diurnal, crepuscular, and nocturnal, depending on the time of year. Burrowing owls nest from March to August (CDFG, 2005).

There are 12 CNDDB records for this species within 5 miles of the study area. Five of the 12 CNDDB records are from the last 5 years. Three of the 5 records documented in the last 5 years are presumed extant; the other two have been extirpated. The nearest record is approximately one mile southeast of the study area (CNDDB occurrence: 488). The record states that the burrowing owl occurrence is presumed extant, though the occurrence was last observed in 1974 (CDFG, 2003).

The majority of the nonnative grassland is maintained on an annual basis through soil compaction and vegetation mowing which reduces the likelihood of the presence of burrowing animals. The study area provides potential habitat for burrowing owls where annual disturbance from routine maintenance is limited, such as along the margins of the maintained nonnative grassland in the vicinity of the cottonwood forest and the elderberry savanna. No ground squirrel burrows, burrowing owls, or their sign were observed during the May 27, 2011 biological survey of the study area. Burrowing owls have the potential to occur within the study area.

Swainson's Hawk (Buteo swainsoni)

Federal Status – None
State Status – Threatened

Swainson's hawks are nesting raptors that arrive to their breeding grounds in the Central Valley in early March. Swainson's hawk nests are generally found in scattered trees or along riparian systems adjacent to agricultural fields or pastures. Valley oak, Fremont cottonwood, walnut, and large willow trees, ranging in height from 41 to 82 feet, are the most commonly used nest trees in the Central Valley (County of Sacramento, 2007). A breeding pair constructs nests and lays eggs from late-April to late-May. The young typically hatch in mid-May, and nestlings generally fledge in mid-August (Cornell Lab of Ornithology, 2011). The young depend on the adults for approximately 4 weeks after fledging until they permanently leave the breeding territory. Swainson's hawks nest from February 15 through September 15. Suitable foraging habitat nearby nesting sites is critical for fledgling success (CDFG, 1994). Swainson's hawk are known to forage distances exceeding 18 miles from the nests (Estep, 1989).

The CDFG (1994) prepared the *State Fish and Game Staff Report Regarding Mitigation for Impacts to Swainson's Hawks in the Central Valley of California* (Swainson's Hawk Staff Report). The report recommends new development projects which adversely modify nesting and/or foraging habitat should mitigate the project's impacts to the species. The CDFG considers whether a project will adversely affect suitable foraging habitat within a 10-mile radius of a Swainson's hawk nest that has been active within the last 5 years. Suitable habitat includes areas that are considered small mammal and insect foraging habitat, such as California ground squirrels, California voles (*Microtus californicus*), valley pocket gophers (*Thomomys bottae*), crickets (*Gryllidae* sp.), and grasshoppers (*Conocephalinae* sp.). Suitable Swainson's hawk foraging habitat includes alfalfa, fallow fields, beet, tomato, and other low-growing row or field crops, dry-land and irrigated pasture, rice land (when not flooded), and cereal grain crops (including corn after harvest). Increased captures occurs in fields that are being harvested, disced, mowed, or irrigated.

There are 85 CNDDB records for Swainson's hawk within 10 miles of the study area. There are 25 CNDDB records for Swainson's hawk within 5 miles of the study area. The nearest record with an active nest within the last 5 years is from 2008 (CNDDB occurrence: 1715) and is mapped approximately 2.5 miles southwest of the study area along the Sacramento River. The record states that a Swainson's hawk chick was observed in a nest along the west side of the Sacramento River.

The study area provides marginal nesting habitat within the cottonwood forest for Swainson's hawk, however, given that the cottonwood forest is comprised of a dense, even-age stand of trees and that the trees are less than 40 feet in height. The Swainson's hawk has a greater potential to nest within the riparian vegetation along the American River outside the northern boundary of the study area. The established riparian habitat along the American River to the north of study area provides optimal nesting habitat for this species within the cottonwood, California sycamore (*Platanus racemosa*), and willow (*Salix* sp.) trees exceeding heights of 50 feet. Several raptors nests were observed during the May 27, 2011 biological survey in the canopies of the cottonwood, California sycamore, and willow trees along the American River to the north of the study area. There was no visible bird activity in the vicinity of the nests at the time of the survey, so it is unclear what species of raptor utilize these nest sites. Swainson's hawk has a low potential to nest within the study area boundaries.

Available foraging habitat in the vicinity of the study area includes land designated as recreational open space to the north of the American River and on land to the south of Business Route 80. The managed nonnative grassland within the study area provides only marginal foraging habitat for Swainson's hawk, which prefers to forage in agricultural lands. No rodents or rodent burrows, which would provide evidence of sources of prey, were observed within the grassland during the May 27, 2011 biological survey, most likely due to annual soil compaction of the study area. Several black-tailed jack rabbits (*Lepis californicus*), less preferable sources of prey, were observed within the study area. A Swainson's hawk pair was observed foraging within the nonnative grassland within the study area and on land to the north of the study area, north of the American River during the May 27, 2011 biological survey. Because the landfill mound lacks preferable prey base due to the absence of small rodents and rodent burrows as a result of annual soil compaction within the managed nonnative grassland, Swainson's hawk has a low potential to forage within the study area.

White-Tailed Kite (Elanus leucurus)

Federal Status – None
State Status – Fully Protected

White-tailed kites are year-round residents in coastal and valley lowlands. White-tailed kites forage in open grasslands, meadows, agricultural fields, and emergent wetlands. Nesting occurs in dense stands of oaks, willow, or other deciduous trees from February through October (CDFG, 2003). There are 5 CNDDB records for white-tailed kite within 5 miles of the study area. The nearest CNDDB record is from 2009 (occurrence number: 142) and is approximately 0.28 miles north of the study area. The record states that a nesting pair was observed bringing food to a nest in a deciduous tree (CDFG, 2003).

The cottonwood forest within the study area provides nesting habitat for this species. The nonnative grassland within the study area provides foraging habitat for this species. A white-tailed kite was observed foraging within the nonnative grassland during the May 27, 2011 biological survey of the study area. White-tailed kite have the potential to forage and nest within the study area.

Migratory Birds and Bird of Prey

Fish and Game Code 3503.5 protects all birds in the orders Falconiformes and Strigiformes (collectively known as birds of prey). The MBTA protects migratory birds and other birds of prey, such as the great egret (*Ardea alba*) and the American kestrel (*Falco sparverius*). Nesting season occurs from March 1 to September 15. A killdeer (*Charadrius vociferous*) nest and the nesting pair were observed within the nonnative grassland during the May 27, 2011 biological survey of the study area. Migratory birds and other birds of prey have the potential to nest in trees within the cottonwood forest and elderberry savanna, within the ornamental landscaping associated with the ruderal/developed areas, and on the ground within the nonnative grassland within the study area.

IMPACTS AND MITIGATION MEASURES

The significance of potential impacts to biological resources was evaluated based on legal protection, local, state, and federal agency policies, and documented resource scarcity and sensitivity. The project would result in a potentially significant impact if it would:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status in local or regional plans, policies, or regulations, or by the CDFG or the USFWS;
- Have a substantial adverse effect on any riparian habitat or sensitive natural community identified in local or regional plans, policies, or regulations, or by the CDFG or the USFWS;
- Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the CWA (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means;
- Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native residents or migratory wildlife corridors or impede the use of native wildlife nursery sites;
- Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance; or
- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

Habitat Types

Table 3 summarizes the acreages of habitat types impacted by the proposed project. Impacts to aquatic habitats are discussed further within the *Potential Waters of the U.S.* section below. The USFWS and the CDFG consider elderberry savanna as a sensitive habitat type. The proposed project was designed to avoid impacts to this habitat type. The proposed project was designed to avoid impacts to the cottonwood forest. No other habitat types are considered sensitive as the ruderal/ developed areas do not provide quality habitat for native plants and wildlife, which the CDFG considers sensitive. Therefore, no mitigation is recommended. A map showing the impacted habitat areas is provided in **Figure 10**.

TABLE 3
ACREAGES OF HABITAT TYPES IMPACTED BY THE PROPOSED PROJECT

Habitat Type	Acreage[1]
Terrestrial	
Managed Nonnative Grassland	97.06
Ruderal/Developed	6.19
Aquatic	
Concrete-Lined Detention Basin	0.72
Total	**103.97**

[1]GIS calculations may not reflect exact acreage of study area due to rounding.

AES, 2011

Potential Waters of the U.S.

The concrete-lined detention basin is not a potentially jurisdictional feature because it is a manmade feature used to hold water received from runoff from the surrounding managed, nonnative grassland and ruderal/developed areas following precipitation events, lacks vegetation and soils, and is an isolated feature that lacks connectivity to a waters of the U.S. regulated under the CWA. The ephemeral drainage ditch located along the southwestern edge of the project site may be considered a potential wetland or other waters of the U.S. and may be subject to USACE jurisdiction under the CWA. The proposed project was designed to avoid impacts to the ephemeral drainage ditch. Therefore, no mitigation is recommended. Should the project be re-designed to impact or alter this drainage, a Section 404 CWA permit application, including formal delineation of waters of the U.S., would be required to be submitted to the USACE.

SOURCE: NAIP Aerial Photograph, 6/21/2009; AES, 2011

City of Sacramento 28th Street Solar Photovoltaic Farm BRA / 211526

Figure 10
Project Impacts

Special Status Plants

Dwarf Downingia (Downingia pusilla), Ahart's Dwarf Rush (Juncus leiospermus var. ahartii), and Heckard's Pepper-Grass (Lepidium latipes var. heckardii)

The proposed project would have no impacts on dwarf downingia, Ahart's dwarf rush, and Heckard's pepper-grass because these species do not occur within the project site.

Northern California Black Walnut (Juglans hindsii)

Northern California black walnut occurs within the cottonwood forest. The proposed project was designed to avoid impacts to the cottonwood forest. Therefore, this species would not be impacted and no mitigation is required.

Special Status Wildlife

Valley Elderberry Longhorn Beetle (Desmocerus californicus dimorphus; VELB)

There are several elderberry shrubs, the host plant for VELB, with stems at least one inch dgl located within 100 feet of the proposed project footprint. These shrubs are located along the southern border of the managed nonnative grassland (**Figure 7**). Removal of elderberry shrubs could result in harm to VELB which would be considered a violation of the FESA unless an incidental take authorization is obtained from the USFWS. Final design of the proposed project shall avoid removal of elderberry shrubs within stems at least one inch dgl. The following mitigation measures are recommended to avoid or reduce impacts to VELB to less than significant:

- A qualified biologist should conduct an elderberry stem survey of all elderberry shrubs within 100 feet of the proposed project footprint, in accordance with the Conservation Guidelines for the Valley Elderberry Longhorn Beetle (Conservation Guidelines; USFWS, 1999b). An Effects Analysis report should be submitted to the USFWS to document the avoidance and minimization measures identified in the Conservation Guidelines. Complete avoidance measures include:
    - The proposed project shall be designed to avoid the installation of equipment within 20 feet of any elderberry shrub with stems measuring at least one inch dgl.
    - Temporary construction fencing should be placed around the driplines of any elderberry shrubs with stems measuring at least one inch dgl prior to commencement of construction activities to ensure that no elderberry shrub is inadvertently removed. A biologist should be present during the installation of the construction fencing.
    - In all locations where the proposed project would occur within 100 feet of elderberry shrubs with stems measuring at least one inch dgl, high visibility construction fencing should be placed at the edge of the construction footprint to denote the limit of disturbance and beginning of the avoidance areas. The construction barriers and fencing should not be removed until construction activities within 100 feet of VELB habitat have been completed.
    - Signs should be erected every 50 feet along the edge of avoidance areas with the following information: "This area is habitat of the valley elderberry longhorn beetle, a threatened species, and must not be disturbed. This species is protected by the FESA, as amended. Violators are subject to prosecution, fines, and imprisonment." The signs

should be clearly readable from a distance of 20 feet, and must be maintained for the duration of construction.

- A qualified biologist should conduct an environmental awareness training to instruct all construction personnel crews about the status of the VELB and the need to protect its elderberry host plant. The training should include identification of special status species, required practices before the start of construction, general measures that are being implemented to conserve these species as they relate to the proposed pipelines, penalties for noncompliance, and boundaries of the survey area and of the permitted disturbance zones. Supporting materials containing training information should be prepared and distributed. Upon completion of training, all construction personnel should sign a form stating that they have attended the training and understand all the conservation measures. Training should be conducted in languages other than English, as appropriate. Proof of this instruction should be kept on file with the contractor. The City should provide the USFWS with a copy of the training materials and copies of the signed forms by project staff indicating that training has been completed within 30 days of the completion of the first training session. The contractor should train and provide training materials to any new crew members that were not present at the environmental awareness training conducted by the biologist. Copies of signed forms should be submitted monthly as additional training occurs for new employees.
- Staging areas should be located at least 100 feet from elderberry shrubs with stems at least one inch dgl. Temporary stockpiling of excavated or imported material should occur only in approved construction staging areas.
- Standard precautions should be employed by the construction contractor to prevent the accidental release of fuel, oil, lubricant, or other hazardous materials.
- A litter control program should be instituted. The contractor should provide closed garbage containers for the disposal of all food-related trash items (e.g., wrappers, cans, bottles, food scraps). All garbage should be removed daily.
- Roadways and areas disturbed by project activities within 100 feet of elderberry shrubs should be watered at least twice a day to minimize dust emissions.

▪ The following mitigation measures should be implemented to minimize adverse effects to VELB habitat within 20 feet of construction activities:

  - A biologist should monitor all construction activities occurring within 20 feet of the elderberry shrubs to ensure that none are harmed.
  - The contractor should ensure that dust control measures (e.g., watering) are implemented in the vicinity of the elderberry shrubs. To further minimize adverse effects associated with dust accumulation, the elderberry shrubs will be covered by a protective cloth (i.e., burlap or weed matting) during all ground-disturbing activities occurring within 20 feet of the elderberry shrubs. The cloth should be removed daily and immediately after ground-disturbing activities are completed.
  - Excluding ongoing maintenance activities within the project site, no insecticides, herbicides, fertilizers, or other chemicals that might harm VELB or the elderberry shrub

should be used in association with the proposed project within 20 feet of the elderberry shrubs.

- The following measures should be implemented following the completion of construction activities:

  - Any disturbed areas should be revegetated and restored to pre-project conditions immediately.
  - The City should provide a written report to the USFWS documenting the results of mitigation and describing how the construction areas are to be restored, protected, and maintained after construction is completed.

Swainson's Hawk (Buteo swainsoni) Nesting Habitat

Swainson's hawk has a low potential to nest within the cottonwood forest given the dense stand of trees and that the tree heights are less than 40 feet tall. The species has a greater potential to nest within the riparian vegetation along the American River outside the northern boundary of the project site. Construction activities within 0.25 miles of an active nest could result in disturbance of potential Swainson's hawk nest sites through temporary increases in ambient noise levels and increased human activity. The nearest active nest listed within the last five years on the CNDDB database was located approximately 2.5 miles from the project site; however, it is possible that active nests are located in greater proximity to the site that have either not been reported or updated on the CNDDB database managed by the CDFG. Potential disruption of nesting Swainson's hawk during construction of the proposed project could result in the abandonment of active nests. This is considered a potentially significant impact. The recommended mitigation measures identified below would ensure that impacts to nesting Swainson's hawks are reduced to less than significant levels through identification and avoidance of active nests. These measures are based on the CDFG's (1994) Swainson's Hawk Staff Report and have been modified as they relate to the proposed project. The following mitigation would be required to avoid or reduce impacts to a less than significant level:

- Prior to any construction activities that occur within the nesting season (March 1 and September 15), a qualified biologist should conduct surveys for active Swainson's hawk nests in the project site and within 0.25 miles of the project site where legally permitted. The biologist should use binoculars to visually determine whether Swainson's hawk nests occur beyond the 0.25-mile survey area if access is denied on adjacent properties. If no active Swainson's hawk nests are identified within 0.25 miles of construction activities, a letter report summarizing the survey results shall be submitted to the City within 30 days following the survey, and no further mitigation for nesting habitat is recommended.
- If active Swainson's hawk nests are found within 0.25 miles of construction activities, the biologist should contact the City within one day following the preconstruction survey to report the findings. No intensive disturbances (e.g., heavy equipment operation associated with construction, use of cranes or draglines, new rock crushing activities) or other project-related activities that could cause nest abandonment or forced fledging, shall be initiated within .25 miles (buffer zone as defined in the CDFG Staff Report) of an active nest between February 15 and September 15 or until the nestlings have fledged. Should a reduced buffer be necessary, then the CDFG should

be consulted to develop take avoidance measures, and implement a monitoring and reporting program prior to any construction activities occurring within 0.25 miles of the nest.

Swainson's Hawk (Buteo swainsoni) Foraging Habitat

The managed nonnative grassland within the project site is consider low quality Swainson's Hawk foraging habitat given the lack of preferable prey base of small rodents and rodent burrows as a result of the City's ongoing landfill management activities, including mowing and annual soil compaction. Approximately 97.06 acres of low quality foraging habitat within the managed nonnative grassland would be temporarily removed as a result of the proposed project. Once the lease for the photovoltaic solar park expires in 20 years, the project site would be restored to its pre-existing condition and landfill areas would continue to be maintained in accordance with applicable permit requirements. The temporary removal of low quality foraging habitat within the project site would not result in harm to the species as higher quality foraging habitat is present in the immediate vicinity of the study area including land designated as recreational open space to the north of the American River and land to the south of Business Route 80.

The CDFG considers 5 or more vacant acres within 5 miles of a nest that has been active within the last 5 years to be significant foraging habitat for Swainson's hawk regardless of quality, the conversion of which to urban uses is considered a significant impact. The proposed project occurs within 2.5 miles of Swainson's hawk nests that have been documented active on the CNDDB database within the last 5 years. The mitigation measure identified below would ensure that impacts to Swainson's hawk foraging habitat would be reduced to less than significant levels through the preservation and management in perpetuity of suitable foraging habitat, contiguous with other areas of suitable foraging habitat, for Swainson's hawk. Because the foraging habitat within the project site is of low quality due to the post closure maintenance activities required for the former 28th Street Landfill, the preservation of foraging habitat at the ratio identified below would be sufficient to ensure that the temporary loss of habitat on the project site would not result in substantial reduction in the numbers of species, significantly limit its range, or cause populations to be reduced below self sustaining levels. The following mitigation measure is required to reduce the loss of foraging habitat to less than significant:

- The City should purchase credits to off-set the conversion of nonnative grassland at a 0.25-to-one ratio (24.26 acres) at a CDFG-approved mitigation bank.

Burrowing Owl (Athene cunicularia)

Burrowing owls or their nests were not observed during May 27, 2011 survey of the project site. Although unlikely, burrowing owls have the potential to nest or winter within nonnative grassland along the margins of the project site. Potential disruption of burrowing owls from construction activities could result in the abandonment or loss of active nests through burrow destruction. This is considered a potentially significant impact. The following mitigation is recommended to avoid or reduce impacts to a less than significant level:

- A qualified biologist should conduct a preconstruction survey within 30 days prior to construction activities occurring within potential nesting or wintering habitat for burrowing owl, including the nonnative grassland areas that occur within the project site. In accordance with the CDFG burrowing owl survey protocol, the survey area should extend 500-feet from construction areas (CDFG, 1995) where legally permitted. The biologist should use binoculars to visually determine whether burrowing owls occur beyond the construction areas if access is denied on adjacent properties. If no burrowing owls or their sign are detected in the vicinity of the project site during the preconstruction survey, a letter report documenting survey methods and findings should be submitted to the City and the CDFG within 30 days following the survey, and no further mitigation is required.

- If unoccupied burrows are detected during the non-breeding season (September through January 31), the City should be contacted within one day following the preconstruction survey to report the findings. The City should collapse the unoccupied burrows, or otherwise obstruct their entrances to prevent owls from entering and nesting in the burrows.
- If occupied burrowing owl burrows are detected, impacts on burrows should be avoided by providing a buffer of 160 feet during the non-breeding season (September 1 through January 31) or 250 feet during the breeding season (February 1 through August 31). The size of the buffer area may be adjusted if a qualified biologist or the CDFG determine the burrowing owl would not likely be affected by the proposed project. Project activities should not commence within the buffer area until a qualified biologist confirms that the burrow is no longer occupied. If the burrow is occupied by a nesting pair, a minimum of 7.5 acres of foraging habitat contiguous to the burrow should be maintained until the breeding season is finished.
- If impacts to occupied burrows are unavoidable, onsite passive relocation techniques approved by the CDFG should be used to encourage burrowing owls to move to alternative burrows outside of the project site. No occupied burrows should be disturbed during the nesting season unless a qualified biologist verifies through non-invasive methods that juveniles from the occupied burrows are foraging independently and are capable of independent survival. Mitigation for foraging habitat for relocated pairs shall follow the guidelines provided in *the California Burrowing Owl Survey Protocol and Mitigation Guidelines* (California Burrowing Owl Consortium, 1993). The mitigation for foraging habitat for relocated pairs range from 7.5 to 19.5 acres per pair.

Migratory Birds and Other Birds of Prey

The proposed project has the potential to impact nest sites for federally and state protected migratory birds and other birds of prey within the project site. Nesting birds and other raptors, including white-tailed kite, may utilize trees in the vicinity of the project site as nesting habitat. The current design of the proposed project would not result in the removal of any trees within the study area. However, potential disruption of nesting migratory birds and other birds of prey during construction could result in nest abandonment or mortality. The mitigation measures below would ensure that impacts to nesting birds are reduced to less than significant levels through identification and avoidance of active nests. The following mitigation measures are required to avoid impacts to nest sites for migratory birds and other birds of prey:

- A preconstruction survey should be conducted by a qualified biologist for nesting birds of prey and migratory birds within 2 weeks prior to commencement of construction activities that occur between March 1 and September 15. The qualified biologist should document and submit the results of the preconstruction survey in a letter to the CDFG and the City within 30 days following the survey. The letter should include: a description of the methodology including dates of field visits, the names of survey personnel, and a list of references cited and persons contacted, and a map showing the location(s) of any bird nests observed on the project site. If no active nests are identified during the preconstruction survey, then no further mitigation is recommended so long as construction activities commence within 14 days of the preconstruction survey. An additional preconstruction survey would be recommended within 14 days of the anticipated construction commencement should construction be delayed beyond the 14 days of the previous preconstruction survey.

- If any active nests are identified during the preconstruction survey within the project site, a buffer zone should be established around the nests, in coordination with CDFG. A qualified biologist should monitor nests weekly during construction to evaluate potential nesting disturbance by construction activities. The biologist should delimit the buffer zone with construction tape or pin flags within 50 feet of the active migratory nest or within 100 feet of an active raptor nest (excluding an active Swainson's hawk nest or an occupied burrowing owl burrow) and maintain the buffer zone until the end of the breeding season or until the young have successfully fledged. If establishing the 50- or 100-foot buffer zone is impractical, then a qualified biologist would monitor any construction activity occurring within the buffer zone on a daily basis. The biologist should have the authority to halt construction activities within the buffer zone should the disturbance have the potential to result in nest abandonment or forced fledging.

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ATTACHMENTS

ATTACHMENT 1

POST-CLOSURE REPORT

ATTACHMENT 2

USFWS, CNPS, AND CNDDB LISTS

ATTACHMENT 3

PLANTS AND WILDLIFE SPECIES OBSERVED

ATTACHMENT 4

REGIONALLY OCCURRING SPECIAL STATUS SPECIES AND THEIR DESIGNATED CRITICAL HABITAT

APPENDIX B1:
SRCSD Biogas Enhancement Report

Final Project Report
June 2013

ARRA CRED Grant Funded Biogas Enhancement Project Contract No. 4110

SRCSD
Sacramento Regional County Sanitation District

Gerardo Aguirre, P.E.
Sanitation Districts Agency
Sacramento Regional Wastewater Treatment Plant
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SUBMITTAL OF

SACRAMENTO REGIONAL WASTEWATER TREATMENT PLANT

ARRA CRED GRANT FUNDED BIOGAS ENHANCEMENT PROJECT
CONTRACT NO. 4110

FINAL PROJECT REPORT

This Final Project Report is submitted by the District Project Team.

Team Member	Signature
Gerardo Aguirre SRCSD Engineering	[signature] 06/03/13
John Nurmi SRCSD Operations	[signature] 6/4/13
Grayson Kohls SRCSD Operations	[signature] 6/03/13
Debra Buckmann SRCSD Engineering	[signature] 6/3/13
Stephen Moore Policy and Planning	[signature] 6/5/13
Tim Weis SRSCD Control and Electrical	[signature] 3 JUN 13
John Bailhache SRSCS Solids Team	[signature] 6/3/13
Roger Jones SRCSD Bufferlands	[signature] 6/3/13
Jose Ramirez Policy and Planning	[signature] 6/3/2013

ARRA CRED GRANT FUNDED BIOGAS ENHANCEMENT PROJECT
CONTRACT NO. 4110

TABLE OF CONTENTS

1 -- INTRODUCTION

A. Purpose of Final Project Report

The Final Project Report is prepared after the project goes through design and construction, and all claims (if any) are settled. Occasionally, this report may be prepared at any other recognized end of project milestone. For example, if the project is terminated before starting construction, this report can be prepared to document project status through the design phase. The purpose of the Final Project Report is to summarize the results of the project delivery process.

The Final Project Report has been circulated to the Project Team members. Each team member has signed the report to acknowledge that the report reflects his/her understanding of the Project.

B. Project Background

The project began in 1996 when the Sacramento Municipal Utility District (SMUD) hired Brown and Caldwell (B&C) to perform feasibility studies. Three feasibility studies were conducted as part of that work. In addition, the Sacramento Regional County Sanitation District (SRCSD) performed a Pilot Project as recommended by B&C and the project team. A brief description of the conclusions of each phase is included below:

Sacramento Regional Wastewater Treatment Plant (SRWTP) Biogas Enhancement Feasibility Study Phase I (Jan 2006) - The study determined that the project was feasible, adequate quantities of feedstock material are available, the solids management systems at the SRWTP have adequate capacity and project constraints were identified.

SRWTP Biogas Enhancement Project Phase II Technical Feasibility (May 2007) - The study confirmed a Level 1 (brown grease) enhancement program can boost biogas production. The study also concluded solids loading to the digesters were running below 2020 Master Plan projections, anaerobic digestion capacity is available, additional gas scrubbers and staffing were required. The report recommended performing an economic feasibility study as well as a pilot study.

SRWTP Biogas Enhancement Project Phase III Economic Feasibility (August 2007) - The study determined the project was economically viable and recommended proceeding with its implementation. The study also continued to recommend performing a pilot project to refine performance expectations.

Pilot Study (Jan 2008 – Dec 2009) - The Pilot Study was designed, operated and it confirmed that the introduction of FOG and food processing wastewater (FPW) directly into the anaerobic digesters improves biogas production. A business case evaluation later prepared by District staff indicated there was a favorable economic incentive for the District to construct and operate a FOG receiving facility at the SRWTP.

The District then began the process to hire a designer to design the facility and a Request for Proposal was issued in March 2011. The District entered into a contract with Carollo Engineers, Inc. on May 25, 2011.

C. Project Description

The project consisted of designing and building a Fat, Oil and Grease (FOG) receiving station sized to receive 42,000 gpd of material. The facility consists of two offloading stations with the ability for only one station to be in use at a time. When the facility is not receiving FOG, the mixing mode is in effect and FOG material is continuously mixed and chopped by the pumps and grinders. Each station has dual strainers for redundancy, a grinder/rock trap, a mixing pump and a stainless steel storage tank. From each tank, a four inch line can feed stock material to the Mixed Sludge (MS) loop for distribution to the in-service Digester Batteries. Each FOG tank has a Variable Frequency Drive (VFD) Pump that can vary the feed rate to the process downstream of the Mixed Sludge (MS) tanks.

The project received funding from Federal and State Agencies (US Dept. of Energy - $1,455,800 and California Energy Commission $100,000). The funds from the Federal government were part of the American Recovery and Reinvestment Act (ARRA) and it was a requirement that the materials/equipment used for the project be domestic products (i.e. Made in the USA).

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2 -- FINAL PROJECT STATISTICS

A. *Project Highlights and Items of Note*

Key highlights that occurred during the project included:

Five Month Design Phase	05/25/11	The SRCSD Board approved the selection of Carollo Engineers, Inc. to begin work on the Biogas Enhancement Project under Contract No. 800000011. The initial work is for Pre-Design Services with an amendment for the design services be done at a later date.
	07/27/11	The amendment to the Agreement with Carollo is approved. The amendment is to complete the Design and provide Construction Support Services.
	08/02/11	The 50% Design Submittal is submitted for review.
	09/12/11	The 90% Design Submittal is submitted for review.
	10/05/11	The 100% Design Submittal is submitted for review.
	10/26/11	The project receives approval to advertise and solicit bids. A total of four addenda are issued and the bid date is revised to December 15th, 2011.
Award	12/15/11	A total of 12 responsive bids are received ranging in cost from $1.99 to $2.86 Million.
	01/11/12	The project is awarded to the lowest bidder Western Water Constructors (WWC), Inc. in the amount of $1,992,432.
Construction Phase	01/23/12	WWC receives Notice To Proceed.
	02/28/12	Expansive soils are encountered during excavation. Kleinfelder Engineering along with Carollo inspect the site and make a recommendation to replace expansive soils with aggregate base (AB) and place a geotextile fabric at the bottom of the excavation.
	03/19/12	The District issues a Field Instruction directing WWC to submit product information for a pump that meets the contract specification. The disagreement is related to pump brands and whether or not the pump the contractor wants to use meets the project specification.

Construction Phase

05/14/12 The contractor submits a formal claim to the District for the cost difference between pump brands plus additional costs for overhead, material mark-up, claim preparation and others. The District discusses the claim merits with District Counsel and the Construction Management and Inspection Division (CMID). The recommendation is to pay for the cost difference. A settlement agreement is reached to pay the difference in WWC's purchase price without mark-up or other additional costs.

07/11/12 The first change order for the project is approved by the District Engineer. The change order is related to the unsuitable project soils replaced with AB and requested changes to the dimensions of the FOG storage tanks.

07/24/12 A conference call is held with contractor and tank fabricator to discuss issues with the tank fabrication shop drawing submittal which shows non-compliant weld sizes. This is a continuing issue because the American Petroleum Institute (API) fabrication standard is not being followed. It is agreed that the weld sizes are to be increased at no additional cost to meet the API standard.

10/22/12 The second change order is approved by the District Engineer. The additional cost is to cover soil replacement costs with AB for a different section of the project and to pay for an additional section of road that was re-constructed.

11/14/12 The SRCSD Board approves change order no. 3 because the District Engineer change order limit has been exceeded. The additional cost is for the settlement agreement related to the pump specification dispute, additional electrical work and other miscellaneous work items.

12/12/12 The SRCSD Board approves change order no. 4 for miscellaneous extra work performed for the FOG tank fabrication and other additional work to resolve utility conflicts in the area during excavation. The change order also establishes a maximum change order amount of $303,000 for the project.

12/31/12 The project receives Substantial Completion after the testing is completed.

Activation Work

01/31/13 Pump vibration issues are observed for the Unload/Mix Pumps. The vibration issue is solved by reducing the pump speed from 240 to 170 revolutions per minute (rpm).

02/07/13 The lobes for the pumps are observed to have swollen. It is confirmed that the urethane layer covering the lobes is not compatible with FOG. The recommendation is made to replace with Buna-N lobes but they are not available off the shelf and have to be fabricated. The District is given a six weeks lead time to obtain the replacement lobes.

Activation Work

03/13/13	The SRCSD Board approves change order no. 5 for grading of the project area, installation of additional pipe supports, changes to instrumentation and other miscellaneous extra work.
03/27/13	The SRCSD Board approves change order no. 6 resulting in a credit for unused contract allowances. The change order also includes a hard fought credit for pipe support towers deleted from the contract.
04/02/13	Field acceptance is issued.
04/30/13	Swabe informs the District of fabrication challenges with the Buna-N lobes. The time period to receive the pump lobes is estimated to take an additional four weeks.
05/07/13	Swabe informs the District that the new Buna-N lobes will be ready for shipment on 05/10/13. The new lobes are received on 05/14/13. Installation and facility re-testing occurs the week of May 20th and the station is made operational by May 24th.
06/12/13	The SRCSD Board is anticipated to give final project acceptance at the June 12, 2013 meeting.

B. Construction Cost Estimate

The construction cost estimate was updated as the project progressed and project details became more refined. Construction cost estimates for the Biogas Enhancement Project at various stages of the project are presented below. Note these are only construction costs and the soft costs for the project are not included.

Planning Level ……………………… $ 1,430,000
Pre-design Level ……………………. $ 1,600,000
Bid Documents ……………………... $ 2,100,000
Low Bid …………………………….. $ 1,992,432

WWC submitted the lowest construction bid for $1,992,432. The contract with WWC had six change orders and copies of the change order summary sheets are provided Appendix C. The total construction cost including change orders is $2,263,896.37

Change Order No	Amount
Change Order No. 1	$52,553.32
Change Order No. 2	$43,433.49
Change Order No. 3	$133,231.00
Change Order No. 4	$19,334.29
Change Order No. 5	$49,727.30
Change Order No. 6	($26,815.03)
Net Change Order Amount	**$271,464.37**

C. ***Schedule & Budget***

The project schedule occurred as follows:

Phase	Schedule
Consultant Selection	May 2011
Pre-design Completion	August 2011
50% Design Stage	August 2011
90% Design Stage	September 2011
100% Design Stage	October 2011
Bid Phase	October to December 2011
Construction Phase	January to December 2012

The total project budget (estimated construction cost plus soft cost) was updated throughout the project. At the various stages, the total project budget had been estimated as follows:

Planning Level (August 2010) …..……………………… $ 2,000,000
Project Update (October 2011) ………………………..... $ 3,200,000
Current Budget (May 2013) …….………………………. $ 3,520,000

Soft costs expended as of May 6, 2013 are $1,114,463, which is 95.2% of total budgeted soft cost amount of $1,170,338. The total budgeted soft cost was 51.7% of the final construction cost including change orders. Planning level estimates assume a 50% total soft cost based on the construction cost and this project is consistent with that assumption.

Table 1 – Biogas Enhancement Project Budget and Cost Breakdown

	Budget	Budget Expended as of 05/06/13	See Notes
District Staff			
Bufferlands	$6,500	$3,161	
Engineering Design	$253,500	$252,605	
Operations Support	$27,000	$25,644	
Mech Support and Control Systems	$7,694	$0	
Policy & Planning	$35,000	$32,119	
Resident Engineer	$355,000	$351,127	
SDA Finance Office	$15,754	$15,043	
Solids Team	$10,500	$6,055	
Subtotal	**$710,948**	**$685,754**	
Consultant Engineering Costs			
Kleinfelder	$1,410	$1,410	1
Brown and Caldwell	$4,360	$4,360	2
Carollo Engineers, Inc.	$455,890	$422,939	3
Subtotal	**$461,660**	**$428,709**	
Construction Cost			
Western Water Constructors, Inc.	$2,263,897	$2,263,897	
Other Costs			
Contingency	$83,495	$32,594	
Total	**$3,520,000**	**$3,410,954**	

Notes:

1. Amount covered by contract 90000012 to evaluate project area expansive soils.
2. Amount covered by contract 93426 to develop a construction schedule.
3. Budget amount reflects the amount available to the consultant excluding Special Services and Contingency.

3 -- ACCOMPLISHMENTS AND LESSONS LEARNED

Major accomplishment and issues that occurred on the project are summarized below:

A. Accomplishments

1 -- Five-Month Design Period and Completed within Budget

The project was designed in a five month period. The design process utilized the Carollo CAMP (Concentrated Accelerated Motivated Problem Solving) concept during a three day workshop to develop the project design requirements. Additionally, the design phase was completed within budget.

2 -- Provided a satisfactory connection point at which to feed FOG

There were a few options at which to make a connection point into the Mixed Sludge (MS) System. Operations decided that the point of connection should bypass the MS tanks and connect on the discharge side the MS feed pumps. Doing this provides the shortest residence time of FOG material in the MS system and limits the amount of FOG returning to the tank. In addition, the dual FOG feed lines allow for the FOG piping to be flushed using MS. An operational strategy exists to reduce the possibility of feed lines getting clogged. This strategy automatically occurs daily or can be performed remotely by the Plant Control Center (PCC) Operators where biologically active MS is pumped through a loop to flush the system.

3 -- Avoided Additional Change Orders for Three-Way Valves

WWC submitted a change order for about $10,000 for having to provide the needed three way valves upstream of the strainers. The District identified adequate contractual description in the specification along with the piping alignment diagrams to be able to determine the correct type of three-way valve. The correct three-way valves were provided without a change order.

4 -- American Recovery and Reinvestment Act Documentation (Buy American Requirement)

Much effort went into ensuring materials used in the project were American Made to meet the grant requirements. The effort to obtain manufacturers' certifications in the product submittals and copies of invoices was significant. The District responded appropriately to all SMUD requests for information.

5 -- Proactive Approach Used to Minimize Change Orders

Utility conflicts were encountered and staff developed solutions that minimized and/or avoided change orders. An example of this was when drain lines were in conflict with electrical duct banks. Rather than lowering the drain line which would have resulted in additional excavation work, the locations of the utilities were shifted to avoid the conflict.

6 -- Held Design Consultant Accountable

The Design Consultant was held accountable for Errors and Omissions. The urethane coating on the pump lobes were found to be incompatible with FOG. An agreement was reached with the consultant to pay for a portion of the repair work. The cost to rectify this issue will be split between the pump distributor, design consultant and the District. This item also includes the changes needed by the mixing pumps to reduce their speed and rectify the pump vibration issue.

B. Lessons Learned

Lessons learned after completion of the project include:

1. *Work Closely with RE to Resolve Issues Timely*

   A number of issues including tank fabrication, pipe supports, and equipment disagreements took longer than necessary to get resolved. CMID should have taken a more active role on the project.

2. *Tight Schedule Resulted in Expedited Design*

   - Tank Material Change - The tank material change from HPDE to Stainless Steel was not fully evaluated in the Addendum during bidding and resulted in significant changes during construction. Changes in geometry, absence of tank fabrication drawings and only having a reference an API construction standard created an opportunity for the contractor to modify the design and optimize it to their benefit. In hind sight, the Addendum to replace the tank material should have been accompanied by a new tank piping layout drawing and tank fabrication details. Significant effort went into ensuring the tanks were constructed appropriately including the piping supports.

   - Grinders - The grinder specification had an error in the model number acceptable. It erroneously indicated a 3 hp model was acceptable but the properties specified in a separate table of the specification indicated the requirement for a 5 hp unit. This discrepancy was used by the contractor to provide a hybrid unit which consists of a 3 hp gearbox and an adapter with a 5 hp motor.

   - Pumps - A pump claim was submitted by the contractor due to an unclear project pump specification. The contractor received a significantly lower bid for one brand of pumps while the project specification called for a different brand or equal. The dispute was whether the brand proposed by the contractor should be considered equal. The pump claim was evaluated by District Counsel and a decision was made to pay for the cost difference of the pumps.

3. *Liquidated Damage Milestones Not Clearly Specified*

   Liquidated damages in the amount of $500 dollars per day were included in the contract as a penalty for not submitting designated critical product submittals by March 29th, 2012. The intent was to have approved submittals by that date. Instead, the pump and tank fabrication submittals were incomplete or unacceptable and the liquidated damages could not be enforced because the contractor had technically met the deadline. This could have been avoided by specifying *approved* submittals by a certain date. A second option was to require critical equipment submittals be pre-approved during the bidding phase.

4. 96-hr Operational Testing Too Short and Use of Water Not Meaningful For The Grinder

The 96-hr Operational testing period was too short and the designation of water as the test medium for the grinders was not beneficial. Two problems occurred:

a. One of the grinders had the blade disconnected from the gear box and therefore did not turn when its motor was on. Because the test medium was water, it was not recognized that a problem existed until later when FOG material was used and the grinder clogged.

b. The same grinder had a large leak in its pressure assembly unit. Too low a pressure reduces the cutting performance of the unit and creates more clogging issues. The 96-hr test was too short to notice the larger than acceptable pressure loss.

Both of these issues were noticed only after FOG material was pumped in to the system which occurred after the water test was done and the equipment was determined to have passed the test.

5. *Grant Funding and Reporting Requires a Significant Effort*

This was the first time in many years that SRCSD had received grant funding for a project which came from Federal (US Department of Energy or "DOE"), State (California Energy Commission) and local (SMUD) agencies. The District was required to set up procedures for tracking costs appropriately and monitor grant requirements. Regular coordination with US DOE and SMUD was necessary to ensure no requirements were overlooked.

In addition, the District made a significant effort to provide the required grant reports, invoices, updates and deliverables. District Finance Staff spent approximately 220 hours on this project to support over 130 reports and invoices through the project duration. In the future grant funded projects should plan for this added effort.

Table A

AGREEMENT FOR ENGINEERING SERVICES
ARRA CRED Grant Funded Biogas Enhancement Project
CONTRACT NO. 80000011

Agreement Price Ceiling	Date	Cost	Fixed Fee	Special Services	Contingency	Totals
Original Agreement	5/25/2011	$ 62,071.00	$ 7,711.00	$ -	$ 6,978.00	$ 76,760.00
Amendment 1	7/27/2011	$ 335,674.00	$ 41,186.00	$ 30,000.00	$ 40,686.00	$ 447,546.00
Total Authorized Amount		$ 397,745.00	$ 48,897.00	$ 30,000.00	$ 47,664.00	$ 524,306.00

Release of Special Services and Contingency

Special Services 1						
Special Services 2						
Special Services 3						
Contingency 1					$ 6,978.00	
Contingency 2					$ 2,270.00	
Totals				$ -	$ 9,248.00	
Remaining Balance				$ 30,000.00	$ 38,416.00	

Available to Consultant		$ 397,745.00	$ 48,897.00	$ -	$ 9,248.00	$ 455,890.00

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Table B - Biogas Project PMR Cost Spreadsheet

Numbers in red = out of balance or under/over budget.

Template Name: Large - over $100,000 (v2)		Phase Schedules >>				Start: 01 Jan 2011 End: 30 Apr 2011			Start: 01 May 2011 End: 31 Jan 2012			Start: 01 Feb 2012 End: 31 Dec 2012			Start: 01 Jan 2013 End: 31 Jul 2013			
Project ID: 459	Team(s)	Project Percentages	Project Totals			PDP2			Design			Construction			Post Construction			Project Totals
			Labor.Hrs.	Budget Amount	Actuals	Labor.Hrs.	Budget Amount	Actuals	Labor.Hrs.	Budget Amount	Actuals	Labor.Hrs.	Budget Amount	Actuals	Labor.Hrs.	Budget Amount	Actuals	Cross Check
Project Management	SRWTP Engineering		145	$13,500	$13,379	0	$0	$0	90	$8,384	$8,384	49	$4,633	$4,633	5	$483	$362	$13,500
	Sub-Total	0%	145	$13,500	$13,379	0	$0	$0	90	$8,384	$8,384	49	$4,633	$4,633	5	$483	$362	$13,500
SRCSD Labor Support	SRWTP Engineering		2580	$240,000	$239,226	0	$0	$0	751	$69,845	$69,845	1429	$132,969	$132,969	399	$37,186	$36,412	$240,000
	Policy & Planning		376	$35,000	$32,119	0	$0	$0	290	$27,000	$26,964	53	$4,942	$4,942	32	$3,058	$213	$35,000
	SDA Office of Finance		169	$15,754	$15,043	0	$0	$0	55	$5,136	$5,136	89	$8,338	$8,338	24	$2,280	$1,569	$15,754
	Operations Support		290	$27,000	$25,644	0	$0	$0	8	$820	$820	144	$13,453	$13,453	136	$12,727	$11,371	$27,000
	Solids/ Res. Team		113	$10,500	$6,055	0	$0	$0	0	$0	$0	65	$6,055	$6,055	47	$4,445	$0	$10,500
	Bufferlands		69	$6,500	$3,161	0	$0	$0	2	$257	$257	31	$2,904	$2,904	36	$3,339	$0	$6,500
	Mechanical Support		26	$2,500	$0	0	$0	$0	0	$0	$0	26	$2,500	$0	0	$0	$0	$2,500
	Control Systems		55	$5,194	$0	0	$0	$0	0	$0	$0	0	$0	$0	55	$5,194	$0	$5,194
	Sub-Total	10%	3682	$342,448	$321,248	0	$0	$0	1108	$103,058	$103,022	1840	$171,161	$168,661	733	$68,229	$49,565	$342,448
Consultant Costs	Sub-Total	13%	0	$453,620	$426,206	0	$0	$0	0	$330,821	$330,821	0	$79,503	$79,503	0	$43,296	$15,882	$453,620
Contractor Costs	Sub-Total	65%	0	$2,295,432	$2,263,898	0	$0	$0	0	$0	$0	0	$2,089,808	$2,089,808	0	$205,624	$174,090	$2,295,432
RE / CMD Costs	Sub-Total	10%	0	$355,000	$351,127	0	$0	$0	0	$0	$0	0	$338,290	$338,290	0	$16,710	$12,837	$355,000
All Other Costs	Sub-Total	1%	0	$40,000	$32,594	0	$0	$0	0	$7,352	$7,352	0	$9,942	$9,942	0	$22,706	$15,300	$40,000
Contingency	Sub-Total	1%	0	$20,000	$0	0	$0	$0	0	$0	$0	0	$0	$0	0	$20,000	$0	$20,000
	Grand Total	100%	3827	$3,520,000	$3,408,452	0	$0	$0	1198	$449,615	$449,579	1889	$2,693,337	$2,690,837	738	$377,048	$268,036	$3,520,000
			Labor.Hrs.	Budget Amount	Actuals	Labor.Hrs.	Budget Amount	Actuals	Labor.Hrs.	Budget Amount	Actuals	Labor.Hrs.	Budget Amount	Actuals	Labor.Hrs.	Budget Amount	Actuals	Cross Check
Project ID: 459	Team(s)	Project Percentages	Project Totals			PDP2			Design			Construction			Post Construction			Project Totals

Approved Project Budget= $3,520,000 Labor rate= $93 History version= 19 Last Compass Download Date= 5/3/2013 You're working with (Last Approved - 5/6/2013) data.

Manage a Team | Reset Amounts | Save Working Copy

Contract No. 4110
Biogas Enhancement Project

Sacramento Regional County Sanitation District

Table C1 - Change Order No. 1

To: Western Water Constructors, Inc., Contractor.

You are hereby directed to make the herein described changes from the plans and specifications or do the following described work not included in the original plans and specifications of this contract.

Description of work to be done, quantities and prices to be paid. Unless otherwise stated, rates for rental of equipment cover only such time as equipment is actually used and no allowance will be made for idle time. Change requested by Resident

1.	PC 6; FI 15, 15A	Overexcavate and Remove Unsuitable Soil at Project Site, Add Mirafi 500X Geotextile Fabric and Class II Aggregate Base: Add 14 Working Days.	INCREASE	$32,449.18
2.	PC 16; FI 27	Increase Height of 2 FOG Tanks from 18'-0" to 20'-0": Add 5 Working Days.	INCREASE	$19,675.74
3.	PC 11; FI 21	Add 3/4" NPT Connection on 2 FOG Tanks.	INCREASE	$428.40
		Total Cost:	**INCREASE**	**$52,553.32**

Contract Summary:

Original Contract: **$1,992,432.00** Change Order Totals: **$52,553.32** New Contract Cost: **$2,044,985.32**

By reason of this order the time of completion will be adjusted as follows: **Add 19 working days.**

Submitted by:	[signature]	Resident Engineer	Date: 7/2/12
Approval Recommended:	[signature]	Construction Manager	Date: 7/3/12
Approved by:		Director of Operations, SRCSD	Date:
Approved by:		District Engineer	Date:

We, the undersigned Contractor, have given careful consideration to the change proposed and all of its impacts, both direct and indirect, and hereby agree, if this proposal is approved, that we will provide all equipment, furnish all materials, except as may otherwise be noted above, and perform all services necessary for the work above specified, and will accept as full payment therefor the prices and time extensions shown above.

Acceptance Date: 7/03/12 Contractor: **Western Water Constructors, Inc.**

By: [signature] Title: Project Superintendent

If the Contractor does not sign acceptance of this order, his attention is directed to the requirements of the specifications as to proceeding with the ordered work and filing a written protest within the time therein specified.

cc: Contractor
Contract Desk
Resident Engineer
Auditor's Office
Board of Directors
Project Engineer

Administrator, Sanitation Districts Agency

Contract No. 4110
Biogas Enhancement Project

Sacramento Regional County Sanitation District

Table C2 - Change Order No. 2

To: Western Water Constructors, Inc., Contractor.

You are hereby directed to make the herein described changes from the plans and specifications or do the following described work not included in the original plans and specifications of this contract.

Description of work to be done, quantities and prices to be paid. Unless otherwise stated, rates for rental of equipment cover only such time as equipment is actually used and no allowance will be made for idle time. Change requested by Resident Engineer.

1.	PC 27; FI 34A	Replace Unsuitable Soil with Class II Aggregate Base, Add Geotextile Fabric along 40 Lineal Feet of Central Street, and Remove & Replace 275 Lineal Feet of Existing Asphalt Paving along Central Street.	5 Days	INCREASE	$23,218.97
2.	PC 25; FI 30	Remove 12" of Native Soil, Add Geotextile Fabric and Class II Aggregate Base along FOG Loop Roadway.	3 Days	INCREASE	$20,214.52
		Total Cost:		INCREASE	$43,433.49

Contract Summary:

Original Contract: $1,992,432.00 Change Order Totals: $95,986.81 New Contract Cost: $2,088,418.81

By reason of this order the time of completion will be adjusted as follows: Add 8 working days.

Submitted by:	[signature]	Resident Engineer	Date: 10/12/12
Approval Recommended:	[signature]	Construction Manager	Date: 10/15/12
Approved by:	Ruben Roble	Director of Operations, SRCSD	Date: 10/17/12
Approved by:	[signature]	District Engineer	Date: 10/22/12

We, the undersigned Contractor, have given careful consideration to the change proposed and all of its impacts, both direct and indirect, and hereby agree, if this proposal is approved, that we will provide all equipment, furnish all materials, except as may otherwise be noted above, and perform all services necessary for the work above specified, and will accept as full payment therefor the prices and time extensions shown above.

Acceptance Date: 10/15/12 Contractor: Western Water Constructors, Inc.

By: [signature] Title: Project Superintendent

If the Contractor does not sign acceptance of this order, his attention is directed to the requirements of the specifications as to proceeding with the ordered work and filing a written protest within the time therein specified.

cc: Contractor, Contract Desk, Resident Engineer, Auditor's Office, Board of Directors, Project Engineer

[signature]
Administrator, Sanitation Districts Agency

ATTACHMENT
Sacramento Regional County Sanitation District

Contract No. 4110
Biogas Enhancement Project

Table C3 - Change Order No. 3

To: Western Water Constructors, Inc., Contractor.

You are hereby directed to make the herein described changes from the plans and specifications or do the following described work not included in the original plans and specifications of this contract.

Description of work to be done, quantities and prices to be paid. Unless otherwise stated, rates for rental of equipment cover only such time as equipment is actually used and no allowance will be made for idle time. Change requested by Resident

1.	PC 9	Provide Swaby Rotary Lobe Positive Displacement Pumps.	INCREASE	$98,320.00
2.	PC 14; FI 33	Add Electrical Circuits for Heat Trace System	INCREASE	$22,712.91
3.	PC 21; FI 26	Remove Abandoned Duct Bank.	INCREASE	$7,407.28
4.	PC 18; FI 23	Remove CLSM at Crossing of Chemical Piping.	INCREASE	$2,347.40
5.	PC 24; FI 35	Provide Ladder Extensions at FOG Tanks	INCREASE	$1,636.10
6.	PC 19; FI 24	Pipe Reclaimed Water to Pumps for Seal Lubrication.	INCREASE	$611.18
7.	PC 7; FI 16, 16A	Add Three 1" Conduits Under the Truck Drive/Unload Pad.	INCREASE	$196.13
		Total Cost:	**INCREASE**	**$133,231.00**

Contract Summary:

Original Contract: **$1,992,432.00** Change Order Totals: **$227,231.80** New Contract Cost: **$2,219,663.80**

By reason of this order the time of completion will be adjusted as follows: **Add 6 working days.**

Submitted by: ______________________ Resident Engineer Date: __________

Approval Recommended: ______________________ Construction Manager Date: __________

Approved by: ______________________ Director of Operations, SRCSD Date: __________

Approved by: ______________________ District Engineer Date: __________

We, the undersigned Contractor, have given careful consideration to the change proposed and all of its impacts, both direct and indirect, and hereby agree, if this proposal is approved, that we will provide all equipment, furnish all materials, except as may otherwise be noted above, and perform all services necessary for the work above specified, and will accept as full payment therefor the prices and time extensions shown above.

Acceptance Date: ______________________ Contractor: **Western Water Constructors, Inc.**

By: ______________________ Title: ______________________

If the Contractor does not sign acceptance of this order, his attention is directed to the requirements of the specifications as to proceeding with the ordered work and filing a written protest within the time therein specified.

cc: Contractor *Auditor's Office*
Contract Desk *Board of Directors*
Resident Engineer *Project Engineer*

____
Chairman of the Board

Contract No. 4110
Biogas Enhancement Project

Sacramento Regional County Sanitation District

For the Agenda of: 12/12/2012
Sheet 1 of 1

Table C4 - Change Order No. 4

To: Western Water Constructors, Inc., Contractor.

You are hereby directed to make the herein described changes from the plans and specifications or do the following described work not included in the original plans and specifications of this contract.

Description of work to be done, quantities and prices to be paid. Unless otherwise stated, rates for rental of equipment cover only such time as equipment is actually used and no allowance will be made for idle time. Change requested by Resident Engineer.

1.	PC 35; FI 40	Increase Access Opening Size from 24" to 30" and Add Hinged Covers on FOG Tanks.	INCREASE	$10,882.24
2.	PC 22; FI 28A	Modify Slab Rebar and Curb & Gutter Rebar at Existing SD Piping (Add 3 working days).	INCREASE	$8,132.42
3.	PC 12; FI 19	Modify Rebar for Channel near FOG Tanks	INCREASE	$2,697.15
4.	PC 34; FI 39	Increase Wire Size and Conduit to Transformer	INCREASE	$692.10
5.	PC 33; FI 38	Delete 34 Lifting Rings for Tread Plates.	DECREASE	($3,069.62)
		Total Cost:	**INCREASE**	**$19,334.29**

Contract Summary:

Original Contract: **$1,992,432.00** Change Order Totals: **$248,552.10** New Contract Cost: **$2,240,984.10**

By reason of this order the time of completion will be adjusted as follows: **Add 3 working days.**

Submitted by:	[signature]	Resident Engineer	Date: 11/16/12
Approval Recommended:	[signature]	Construction Manager	Date: 11/16/12
Approved by:	[signature]	Director of Operations, SRCSD	Date: 11/20/12
Approved by:	[signature]	District Engineer	Date: 11/26/12

We, the undersigned Contractor, have given careful consideration to the change proposed and all of its impacts, both direct and indirect, and hereby agree, if this proposal is approved, that we will provide all equipment, furnish all materials, except as may otherwise be noted above, and perform all services necessary for the work above specified, and will accept as full payment therefor the prices and time extensions shown above.

Acceptance Date: 11/16/12 Contractor: Western Water Constructors, Inc.

By: [signature] Title: Project Superintendent

If the Contractor does not sign acceptance of this order, his attention is directed to the requirements of the specifications as to proceeding with the ordered work and filing a written protest within the time therein specified.

[signature]
Chairman of the Board

cc: *Contractor*, *Contract Desk*, *Resident Engineer*, *Auditor's Office*, *Board of Directors*, *Project Engineer*

Contract No. 4110
Biogas Enhancement Project

Sacramento Regional County Sanitation District

Table C5 - Change Order No. 5

To: Western Water Constructors, Inc., Contractor.

You are hereby directed to make the herein described changes from the plans and specifications or do the following described work not included in the original plans and specifications of this contract.

Description of work to be done, quantities and prices to be paid. Unless otherwise stated, rates for rental of equipment cover only such time as equipment is actually used and no allowance will be made for idle time. Change requested by Resident Engineer.

1.	PC 23; FI 29, 29A	Grade Site to Meet Facility Elevations and Add Storm Drain Culvert Across Central Street.	INCREASE	$15,855.13
2.	PC 20; FI 25, 25A, 25B	Add 11 Pipe Hangers and 7 Unistrut Supports for Fats, Oil and Grease (FOG) Piping in Pipe Chase and Mixed Sludge Gallery.	INCREASE	$13,783.98
3.	PC 4	Upgrade Connection Seals and Add Four Connections for Pressure Gauges and Switches.	INCREASE	$9,596.16
4.	PC 30; FI 36	Add Two Reducers and Modify 4-inch Glass-Lined Piping to 6-inch Pumps.	INCREASE	$5,053.74
5.	PC 49	Add Concrete and Fill Around FOG Station.	INCREASE	$2,642.50
6.	PC 8; FI 17	Add Pipe Supports for Two Flowmeters in the FOG Piping System.	INCREASE	$1,576.88
7.	PC 17; FI 22	Add Mop Sink Slab and Piping to Trench Drain.	INCREASE	$1,213.63
8.	PC 37; FI 42	Add Orifices to Blind Flanges and Relocate Two Tank Level Sensors.	INCREASE	$1,094.29
9.	PC 38; FI 43, 43A	Add Gate in Facility Fence.	INCREASE	$989.60
10.	PC 29; FI 37	Add Three Supports for FOG Influent Piping.	INCREASE	$691.57
11.	PC 48	Resurvey Site to Revised Coordinates.	INCREASE	$449.30
12.	PC 46; FI 48	Rotate Water Heater.	INCREASE	$188.12
13.	PC 39	Delete Two Aluminum Fire Extinguisher Stands.	DECREASE	($802.18)
14.	PC 47	Delete Installation of One Set of Stairs.	DECREASE	($1,031.36)
15.	PC 15; FI 44	Substitute Plastic for SS Rebar Chairs.	DECREASE	($1,574.06)
		Total Cost:	**INCREASE**	**$49,727.30**

Contract Summary:

Original Contract: **$1,992,432.00** Change Order Totals: **$298,279.40** New Contract Cost: **$2,290,711.40**

By reason of this order the time of completion will be adjusted as follows: **Add 14 working days.**

Submitted by:	[signature]	Resident Engineer	Date: 2/1/13
Approval Recommended:	[signature]	Construction Manager	Date: 2/1/13
Approved by:	[signature]	Director of Operations, SRCSD	Date: 2/12/13
Approved by:		District Engineer	Date:

We, the undersigned Contractor, have given careful consideration to the change proposed and all of its impacts, both direct and indirect, and hereby agree, if this proposal is approved, that we will provide all equipment, furnish all materials, except as may otherwise be noted above, and perform all services necessary for the work above specified, and will accept as full payment therefor the prices and time extensions shown above.

Acceptance Date: 1/30/13 Contractor: Western Water Constructors, Inc.

By: [signature] Title: PROJECT MANAGER

If the Contractor does not sign acceptance of this order, his attention is directed to the requirements of the specifications as to proceeding with the ordered work and filing a written protest within the time therein specified.

[signature]
Chairman of the Board

cc: *Contractor*
Contract Desk
Resident Engineer
Auditor's Office
Board of Directors
Project Engineer

Contract No. 4110
Biogas Enhancement Project

Sacramento Regional County Sanitation District

For the Agenda of: 3/27/2013
Sheet 1 of 1

Table C6 - Change Order No. 6

To: Western Water Constructors, Inc., Contractor.

You are hereby directed to make the herein described changes from the plans and specifications or do the following described work not included in the original plans and specifications of this contract.

Description of work to be done, quantities and prices to be paid. Unless otherwise stated, rates for rental of equipment cover only such time as equipment is actually used and no allowance will be made for idle time. Change requested by Resident Engineer.

1.	PC 51	Unused Allowance for Implementation and Maintenance of the WPCP .	DECREASE	($1,135.61)
2.	PC 45	Delete Pipe Towers at FOG Tanks.	DECREASE	($4,519.15)
3.	PC 50	Unused Allowance for Utility Conflicts.	DECREASE	($6,545.88)
4.	PC 52	Unused Allowance for Environmental Mitigation Allowance.	DECREASE	($14,614.39)
		Total Cost:	**DECREASE**	**($26,815.03)**

Contract Summary:

Original Contract: **$1,992,432.00** Change Order Totals: **$271,464.37** New Contract Cost: **$2,263,896.37**

By reason of this order the time of completion will be adjusted as follows: **No adjustment warranted.**

Submitted by: ______________________ Resident Engineer Date: __________

Approval Recommended: ______________________ Construction Manager Date: __________

Approved by: ______________________ Director of Operations, SRCSD Date: __________

Approved by: ______________________ District Engineer Date: __________

We, the undersigned Contractor, have given careful consideration to the change proposed and all of its impacts, both direct and indirect, and hereby agree, if this proposal is approved, that we will provide all equipment, furnish all materials, except as may otherwise be noted above, and perform all services necessary for the work above specified, and will accept as full payment therefor the prices and time extensions shown above.

Acceptance Date: ______________________ Contractor: **Western Water Constructors, Inc.**

By: ______________________ Title: ______________________

If the Contractor does not sign acceptance of this order, his attention is directed to the requirements of the specifications as to proceeding with the ordered work and filing a written protest within the time therein specified.

cc: Contractor *Auditor's Office*
Contract Desk *Board of Directors*
Resident Engineer *Project Engineer*

____
Chairman of the Board

APPENDIX B2:
SRCSD Supplemental Operational Data Report

Biogas Enhancement Project

Operational Data Report

Supplement to the June 2013 Final Report

May 2014

Contents

The cover image shows the Biogas Enhancement Plant offloading facility with the heated pipes that lead to the digesters in the lower right.

Executive Summary

At the request of the Sacramento Municipal Utility District (SMUD), the Sacramento Regional County Sanitation District (Regional San) has prepared this Operational Data Report as a supplement to the Biogas Enhancement Project (BEP) Final Project Report that was completed in June 2013. The implementation of the BEP was a joint effort between Regional San and SMUD. The BEP began operational testing in January 2013 and became functional in June 2013.

The BEP is located at the Sacramento Regional Wastewater Treatment Plant (SRWTP). The BEP was designed to handle up to 42,000 gallons per day (gpd) of feedstock material that includes fats, oils, and greases (FOG) and food processing wastes (FPW), such as soda pop waste. The estimated 42,000 gpd includes 30,000 gpd of FOG and 12,000 gpd of FPW materials. The BEP facility allows these materials to bypass the primary and secondary treatment processes at SRWTP, as shown in Figure 1. The material is injected into anaerobic digesters to enhance the generation of biogas, which SMUD uses to produce renewal energy.

A phased approach is being implemented to introduce FOG and FPW material into the BEP. The initial stage of operation for the BEP started in July 2013. In the initial phase, only FOG deliveries were allowed into the BEP. The BEP received FOG deliveries ranging from no daily deliveries to approximately 15,000 gpd. Regional San limited FOG deliveries in the first few months so staff could gain operational experience, avoid digester upsets, and ensure system stability. Only FOG material within Sacramento County were accepted during the startup phase. In December 2013, Regional San started allowing out-of-County FOG sources. As operational issues are resolved and system stability is ensured, the system capacity will be gradually increased to receive more FOG material. The next phase is also planned to include the introduction of FPW material into the BEP.

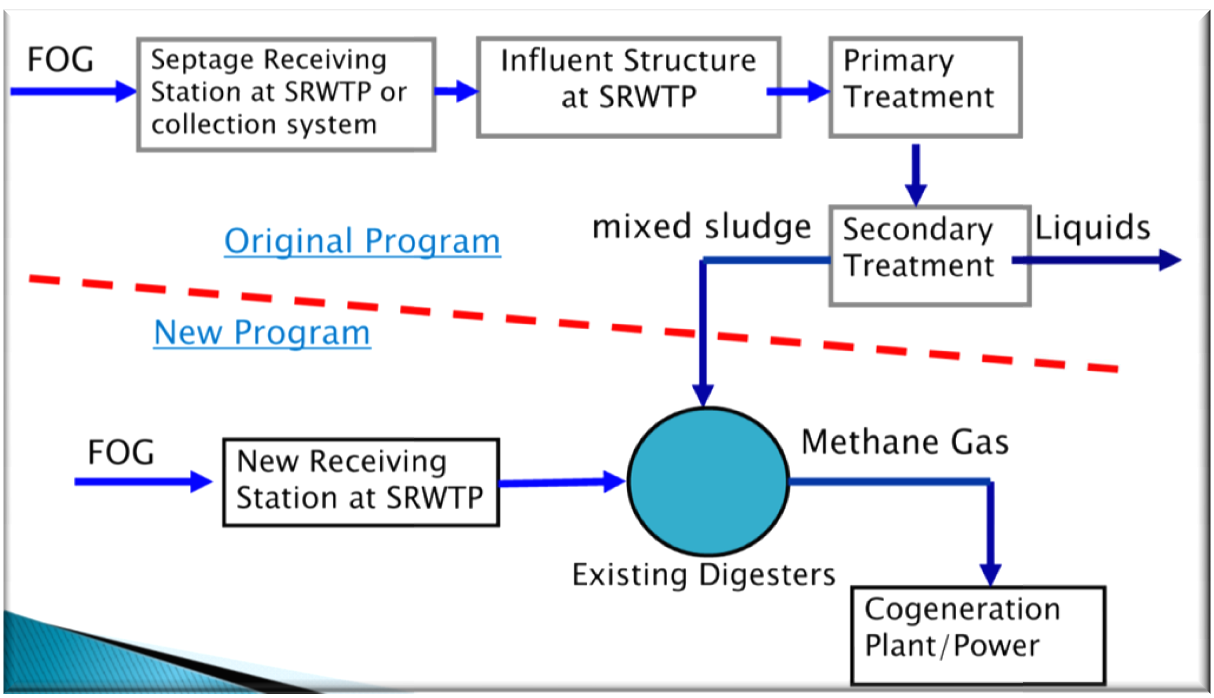


Figure 1 – Schematic of Existing vs. New Biogas Program

Background

The Biogas Enhancement Plant (BEP) began operational testing in January 2013. Its construction was a joint effort by the Sacramento Regional County Sanitation District (Regional San) and the Sacramento Municipal Utilities District (SMUD). The project's goal was to increase the production of "green" renewable energy in the Sacramento region. (Please see the *Biogas Enhancement Final Project Report* dated June 6, 2013 for additional history for this project.)

Figure 2 – Project Sign

The BEP was made feasible by two grants that SMUD received: $1,455,800 from the U.S. Department of Energy and $100,000 from the California Energy Commission. These grants were provided through the American Recovery and Reinvestment Act.

Figure 3 – Connection Port

The BEP is located at Sacramento Regional Wastewater Treatment Plant (SRWTP). The BEP facility was designed to handle up to 42,000 gallons per day of fats, oils, and greases (FOG) and food processing waste (FPW) feedstock material. This material is injected directly into an anaerobic digester to generate biogas. SMUD uses the biogas to produce renewable energy.

The facility consists of two 13,500 storage tanks, two offloading stations, pumps, odor control, strainers, rock traps, grinders, flow meters, and valves along two heated pipes from the offloading facility to the digesters.

Figure 4 – Hauler Connecting to the BEP

The BEP started operations in July 2013. In the first few months, deliveries were limited so Regional San staff could gain operational experience, avoid digester upsets, and ensure system stability. Initially, Regional San only accepted FOG and FPW from within Sacramento County that was delivered by certified haulers. This out-of-county restriction was lifted in December 2013. As operational issues are resolved and system stability is ensured, the system capacity will be gradually increased to receive more FOG and FPW material.

Results

Figure 5 – Unloading Station and BEP Tanks

A phased approach is being implemented to introduce FOG and FPW material into the BEP. The initial stage of operation for the BEP started in July 2013. In the initial phase, only FOG deliveries were allowed into the BEP. The BEP received FOG deliveries ranging from no daily deliveries up to 15,000 gpd. When there is a FOG discharge, i.e. not counting days when there is no FOG delivery or discharge, the average daily discharge is approximately 4,500 gpd. With these lower feed rates, a significant increase in biogas was not expected. Regional San staff have seen a 9% increase in biogas production between 2012 and 2013. However, it is not clear at this time how much of this increase is due to the BEP versus normal operational fluctuations.

Regional will continue to monitor its measuring methods and monitor biogas production to better determine the amount of additional biogas that is being produced by the BEP.

Data Analysis

The complete operational data from July 1, 2013 through December 31, 2013 can be found in Appendix A. The next two tables below shows a typical BEP high-feed day (Table 1) and a low-feed day (Table 2).

Table 1: BEP High-feed Day (7/10/2013)

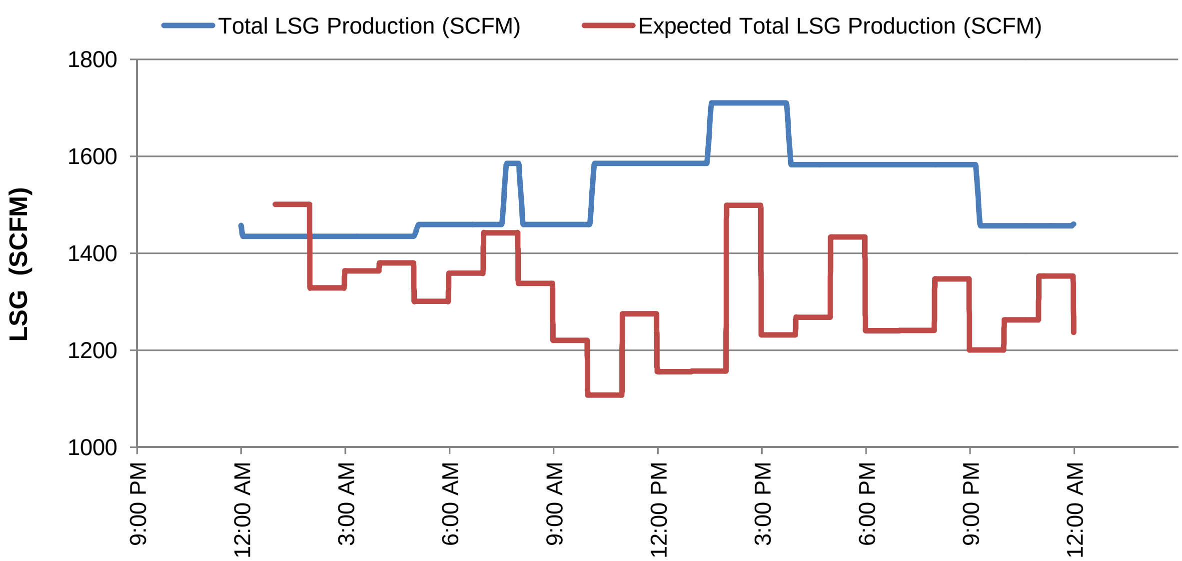
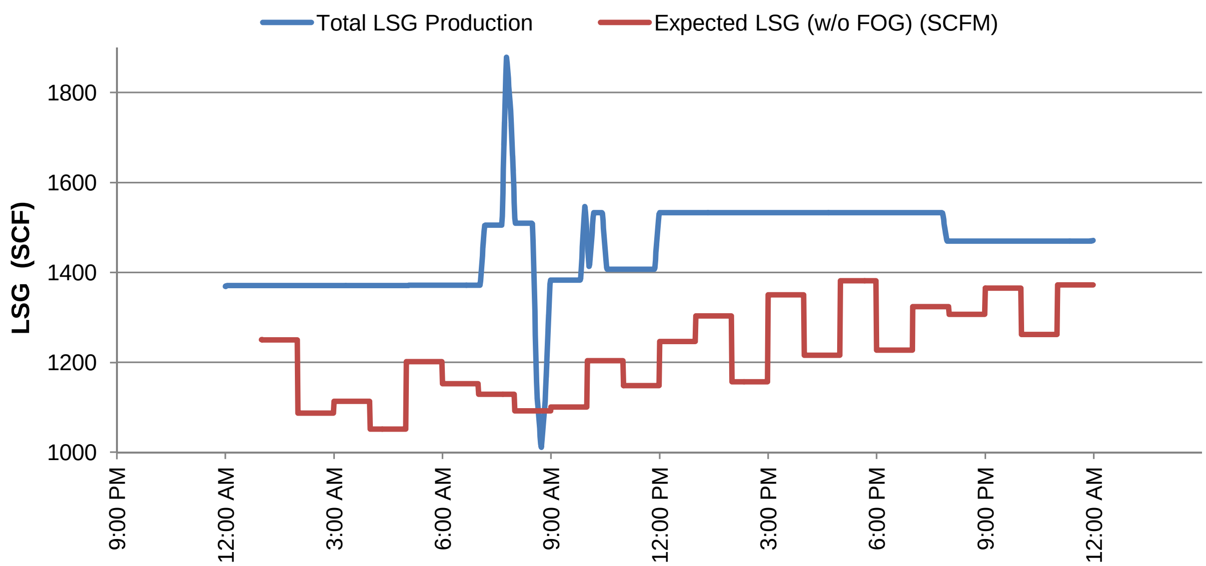
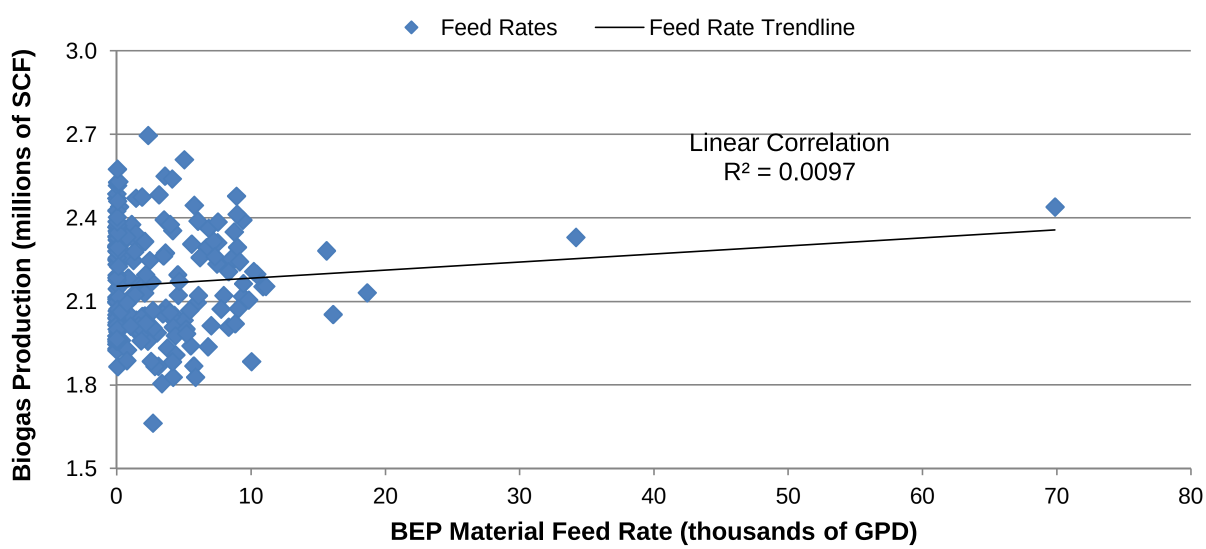


Table 2: BEP Low -feed Day (8/8/2014)



When comparing these two graphs, it is difficult to see a substantial difference on these two days. When staff looked at the overall data, there is a general trend toward more biogas than expected produced during FOG feeding. On days when there was no material from the BEP, biogas production was still greater than baseline levels. On a larger time scale, there is a trend toward greater gas production as feeds increased but the correlation is very weak as shown in Table 3. Until more regular and substantial FOG and FPW feeds are received, it will likely be difficult to see the ultimate increase in biogas production.

Table 3: BEP Material and Biogas Produced



Next Steps

Regional San plans to implement the following steps to increase the production of biogas at the SRWTP through the BEP:

- Identify and resolve any outstanding operational issues that may hinder the delivery of more feedstock materials
- Engage the liquid FOG waste haulers to increase FOG deliveries to the BEP
- Engage the producers and waste haulers of FPW material, e.g. soda pop waste streams, to start bringing FPW into the BEP

Regional San staff also anticipates confirming or updating in the future the assumptions used in the business case evaluation that determined the feasibility of the BEP.

Appendix A: Operational Data

Appendix A contains Operational information collected by Regional San from 7/1/2013 to 12/31/2013.

Abbreviations

- ACC: area control center
- BATT: battery
- BEP: Biogas Enhancement Plant
- Calc: calculated
- COD: chemical oxygen demand
- DL:daily log
- FOG or Fog: fats, oils, and grease
- FPW: food processor waste
- Gal/Day: gallons per day
- GPD: gallons per day
- KSCF: thousands of standard cubic feet
- LIMS: laboratory information management system
- LSG: low-pressure
- MaRS: monitoring and reporting system
- MG/L or mg/L: milligrams per liter
- MGD: million gallons per day
- MODS: monthly operating data system
- MS: mixed sludge
- PCCS: plant computer control system
- pH: standard measure of acidity
- PROD: produced
- R^2: R-squared, a measure of how well the data matches a trend, 1 being the closest match
- Regional San: Sacramento County Regional County Sanitation District
- SCF/Gallons: standard cubic feet of biogas per gallon of sludge
- SCF: standard cubic foot
- SMUD: Sacrament Municipal Utility District
- STD: standard
- lbs: pounds

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Std Rpt ppc - C - From Material

Column #	1	2	3	4	5	6	7	8	9		10		
MaRS ID	1554	1549	1553	1550	1551	1555	1547	1548	244		795		
Test Point	FOG MS Volatile Solids	FOG COD	Fog MS Total Solids	FOG pH	FOG Receiving 1 Deliveries	FOG Receiving 2 Deliveries	FOG Total Solids	FOG Volatile Solids	TOTAL LSG PRODUCTION	**TOTAL LSG PRODUCTION**	TOTAL MS FLOW BATT 2-3	**TOTAL MS FLOW BATT 2-3**	**Gas/Flow**
ACC	8	8	8	8	8	8	8	8	8		8		
Source	Calc	LIMS	Calc	LIMS	PCCS DL	PCCS DL	LIMS	LIMS	PCCS DL		Calc		
Sample Freq		7 per Week		7 per Week	7 per Week	7 per Week	7 per Week	7 per Week					
Source ID		FOG StationCOD-HA-W		FOG StationSM4500-H+B	V890001R	V890002R	FOG StationSM2540B	FOG StationVS-S	TOT_LSG_PROD				
Compound		COD,Total-HighRange		pH,Field Measurement			Total Solids	Volatile Solids					
MODS ID									201011		301608		
Units	%	MG/L	%	STD UNITS	DELIVERIES	DELIVERIES	%	%	KSCF	**SCF**	MGD	**Gal/Day**	**SCF/Gallons**
1/1/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,428	2,428,000	0.92	920,000	2.6
1/2/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,331	2,331,000	0.87	870,000	2.7
1/3/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,383	2,383,000	0.87	870,000	2.7
1/4/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,337	2,337,000	0.8	800,000	2.9
1/5/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,383	2,383,000	0.86	860,000	2.8
1/6/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,421	2,421,000	0.81	810,000	3.0
1/7/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,280	2,280,000	0.93	930,000	2.5
1/8/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,329	2,329,000	1.02	1,020,000	2.3
1/9/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,369	2,369,000	0.89	890,000	2.7
1/10/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,445	2,445,000	0.94	940,000	2.6
1/11/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,354	2,354,000	0.86	860,000	2.7
1/12/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,283	2,283,000	0.86	860,000	2.7
1/13/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,187	2,187,000	0.81	810,000	2.7
1/14/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,248	2,248,000	0.89	890,000	2.5
1/15/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,263	2,263,000	0.94	940,000	2.4
1/16/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,438	2,438,000	0.96	960,000	2.5
1/17/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,399	2,399,000	0.93	930,000	2.6
1/18/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,355	2,355,000	0.86	860,000	2.7
1/19/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,450	2,450,000	0.89	890,000	2.8
1/20/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,432	2,432,000	0.89	890,000	2.7
1/21/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,361	2,361,000	0.89	890,000	2.7
1/22/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,380	2,380,000	0.91	910,000	2.6
1/23/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,357	2,357,000	0.94	940,000	2.5
1/24/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,385	2,385,000	0.94	940,000	2.5
1/25/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,464	2,464,000	0.99	990,000	2.5
1/26/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,396	2,396,000	0.94	940,000	2.5
1/27/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,208	2,208,000	0.89	890,000	2.5
1/28/2013	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	2,259	2,259,000	0.99	990,000	2.3
1/29/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.99	990,000	
1/30/2013	No Data	No Data	No Data	No Data	2	0	No Data	No Data	0		0.99	990,000	
1/31/2013	10,459,740,920	16,000	-30,333,248,412.30	4.2	0	2	0.4	88	0		1.12	1,120,000	
2/1/2013	No Data	No Data	No Data	No Data	2	1	No Data	No Data	0		1.15	1,150,000	
2/2/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.07	1,070,000	
2/3/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.03	1,030,000	
2/4/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
2/5/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.06	1,060,000	
2/6/2013	No Data	No Data	No Data	No Data	1	0	No Data	No Data	0		1.04	1,040,000	

Std Rpt ppc - C - From Material

Column #	1	2	3	4	5	6	7	8	9		10		
MaRS ID	1554	1549	1553	1550	1551	1555	1547	1548	244		795		
Test Point	FOG MS Volatile Solids	FOG COD	Fog MS Total Solids	FOG pH	FOG Receiving 1 Deliveries	FOG Receiving 2 Deliveries	FOG Total Solids	FOG Volatile Solids	TOTAL LSG PRODUCTION	**TOTAL LSG PRODUCTION**	TOTAL MS FLOW BATT 2-3	**TOTAL MS FLOW BATT 2-3**	**Gas/Flow**
ACC	8	8	8	8	8	8	8	8	8		8		
Source	Calc	LIMS	Calc	LIMS	PCCS DL	PCCS DL	LIMS	LIMS	PCCS DL		Calc		
Sample Freq		7 per Week		7 per Week	7 per Week	7 per Week	7 per Week	7 per Week					
Source ID		FOG StationCOD-HA-W		FOG StationSM4500-H+B	V890001R	V890002R	FOG StationSM2540B	FOG StationVS-S	TOT_LSG_PROD				
Compound		COD,Total-HighRange		pH,Field Measurement			Total Solids	Volatile Solids					
MODS ID									201011		301608		
Units	%	MG/L	%	STD UNITS	DELIVERIES	DELIVERIES	%	%	KSCF	**SCF**	MGD	**Gal/Day**	**SCF/Gallons**
2/7/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
2/8/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
2/9/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.12	1,120,000	
2/10/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.04	1,040,000	
2/11/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.99	990,000	
2/12/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.07	1,070,000	
2/13/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.12	1,120,000	
2/14/2013	No Data	No Data	No Data	No Data	1	0	No Data	No Data	0		1.12	1,120,000	
2/15/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
2/16/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.07	1,070,000	
2/17/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
2/18/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.07	1,070,000	
2/19/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.1	1,100,000	
2/20/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.15	1,150,000	
2/21/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.07	1,070,000	
2/22/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.06	1,060,000	
2/23/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
2/24/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.04	1,040,000	
2/25/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.09	1,090,000	
2/26/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.09	1,090,000	
2/27/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.17	1,170,000	
2/28/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.1	1,100,000	
3/1/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.14	1,140,000	
3/2/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.14	1,140,000	
3/3/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.06	1,060,000	
3/4/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
3/5/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.14	1,140,000	
3/6/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.07	1,070,000	
3/7/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.99	990,000	
3/8/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.06	1,060,000	
3/9/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.1	1,100,000	
3/10/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.08	1,080,000	
3/11/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.05	1,050,000	
3/12/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.98	980,000	
3/13/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.98	980,000	
3/14/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.04	1,040,000	
3/15/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.11	1,110,000	
3/16/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.05	1,050,000	

Std Rpt ppc - C - From Material

Column #	1	2	3	4	5	6	7	8	9		10		
MaRS ID	1554	1549	1553	1550	1551	1555	1547	1548	244		795		
Test Point	FOG MS Volatile Solids	FOG COD	Fog MS Total Solids	FOG pH	FOG Receiving 1 Deliveries	FOG Receiving 2 Deliveries	FOG Total Solids	FOG Volatile Solids	TOTAL LSG PRODUCTION	**TOTAL LSG PRODUCTION**	TOTAL MS FLOW BATT 2-3	**TOTAL MS FLOW BATT 2-3**	**Gas/Flow**
ACC	8	8	8	8	8	8	8	8	8		8		
Source	Calc	LIMS	Calc	LIMS	PCCS DL	PCCS DL	LIMS	LIMS	PCCS DL		Calc		
Sample Freq		7 per Week		7 per Week	7 per Week	7 per Week	7 per Week	7 per Week					
Source ID		FOG StationCOD-HA-W		FOG StationSM4500-H+B	V890001R	V890002R	FOG StationSM2540B	FOG StationVS-S	TOT_LSG_PROD				
Compound		COD,Total-HighRange		pH,Field Measurement			Total Solids	Volatile Solids					
MODS ID									201011		301608		
Units	%	MG/L	%	STD UNITS	DELIVERIES	DELIVERIES	%	%	KSCF	**SCF**	MGD	**Gal/Day**	**SCF/Gallons**
3/17/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.96	960,000	
3/18/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
3/19/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.06	1,060,000	
3/20/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.03	1,030,000	
3/21/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
3/22/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.97	970,000	
3/23/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1	1,000,000	
3/24/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.99	990,000	
3/25/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.99	990,000	
3/26/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.96	960,000	
3/27/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.92	920,000	
3/28/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.94	940,000	
3/29/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.01	1,010,000	
3/30/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1	1,000,000	
3/31/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.92	920,000	
4/1/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.92	920,000	
4/2/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1	1,000,000	
4/3/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.79	790,000	
4/4/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.12	1,120,000	
4/5/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.05	1,050,000	
4/6/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
4/7/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.02	1,020,000	
4/8/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.95	950,000	
4/9/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		1.05	1,050,000	
4/10/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.91	910,000	
4/11/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.92	920,000	
4/12/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.87	870,000	
4/13/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.91	910,000	
4/14/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.92	920,000	
4/15/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.87	870,000	
4/16/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	0		0.82	820,000	
4/17/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,367	2,367,000	0.9	900,000	2.6
4/18/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,470	2,470,000	0.92	920,000	2.7
4/19/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,387	2,387,000	0.87	870,000	2.7
4/20/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,299	2,299,000	0.87	870,000	2.6
4/21/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,333	2,333,000	0.87	870,000	2.7
4/22/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,281	2,281,000	0.87	870,000	2.6
4/23/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,331	2,331,000	0.92	920,000	2.5

Std Rpt ppc - C - From Material

Column #	1	2	3	4	5	6	7	8	9		10		
MaRS ID	1554	1549	1553	1550	1551	1555	1547	1548	244		795		
Test Point	FOG MS Volatile Solids	FOG COD	Fog MS Total Solids	FOG pH	FOG Receiving 1 Deliveries	FOG Receiving 2 Deliveries	FOG Total Solids	FOG Volatile Solids	TOTAL LSG PRODUCTION	**TOTAL LSG PRODUCTION**	TOTAL MS FLOW BATT 2-3	**TOTAL MS FLOW BATT 2-3**	**Gas/Flow**
ACC	8	8	8	8	8	8	8	8	8		8		
Source	Calc	LIMS	Calc	LIMS	PCCS DL	PCCS DL	LIMS	LIMS	PCCS DL		Calc		
Sample Freq		7 per Week		7 per Week	7 per Week	7 per Week	7 per Week	7 per Week					
Source ID		FOG StationCOD-HA-W		FOG StationSM4500-H+B	V890001R	V890002R	FOG StationSM2540B	FOG StationVS-S	TOT_LSG_PROD				
Compound		COD,Total-HighRange		pH,Field Measurement			Total Solids	Volatile Solids					
MODS ID									201011		301608		
Units	%	MG/L	%	STD UNITS	DELIVERIES	DELIVERIES	%	%	KSCF	**SCF**	MGD	**Gal/Day**	**SCF/Gallons**
4/24/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,435	2,435,000	0.88	880,000	2.8
4/25/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,401	2,401,000	0.86	860,000	2.8
4/26/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,303	2,303,000	0.87	870,000	2.6
4/27/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,256	2,256,000	0.85	850,000	2.7
4/28/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,266	2,266,000	0.87	870,000	2.6
4/29/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,197	2,197,000	0.83	830,000	2.6
4/30/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,241	2,241,000	0.92	920,000	2.4
5/1/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,358	2,358,000	0.91	910,000	2.6
5/2/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,440	2,440,000	0.92	920,000	2.7
5/3/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,375	2,375,000	0.86	860,000	2.8
5/4/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,366	2,366,000	0.82	820,000	2.9
5/5/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,204	2,204,000	0.79	790,000	2.8
5/6/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,153	2,153,000	0.79	790,000	2.7
5/7/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,288	2,288,000	0.81	810,000	2.8
5/8/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,247	2,247,000	0.85	850,000	2.6
5/9/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,205	2,205,000	0.84	840,000	2.6
5/10/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,331	2,331,000	0.83	830,000	2.8
5/11/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,347	2,347,000	0.81	810,000	2.9
5/12/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,275	2,275,000	0.79	790,000	2.9
5/13/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,252	2,252,000	0.82	820,000	2.7
5/14/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,156	2,156,000	0.74	740,000	2.9
5/15/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,306	2,306,000	0.74	740,000	3.1
5/16/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,295	2,295,000	0.75	750,000	3.1
5/17/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,301	2,301,000	0.75	750,000	3.1
5/18/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,401	2,401,000	0.68	680,000	3.5
5/19/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,318	2,318,000	0.68	680,000	3.4
5/20/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,303	2,303,000	0.68	680,000	3.4
5/21/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,247	2,247,000	0.65	650,000	3.5
5/22/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,330	2,330,000	0.74	740,000	3.1
5/23/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,439	2,439,000	0.69	690,000	3.5
5/24/2013	No Data	No Data	No Data	No Data	1	1	No Data	No Data	2,363	2,363,000	0.69	690,000	3.4
5/25/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,369	2,369,000	0.68	680,000	3.5
5/26/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,358	2,358,000	0.72	720,000	3.3
5/27/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,315	2,315,000	0.66	660,000	3.5
5/28/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,181	2,181,000	0.63	630,000	3.5
5/29/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,194	2,194,000	0.62	620,000	3.5
5/30/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,286	2,286,000	0.69	690,000	3.3
5/31/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,324	2,324,000	0.64	640,000	3.6

Std Rpt ppc - C - From Material

Column #	1	2	3	4	5	6	7	8	9		10		
MaRS ID	1554	1549	1553	1550	1551	1555	1547	1548	244		795		
Test Point	FOG MS Volatile Solids	FOG COD	Fog MS Total Solids	FOG pH	FOG Receiving 1 Deliveries	FOG Receiving 2 Deliveries	FOG Total Solids	FOG Volatile Solids	TOTAL LSG PRODUCTION	**TOTAL LSG PRODUCTION**	TOTAL MS FLOW BATT 2-3	**TOTAL MS FLOW BATT 2-3**	**Gas/Flow**
ACC	8	8	8	8	8	8	8	8	8		8		
Source	Calc	LIMS	Calc	LIMS	PCCS DL	PCCS DL	LIMS	LIMS	PCCS DL		Calc		
Sample Freq		7 per Week		7 per Week	7 per Week	7 per Week	7 per Week	7 per Week					
Source ID		FOG StationCOD-HA-W		FOG StationSM4500-H+B	V890001R	V890002R	FOG StationSM2540B	FOG StationVS-S	TOT_LSG_PROD				
Compound		COD,Total-HighRange		pH,Field Measurement			Total Solids	Volatile Solids					
MODS ID									201011		301608		
Units	%	MG/L	%	STD UNITS	DELIVERIES	DELIVERIES	%	%	KSCF	**SCF**	MGD	**Gal/Day**	**SCF/Gallons**
6/1/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,322	2,322,000	0.61	610,000	3.8
6/2/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,316	2,316,000	0.61	610,000	3.8
6/3/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,260	2,260,000	0.63	630,000	3.6
6/4/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,267	2,267,000	0.67	670,000	3.4
6/5/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,321	2,321,000	0.61	610,000	3.8
6/6/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,233	2,233,000	0.62	620,000	3.6
6/7/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,284	2,284,000	0.56	560,000	4.1
6/8/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,268	2,268,000	0.56	560,000	4.1
6/9/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,101	2,101,000	0.56	560,000	3.8
6/10/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,025	2,025,000	0.6	600,000	3.4
6/11/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,158	2,158,000	0.67	670,000	3.2
6/12/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,353	2,353,000	0.74	740,000	3.2
6/13/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,410	2,410,000	0.69	690,000	3.5
6/14/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,486	2,486,000	0.73	730,000	3.4
6/15/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,359	2,359,000	0.68	680,000	3.5
6/16/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,231	2,231,000	0.67	670,000	3.3
6/17/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,149	2,149,000	0.69	690,000	3.1
6/18/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,108	2,108,000	0.65	650,000	3.2
6/19/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,239	2,239,000	0.74	740,000	3.0
6/20/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,433	2,433,000	0.74	740,000	3.3
6/21/2013	No Data	No Data	No Data	No Data	0	1	No Data	No Data	2,335	2,335,000	0.74	740,000	3.2
6/22/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,239	2,239,000	0.74	740,000	3.0
6/23/2013	No Data	No Data	No Data	No Data	0	0	No Data	No Data	2,155	2,155,000	0.74	740,000	2.9
6/24/2013	-601,369,952,947	14,000	-55,261,022,707.50	4.7	0	0	0.3	50	2,153	2,153,000	0.67	670,000	3.2
6/25/2013	-34,305,637,699	15,000	-37,736,201,559.70	4.7	0	0	0.3	83	2,227	2,227,000	0.72	720,000	3.1
6/26/2013	13,213,655,288	6,200	<-2,951,049,658.4	5	0	0	<0.3	100	2,272	2,272,000	0.67	670,000	3.4
6/27/2013	113,552,721,111	5,500	<-39,175,688,748.6	No Data	0	0	<0.3	100	2,350	2,350,000	0.77	770,000	3.1
6/28/2013	<-1,059,107,328,072	4,800	<-37,975,959,970.6	4.9	0	1	<0.3	<0	2,478	2,478,000	0.74	740,000	3.3
6/29/2013	-52,635,049	4,500	<-7,618,240.3	4.9	0	0	<0.3	67	2,426	2,426,000	0.74	740,000	3.3
6/30/2013	86	4,700	<3.1	4.9	0	0	<0.3	100	2,259	2,259,000	0.68	680,000	3.3
7/1/2013	21,397,144	4,200	<-4,350,732.1	5	0	0	<0.3	100	2,115	2,115,000	0.68	680,000	3.1
7/2/2013	-57,658,668,341	4,900	<-4,073,710,265.9	4.9	0	0	<0.3	40	2,184	2,184,000	0.69	690,000	3.2
7/3/2013	-45,098,958,159	350	<-5,637,369,777.3	5.2	0	0	<0.3	60	2,325	2,325,000	0.73	730,000	3.2
7/4/2013	-3,011,420,295	3,700	<-1,269,098,586.4	5.2	0	0	<0.3	80	2,305	2,305,000	0.69	690,000	3.3
7/5/2013	-794,666,583	3,400	<-105,379,706.9	5.2	0	0	<0.3	60	2,176	2,176,000	0.69	690,000	3.2
7/6/2013	-10,013,615	3,600	<-1,678,764.1	4.7	0	0	<0.3	67	2,117	2,117,000	0.73	730,000	2.9
7/7/2013	-4,304,259	3,200	<-1,458,692.5	5.1	0	0	<0.3	80	2,092	2,092,000	0.69	690,000	3.0
7/8/2013	88	3,500	<3.1	5.1	0	0	<0.3	100	2,116	2,116,000	0.69	690,000	3.1

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Std Rpt ppc - C - From Material

Column #	1	2	3	4	5	6	7	8	9		10		
MaRS ID	1554	1549	1553	1550	1551	1555	1547	1548	244		795		
Test Point	FOG MS Volatile Solids	FOG COD	Fog MS Total Solids	FOG pH	FOG Receiving 1 Deliveries	FOG Receiving 2 Deliveries	FOG Total Solids	FOG Volatile Solids	TOTAL LSG PRODUCTION	**TOTAL LSG PRODUCTION**	TOTAL MS FLOW BATT 2-3	**TOTAL MS FLOW BATT 2-3**	**Gas/Flow**
ACC	8	8	8	8	8	8	8	8	8		8		
Source	Calc	LIMS	Calc	LIMS	PCCS DL	PCCS DL	LIMS	LIMS	PCCS DL		Calc		
Sample Freq		7 per Week		7 per Week	7 per Week	7 per Week	7 per Week	7 per Week					
Source ID		FOG StationCOD-HA-W		FOG StationSM4500-H+B	V890001R	V890002R	FOG StationSM2540B	FOG StationVS-S	TOT_LSG_PROD				
Compound		COD,Total-HighRange		pH,Field Measurement			Total Solids	Volatile Solids					
MODS ID									201011		301608		
Units	%	MG/L	%	STD UNITS	DELIVERIES	DELIVERIES	%	%	KSCF	**SCF**	MGD	**Gal/Day**	**SCF/Gallons**
7/9/2013	-94,129,121,827	3,800	<-14,119,368,283.9	4.7	0	3	<0.3	67	2,274	2,274,000	0.73	730,000	3.1
7/10/2013	<-1,250,383,797,927	3,900	<-47,540,240,959.0	5	0	0	<0.3	<0	2,198	2,198,000	0.69	690,000	3.2
7/11/2013	-26,249,915	3,600	<-1,421,871.6	4.8	0	1	<0.3	25	2,205	2,205,000	0.64	640,000	3.4
7/12/2013	-244,809,336,879	3,800	<-44,201,685,837.3	5.1	0	1	<0.3	67	2,392	2,392,000	0.69	690,000	3.5
7/13/2013	1,602,827	3,500	<-351,366.9	4.9	0	0	<0.3	100	2,223	2,223,000	0.73	730,000	3.0
7/14/2013	<85	4,000	<3.1	5.1	0	0	<0.3	<0	2,133	2,133,000	0.69	690,000	3.1
7/15/2013	<-60,643,562	3,700	<-2,218,250.6	4.8	0	0	<0.3	<0	2,013	2,013,000	0.63	630,000	3.2
7/16/2013	<-356,093,933,289	4,400	<-14,310,123,119.8	5.1	0	2	<0.3	<0	1,994	1,994,000	0.66	660,000	3.0
7/17/2013	-168,666,579	4,400	<-42,166,663.3	5.1	0	0	<0.3	75	2,233	2,233,000	0.78	780,000	2.9
7/18/2013	88	4,500	<3.2	4.9	0	1	<0.3	48	2,263	2,263,000	0.74	740,000	3.1
7/19/2013	-387,723,693,404	4,600	<-30,694,792,398.6	4.9	0	1	<0.3	54	2,121	2,121,000	0.74	740,000	2.9
7/20/2013	-30,122,372,422	14,000	<-12,990,273,140.3	4.8	0	0	<0.3	78	2,178	2,178,000	0.64	640,000	3.4
7/21/2013	89	13,000	3.2	4.8	0	0	0.4	62	2,177	2,177,000	0.69	690,000	3.2
7/22/2013	-858,218,660	12,000	-85,821,871.70	4.9	0	0	0.4	61	2,066	2,066,000	0.64	640,000	3.2
7/23/2013	-339,006,616,533	12,000	-40,680,793,990.90	4.8	0	3	0.4	61	2,118	2,118,000	0.69	690,000	3.1
7/24/2013	-288,646,368,156	13,000	-28,864,636,820.90	4.9	0	3	0.4	57	2,294	2,294,000	0.72	720,000	3.2
7/25/2013	-4,549,211	14,000	-802,813.40	5	0	0	0.5	68	2,246	2,246,000	0.71	710,000	3.2
7/26/2013	87	13,000	3.4	4.9	0	2	0.4	61	2,312	2,312,000	0.79	790,000	2.9
7/27/2013	-142,621,739,313	13,000	-30,425,971,066.60	4.9	0	1	0.4	64	2,311	2,311,000	0.79	790,000	2.9
7/28/2013	-75,413,399,924	13,000	-11,148,067,823.80	5	0	0	0.4	63	2,163	2,163,000	0.64	640,000	3.4
7/29/2013	-385,476,905,789	13,000	-50,408,518,457.00	5	0	3	0.4	62	2,074	2,074,000	0.61	610,000	3.4
7/30/2013	88	12,000	3.6	5.1	0	0	0.4	63	2,191	2,191,000	0.64	640,000	3.4
7/31/2013	-501,033,887,351	14,000	-36,742,485,075.00	5.1	0	4	0.5	42	2,235	2,235,000	0.67	670,000	3.3
8/1/2013	1,631,295,840	14,000	-384,519,709.80	4.9	0	0	0.3	100	2,328	2,328,000	0.71	710,000	3.3
8/2/2013	-247,650,191,071	14,000	-31,225,458,881.40	4.9	0	2	0.5	62	2,316	2,316,000	0.67	670,000	3.5
8/3/2013	-1,103,136,506,766	14,000	-70,915,918,294.10	4.9	0	0	0.5	38	2,131	2,131,000	0.71	710,000	3.0
8/4/2013	-74,120,665,923	No Data	-8,400,342,144.00	5.1	0	0	0.3	56	1,999	1,999,000	0.61	610,000	3.3
8/5/2013	-58,465,473,675	180,000	-3,897,698,247.00	5.1	2	0	3.2	78	2,050	2,050,000	0.66	660,000	3.1
8/6/2013	70,381,123,223	140,000	26,392,921,180.00	5.1	7	0	6.5	94	2,033	2,033,000	0.57	570,000	3.6
8/7/2013	85,012,945,714	51,000	-8,501,294,559.90	4.6	2	0	2.4	91	1,937	1,937,000	0.56	560,000	3.5
8/8/2013	25,107,778	180,000	34,313,849.80	4.4	0	0	20	98	2,096	2,096,000	0.65	650,000	3.2
8/9/2013	55,076,861,801	240,000	56,650,486,340.20	4.3	1	0	18	99	2,170	2,170,000	0.66	660,000	3.3
8/10/2013	86	390,000	3.3	4.9	0	0	19	99	2,127	2,127,000	0.63	630,000	3.4
8/11/2013	87	130,000	3.5	4.4	0	0	3.8	99	2,119	2,119,000	0.67	670,000	3.2
8/12/2013	85	120,000	3.7	4.6	2	0	2.3	92	2,090	2,090,000	0.67	670,000	3.1
8/13/2013	88	76,000	-23,211,427,892.80	4.7	0	0	0.6	88	2,096	2,096,000	0.67	670,000	3.1
8/14/2013	156,070,163,607	390,000	126,590,243,747.90	4.5	3	0	11	96	2,154	2,154,000	0.64	640,000	3.4
8/15/2013	49,121,045,827	410,000	57,307,886,699.50	4.4	0	1	14	97	2,076	2,076,000	0.67	670,000	3.1

Std Rpt ppc - C - From Material

Column #	1	2	3	4	5	6	7	8	9		10		
MaRS ID	1554	1549	1553	1550	1551	1555	1547	1548	244		795		
Test Point	FOG MS Volatile Solids	FOG COD	Fog MS Total Solids	FOG pH	FOG Receiving 1 Deliveries	FOG Receiving 2 Deliveries	FOG Total Solids	FOG Volatile Solids	TOTAL LSG PRODUCTION	**TOTAL LSG PRODUCTION**	TOTAL MS FLOW BATT 2-3	**TOTAL MS FLOW BATT 2-3**	**Gas/Flow**
ACC	8	8	8	8	8	8	8	8	8		8		
Source	Calc	LIMS	Calc	LIMS	PCCS DL	PCCS DL	LIMS	LIMS	PCCS DL		Calc		
Sample Freq		7 per Week		7 per Week	7 per Week	7 per Week	7 per Week	7 per Week					
Source ID		FOG StationCOD-HA-W		FOG StationSM4500-H+B	V890001R	V890002R	FOG StationSM2540B	FOG StationVS-S	TOT_LSG_PROD				
Compound		COD,Total-HighRange		pH,Field Measurement			Total Solids	Volatile Solids					
MODS ID									201011		301608		
Units	%	MG/L	%	STD UNITS	DELIVERIES	DELIVERIES	%	%	KSCF	**SCF**	MGD	**Gal/Day**	**SCF/Gallons**
8/16/2013	51,162,045,015	230,000	5,755,730,057.70	4.7	0	2	4.2	95	2,196	2,196,000	0.71	710,000	3.1
8/17/2013	-146,492,224	69,000	-65,921,535.60	4.8	0	0	0.3	78	2,195	2,195,000	0.65	650,000	3.4
8/18/2013	-262,153,762	38,000	-69,907,688.80	4.3	0	0	0.4	73	2,145	2,145,000	0.65	650,000	3.3
8/19/2013	21,364,203,311	67,000	-3,967,637,737.80	4.2	0	1	2.1	96	2,130	2,130,000	0.68	680,000	3.1
8/20/2013	No Data	No Data	No Data	No Data	0	2	6.0	90	2,008	2,008,000	0.68	680,000	3.0
8/21/2013	No Data	No Data	No Data	No Data	0	5	6.0	90	2,044	2,044,000	0.71	710,000	2.9
8/22/2013	No Data	No Data	No Data	No Data	0	1	6.0	90	2,122	2,122,000	0.72	720,000	2.9
8/23/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,127	2,127,000	0.7	700,000	3.0
8/24/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,149	2,149,000	0.73	730,000	2.9
8/25/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,070	2,070,000	0.72	720,000	2.9
8/26/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	1,946	1,946,000	0.64	640,000	3.0
8/27/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	1,988	1,988,000	0.67	670,000	3.0
8/28/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,008	2,008,000	0.67	670,000	3.0
8/29/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	1,958	1,958,000	0.71	710,000	2.8
8/30/2013	87	18,000	3.3	5.4	0	0	1	88	2,013	2,013,000	0.65	650,000	3.1
8/31/2013	85	19,000	3.8	5	0	0	0.8	86	1,940	1,940,000	0.65	650,000	3.0
9/1/2013	861,622	18,000	-1,119,996.70	5.2	0	0	0.7	86	1,909	1,909,000	0.65	650,000	2.9
9/2/2013	85	30,000	3.2	5.5	0	0	1.2	89	1,895	1,895,000	0.65	650,000	2.9
9/3/2013	173,194,526	32,000	-216,493,050.90	5.4	0	0	1.3	84	1,991	1,991,000	0.72	720,000	2.8
9/4/2013	No Data	33,000	No Data	5.9	0	1	1.2	93	1,663	1,663,000	0.44	440,000	3.8
9/5/2013	936,164,472	110,000	3.4	5.4	0	0	3.4	94	1,866	1,866,000	0.73	730,000	2.6
9/6/2013	22,246,619,374	22,000	-278,082,737.80	5.3	0	2	3.2	91	2,048	2,048,000	0.75	750,000	2.7
9/7/2013	-264,954,462	21,000	-141,309,088.90	5	0	0	0.9	81	2,036	2,036,000	0.66	660,000	3.1
9/8/2013	-408,869,476	18,000	-255,543,472.00	5.7	0	0	1	81	2,013	2,013,000	0.69	690,000	2.9
9/9/2013	16,052,108,600	24,000	-5,417,586,620.40	6.2	0	0	0.9	92	2,033	2,033,000	0.72	720,000	2.8
9/10/2013	7,556,625,406	25,000	-17,380,238,231.10	5.4	0	1	0.9	88	1,941	1,941,000	0.73	730,000	2.7
9/11/2013	745,813,417	100,000	-139,839,997.00	5	0	0	1.9	90	2,017	2,017,000	0.75	750,000	2.7
9/12/2013	-7,795,851,058	42,000	-6,236,680,907.50	5.3	0	17	0.8	77	2,046	2,046,000	0.81	810,000	2.5
9/13/2013	19,198,559,275	240,000	12,799,039,461.50	4.6	0	1	8.9	96	1,981	1,981,000	0.81	810,000	2.4
9/14/2013	6,318,732,526	180,000	3,305,183,125.70	4.9	0	0	9.7	98	1,960	1,960,000	0.71	710,000	2.8
9/15/2013	3,220,800,094	240,000	1,717,760,007.30	4.4	0	0	9.4	98	1,947	1,947,000	0.75	750,000	2.6
9/16/2013	23,095,074,331	280,000	9,060,375,284.40	4.5	23	15	8.3	98	2,009	2,009,000	0.79	790,000	2.5
9/17/2013	57,342,915,921	110,000	22,937,166,336.80	5.1	1	0	6.6	95	2,001	2,001,000	0.81	810,000	2.5
9/18/2013	86,839,423,609	480,000	244,018,780,100.40	4.5	1	1	31	97	2,013	2,013,000	0.81	810,000	2.5
9/19/2013	32,362,407	72,000	-12,020,286.60	5.3	0	6	0.7	95	1,930	1,930,000	0.69	690,000	2.8
9/20/2013	-198,119,006,590	11,000	-28,479,607,206.90	5	0	2	0.6	71	1,884	1,884,000	0.81	810,000	2.3
9/21/2013	60,453,880,343	290,000	57,198,671,325.00	5.1	0	2	15	97	1,933	1,933,000	0.81	810,000	2.4
9/22/2013	50,367,160,235	380,000	21,924,528,541.50	3.8	0	0	11	97	2,018	2,018,000	0.75	750,000	2.7

Std Rpt ppc - C - From Material

Column #	1	2	3	4	5	6	7	8	9		10		
MaRS ID	1554	1549	1553	1550	1551	1555	1547	1548	244		795		
Test Point	FOG MS Volatile Solids	FOG COD	Fog MS Total Solids	FOG pH	FOG Receiving 1 Deliveries	FOG Receiving 2 Deliveries	FOG Total Solids	FOG Volatile Solids	TOTAL LSG PRODUCTION	**TOTAL LSG PRODUCTION**	TOTAL MS FLOW BATT 2-3	**TOTAL MS FLOW BATT 2-3**	**Gas/Flow**
ACC	8	8	8	8	8	8	8	8	8		8		
Source	Calc	LIMS	Calc	LIMS	PCCS DL	PCCS DL	LIMS	LIMS	PCCS DL		Calc		
Sample Freq		7 per Week		7 per Week	7 per Week	7 per Week	7 per Week	7 per Week					
Source ID		FOG StationCOD-HA-W		FOG StationSM4500-H+B	V890001R	V890002R	FOG StationSM2540B	FOG StationVS-S	TOT_LSG_PROD				
Compound		COD,Total-HighRange		pH,Field Measurement			Total Solids	Volatile Solids					
MODS ID									201011		301608		
Units	%	MG/L	%	STD UNITS	DELIVERIES	DELIVERIES	%	%	KSCF	**SCF**	MGD	**Gal/Day**	**SCF/Gallons**
9/23/2013	30,478,239,006	230,000	7,619,559,734.00	4	0	2	6.5	96	2,047	2,047,000	0.75	750,000	2.7
9/24/2013	26,271,479,160	230,000	7,531,157,338.60	5.2	0	0	7.4	98	2,004	2,004,000	0.81	810,000	2.5
9/25/2013	82,283,219,989	280,000	42,407,505,645.70	4.2	0	1	9.7	98	1,977	1,977,000	0.69	690,000	2.9
9/26/2013	116,364,757,259	180,000	18,285,890,416.40	4.2	0	3	5.2	97	1,868	1,868,000	0.69	690,000	2.7
9/27/2013	140,502,352,506	240,000	21,075,352,868.80	4.5	0	1	7.2	95	1,908	1,908,000	0.75	750,000	2.5
9/28/2013	192,844,411,741	77,000	-4,484,753,755.30	5	0	0	3.8	98	1,867	1,867,000	0.69	690,000	2.7
9/29/2013	44,428,086,208	84,000	3.2	4.8	0	0	3.2	91	1,828	1,828,000	0.66	660,000	2.8
9/30/2013	24,664,188,190	71,000	-5,426,121,379.60	4.4	0	0	2.4	90	1,805	1,805,000	0.68	680,000	2.7
10/1/2013	4,113,055,467	65,000	-3,290,444,305.90	4.4	0	0	2	82	1,867	1,867,000	0.69	690,000	2.7
10/2/2013	9,152,829,205	71,000	-7,322,263,290.40	5.2	0	0	2.2	89	2,055	2,055,000	0.75	750,000	2.7
10/3/2013	-53,779,417,686	41,000	-26,889,708,880.70	5	0	1	1.2	78	2,105	2,105,000	0.73	730,000	2.9
10/4/2013	-44,916,255,439	29,000	-29,195,566,085.90	5.3	0	0	0.9	79	2,253	2,253,000	0.76	760,000	3.0
10/5/2013	6,141,179,526	28,000	-3,889,413,644.10	5.1	0	0	1.2	86	2,124	2,124,000	0.67	670,000	3.2
10/6/2013	-8,096,416,897	29,000	-3,508,447,355.50	5.5	0	0	1.2	80	2,053	2,053,000	0.67	670,000	3.1
10/7/2013	-3,486,400	37,000	-4,183,780.40	5.5	0	1	1	84	2,098	2,098,000	0.74	740,000	2.8
10/8/2013	29,097,914,503	44,000	-17,458,748,646.80	5.3	0	2	1.1	90	2,172	2,172,000	0.64	640,000	3.4
10/9/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,164	2,164,000	0.73	730,000	3.0
10/10/2013	-219,618,967	100,000	219,619,055.10	5.3	0	0	4.4	84	2,154	2,154,000	0.84	840,000	2.6
10/11/2013	177,959,476,806	No Data	379,646,883,678.70	4.7	5	0	35	98	2,207	2,207,000	0.86	860,000	2.6
10/12/2013	88,030,390	110,000	-3,521,209.00	5.1	0	0	2.7	97	2,099	2,099,000	0.66	660,000	3.2
10/13/2013	184,884,737,227	56,000	-28,443,805,710.60	5	0	0	1.8	96	2,020	2,020,000	0.62	620,000	3.3
10/14/2013	-22,062,794,242	44,000	-41,919,309,231.10	5.5	1	0	1.4	91	2,053	2,053,000	0.73	730,000	2.8
10/15/2013	-2,287,036,984	44,000	-439,814,817.60	5.4	1	0	0.8	71	2,116	2,116,000	0.81	810,000	2.6
10/16/2013	10,328,850	150,000	238,359.50	4.4	0	0	3.6	96	2,185	2,185,000	0.73	730,000	3.0
10/17/2013	132,237,189,499	73,000	2,644,743,791.60	4.3	2	0	3.5	95	2,295	2,295,000	0.68	680,000	3.4
10/18/2013	43,729,270,063	85,000	5,684,805,100.20	No Data	1	0	4.2	94	2,550	2,550,000	0.82	820,000	3.1
10/19/2013	41,023,611	160,000	11,934,120.50	No Data	0	0	6	93	2,052	2,052,000	0.85	850,000	2.4
10/20/2013	19,454,628	160,000	5,350,003.40	4.2	0	0	6.7	95	2,040	2,040,000	0.66	660,000	3.1
10/21/2013	42,560,082	170,000	14,541,336.50	4	0	0	7.3	94	2,016	2,016,000	0.75	750,000	2.7
10/22/2013	94,080,923,482	170,000	27,500,577,612.50	4.2	5	0	6.5	93	2,121	2,121,000	0.84	840,000	2.5
10/23/2013	3,739,166,734	180,000	922,327,777.00	4.1	1	0	6.4	97	2,064	2,064,000	0.72	720,000	2.9
10/24/2013	85,569,316	160,000	28,523,079.80	4	2	3	5.9	94	1,976	1,976,000	0.65	650,000	3.0
10/25/2013	12,687,582	310,000	11,600,003.50	5.2	0	1	9.9	89	1,925	1,925,000	0.64	640,000	3.0
10/26/2013	24,786,972	280,000	9,088,528.00	4.6	0	0	6.7	96	1,963	1,963,000	0.61	610,000	3.2
10/27/2013	16,166,752	170,000	4,703,033.70	3.8	0	0	6.6	96	1,956	1,956,000	0.66	660,000	3.0
10/28/2013	24,414,314,865	92,000	2,712,701,645.60	3.9	2	0	4.5	95	1,959	1,959,000	0.67	670,000	2.9
10/29/2013	380,376,892	73,000	17,289,858.40	4.1	0	0	3.8	92	2,000	2,000,000	0.69	690,000	2.9
10/30/2013	15,225,002,431	220,000	19,792,503,053.40	5.3	4	0	11	91	2,042	2,042,000	0.72	720,000	2.8

Std Rpt ppc - C - From Material

Column #	1	2	3	4	5	6	7	8	9		10		
MaRS ID	1554	1549	1553	1550	1551	1555	1547	1548	244		795		
Test Point	FOG MS Volatile Solids	FOG COD	Fog MS Total Solids	FOG pH	FOG Receiving 1 Deliveries	FOG Receiving 2 Deliveries	FOG Total Solids	FOG Volatile Solids	TOTAL LSG PRODUCTION	**TOTAL LSG PRODUCTION**	TOTAL MS FLOW BATT 2-3	**TOTAL MS FLOW BATT 2-3**	**Gas/Flow**
ACC	8	8	8	8	8	8	8	8	8		8		
Source	Calc	LIMS	Calc	LIMS	PCCS DL	PCCS DL	LIMS	LIMS	PCCS DL		Calc		
Sample Freq		7 per Week		7 per Week	7 per Week	7 per Week	7 per Week	7 per Week					
Source ID		FOG StationCOD-HA-W		FOG StationSM4500-H+B	V890001R	V890002R	FOG StationSM2540B	FOG StationVS-S	TOT_LSG_PROD				
Compound		COD,Total-HighRange		pH,Field Measurement			Total Solids	Volatile Solids					
MODS ID									201011		301608		
Units	%	MG/L	%	STD UNITS	DELIVERIES	DELIVERIES	%	%	KSCF	**SCF**	MGD	**Gal/Day**	**SCF/Gallons**
10/31/2013	30,121,328,546	61,000	3.4	4	0	0	3.4	91	2,005	2,005,000	0.72	720,000	2.8
11/1/2013	14,328,537,257	55,000	2,149,280,578.70	4.4	1	0	3.7	91	2,067	2,067,000	0.75	750,000	2.8
11/2/2013	11,931,301,924	170,000	8,086,771,249.50	4.5	0	0	9.4	94	1,926	1,926,000	0.6	600,000	3.2
11/3/2013	9,780,652,556	240,000	6,411,761,068.60	4.4	0	0	9.2	92	1,888	1,888,000	0.69	690,000	2.7
11/4/2013	-2,381,896,673	210,000	9,051,207,699.30	4.7	0	0	6.8	88	2,013	2,013,000	0.68	680,000	3.0
11/5/2013	1,246,909,205	160,000	852,054,570.30	4.6	13	0	7.7	89	1,962	1,962,000	0.66	660,000	3.0
11/6/2013	-36,138,494,074	23,000	-7,227,698,827.90	5.2	1	0	1.1	71	2,022	2,022,000	0.72	720,000	2.8
11/7/2013	-1,398,985,842	14,000	-253,566,195.50	5	0	0	0.6	68	2,072	2,072,000	0.71	710,000	2.9
11/8/2013	-97,565,220,282	14,000	-17,217,391,826.70	5	1	0	0.4	71	2,060	2,060,000	0.69	690,000	3.0
11/9/2013	800,081	26,000	-499,996.20	5	0	0	1.3	85	1,950	1,950,000	0.6	600,000	3.3
11/10/2013	85	44,000	3.5	5.5	0	0	1.5	91	1,868	1,868,000	0.54	540,000	3.5
11/11/2013	17,073,932,813	39,000	-8,536,966,361.10	4.6	1	0	1.6	88	1,885	1,885,000	0.6	600,000	3.1
11/12/2013	-21,478,174	20,000	-4,460,866.00	4.8	3	0	0.9	74	1,965	1,965,000	0.69	690,000	2.8
11/13/2013	94,255,688,175	150,000	104,406,300,658.30	4.9	0	0	18	97	2,068	2,068,000	0.75	750,000	2.8
11/14/2013	69,846,532,908	100,000	60,533,661,781.50	4.4	2	0	11	96	1,828	1,828,000	0.54	540,000	3.4
11/15/2013	-19,442,187,618	29,000	-16,201,823,081.20	4.8	2	0	1.2	81	1,883	1,883,000	0.64	640,000	2.9
11/16/2013	No Data	360,000	223,517,463,765.80	4	4	0	31	90	1,984	1,984,000	0.63	630,000	3.1
11/17/2013	No Data	450,000	21,046,255,259.20	4.1	0	0	19	90	2,012	2,012,000	0.75	750,000	2.7
11/18/2013	No Data	320,000	3,771,647,870.00	4.4	0	3	13	90	2,063	2,063,000	0.75	750,000	2.8
11/19/2013	8,569,222,280	280,000	10,497,297,185.60	4.4	0	0	13	98	2,094	2,094,000	0.72	720,000	2.9
11/20/2013	191,354,958,673	370,000	107,637,164,212.50	4.1	2	0	13	96	2,073	2,073,000	0.65	650,000	3.2
11/21/2013	No Data	110,000	No Data	4	13	0	6.0	90	2,243	2,243,000	0.75	750,000	3.0
11/22/2013	No Data	170,000	No Data	4.3	1	0	6.0	90	2,389	2,389,000	0.81	810,000	2.9
11/23/2013	No Data	250,000	No Data	4.2	1	0	6.0	90	2,393	2,393,000	0.75	750,000	3.2
11/24/2013	No Data	350,000	No Data	3.7	1	0	6.0	90	2,263	2,263,000	0.75	750,000	3.0
11/25/2013	No Data	210,000	No Data	3.9	0	0	6.0	90	2,258	2,258,000	0.81	810,000	2.8
11/26/2013	No Data	170,000	No Data	4	1	1	6.0	90	2,354	2,354,000	0.81	810,000	2.9
11/27/2013	No Data	240,000	No Data	5.1	7	17	6.0	90	2,385	2,385,000	0.91	910,000	2.6
11/28/2013	No Data	320,000	No Data	5	0	0	6.0	90	2,471	2,471,000	0.87	870,000	2.8
11/29/2013	No Data	110,000	No Data	4.8	0	1	6.0	90	2,376	2,376,000	0.8	800,000	3.0
11/30/2013	No Data	No Data	No Data	4.8	0	0	6.0	90	2,343	2,343,000	0.91	910,000	2.6
12/1/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,296	2,296,000	0.81	810,000	2.8
12/2/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,278	2,278,000	0.81	810,000	2.8
12/3/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,196	2,196,000	0.78	780,000	2.8
12/4/2013	No Data	No Data	No Data	No Data	0	3	6.0	90	2,207	2,207,000	0.75	750,000	2.9
12/5/2013	No Data	No Data	No Data	No Data	0	1	6.0	90	2,247	2,247,000	0.75	750,000	3.0
12/6/2013	No Data	No Data	No Data	No Data	0	4	6.0	90	2,258	2,258,000	0.8	800,000	2.8
12/7/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,293	2,293,000	0.81	810,000	2.8

Std Rpt ppc - C - From Material

Column #	1	2	3	4	5	6	7	8	9		10		
MaRS ID	1554	1549	1553	1550	1551	1555	1547	1548	244		795		
Test Point	FOG MS Volatile Solids	FOG COD	Fog MS Total Solids	FOG pH	FOG Receiving 1 Deliveries	FOG Receiving 2 Deliveries	FOG Total Solids	FOG Volatile Solids	TOTAL LSG PRODUCTION	**TOTAL LSG PRODUCTION**	TOTAL MS FLOW BATT 2-3	**TOTAL MS FLOW BATT 2-3**	**Gas/Flow**
ACC	8	8	8	8	8	8	8	8	8		8		
Source	Calc	LIMS	Calc	LIMS	PCCS DL	PCCS DL	LIMS	LIMS	PCCS DL		Calc		
Sample Freq		7 per Week		7 per Week	7 per Week	7 per Week	7 per Week	7 per Week					
Source ID		FOG StationCOD-HA-W		FOG StationSM4500-H+B	V890001R	V890002R	FOG StationSM2540B	FOG StationVS-S	TOT_LSG_PROD				
Compound		COD,Total-HighRange		pH,Field Measurement			Total Solids	Volatile Solids					
MODS ID									201011		301608		
Units	%	MG/L	%	STD UNITS	DELIVERIES	DELIVERIES	%	%	KSCF	**SCF**	MGD	**Gal/Day**	**SCF/Gallons**
12/8/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,331	2,331,000	0.81	810,000	2.9
12/9/2013	No Data	No Data	No Data	No Data	0	1	6.0	90	2,376	2,376,000	0.81	810,000	2.9
12/10/2013	No Data	No Data	No Data	No Data	0	1	6.0	90	2,373	2,373,000	0.75	750,000	3.2
12/11/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,279	2,279,000	0.71	710,000	3.2
12/12/2013	No Data	No Data	No Data	No Data	0	5	6.0	90	2,226	2,226,000	0.75	750,000	3.0
12/13/2013	No Data	No Data	No Data	No Data	0	8	6.0	90	2,282	2,282,000	0.75	750,000	3.0
12/14/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,315	2,315,000	0.81	810,000	2.9
12/15/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,346	2,346,000	0.81	810,000	2.9
12/16/2013	No Data	No Data	No Data	No Data	0	4	6.0	90	2,261	2,261,000	0.75	750,000	3.0
12/17/2013	No Data	No Data	No Data	No Data	0	4	6.0	90	2,306	2,306,000	0.83	830,000	2.8
12/18/2013	No Data	No Data	No Data	No Data	3	0	6.0	90	2,445	2,445,000	0.99	990,000	2.5
12/19/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,386	2,386,000	0.9	900,000	2.7
12/20/2013	No Data	No Data	No Data	No Data	2	0	6.0	90	2,413	2,413,000	0.81	810,000	3.0
12/21/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,516	2,516,000	0.87	870,000	2.9
12/22/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,528	2,528,000	0.93	930,000	2.7
12/23/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,530	2,530,000	0.92	920,000	2.8
12/24/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,575	2,575,000	0.87	870,000	3.0
12/25/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,696	2,696,000	0.87	870,000	3.1
12/26/2013	No Data	No Data	No Data	No Data	1	0	6.0	90	2,609	2,609,000	0.94	940,000	2.8
12/27/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,403	2,403,000	0.84	840,000	2.9
12/28/2013	No Data	No Data	No Data	No Data	1	0	6.0	90	2,475	2,475,000	0.87	870,000	2.8
12/29/2013	No Data	No Data	No Data	No Data	3	0	6.0	90	2,483	2,483,000	0.96	960,000	2.6
12/30/2013	No Data	No Data	No Data	No Data	2	0	6.0	90	2,540	2,540,000	0.94	940,000	2.7
12/31/2013	No Data	No Data	No Data	No Data	0	0	6.0	90	2,460	2,460,000	0.81	810,000	3.0
Average	-37,229,115,366	105,128	5,266,835,358.90	4.8	0	0	4.3	81	1,728	2,198,101	0.807	807,452	3.0
Total	-5,063,159,689,820	15,453,750	732,090,114,887.20	704.3	139	161	604.6	11,085	630,856	630,856,000	294.72	294,720,000	2.1
Median	5965838.5	55,000	<-1,421,871.6	4.9	0	0	1.25	90	2,127	2,127,000	0.77	770,000	2.8
Target													
MAX	192,844,411,741	480,000	379,646,883,678.70	6.2	23	17	35	100	2,696	2,696,000	1.17	1,170,000	2.3
MAX Date	9/28/2013	9/18/2013	10/11/2013	9/9/2013	9/16/2013	9/12/2013	10/11/2013	6/26/2013	12/25/2013		2/27/2013		
MIN	<-1,250,383,797,927	350	-70,915,918,294.10	3.7	0	0	<0.3	<0	0	0	0.44	440,000	0.0
MIN Date	7/10/2013	7/3/2013	8/3/2013	11/24/2013	1/29/2013	1/29/2013	7/20/2013	7/16/2013	1/29/2013		9/4/2013		
Comments													

APPENDIX B3:
SRCSD Supplemental Review of Biogas Enhancement Project

Review of Biogas Enhancement Project

Project Team

FOG System Evaluations

- Rashi Gupta – Evaluation Lead
- Daniel Meacham
- Kathy Marks
- Gary Deis

QA/QC

- Scott Parker
- Steve Swanback
- John Fraser

Discussion Outline

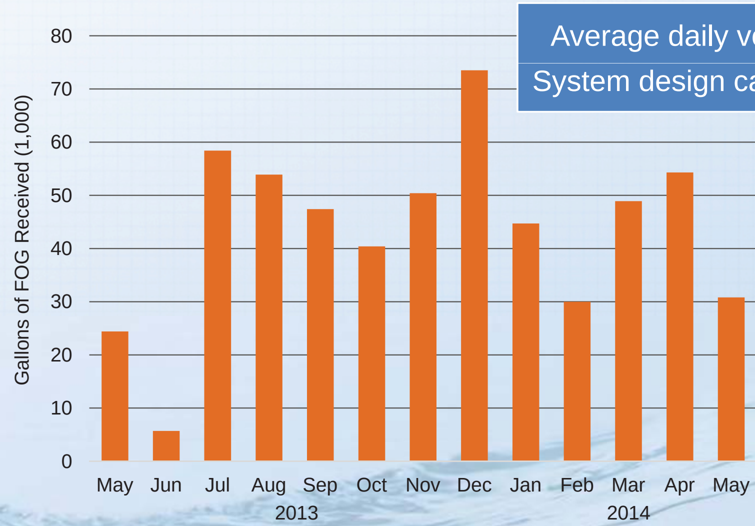
- Summary of Operations and Issues
- Operating Experience at Other FOG Facilities
- Materials Selection
- Summary of Findings and Next Steps

Summary of Operations and Issues

Operations Summary

- Operational for 370 days (May 23, 2013 – May 28, 2014)
- 565,000 gallons of FOG received from 8 different haulers

Average daily volume = 1,500 gpd
System design capacity = 30,000 gpd



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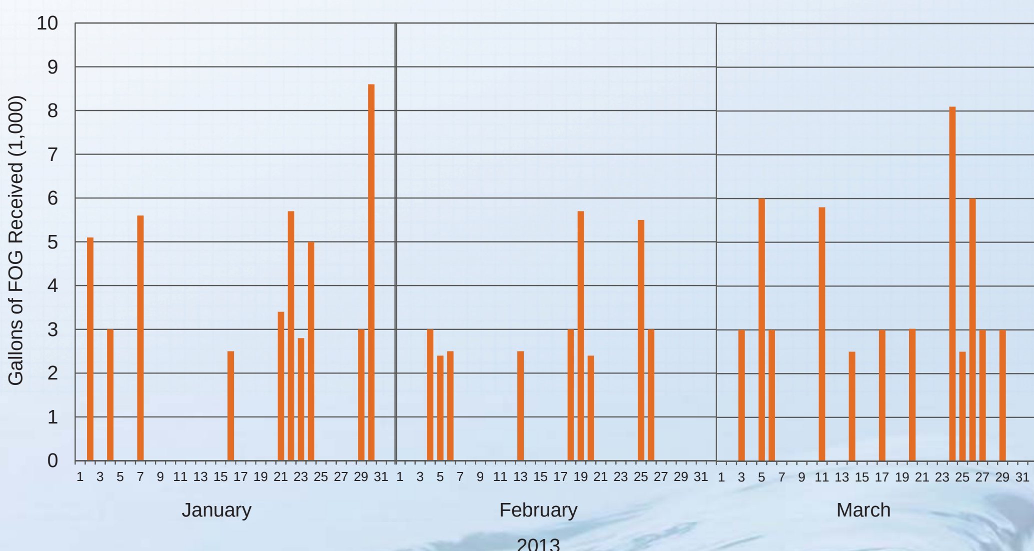
FOG was received on 134 days during the 370 day operating period



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Available FOG quality data is highly variable

- pH: 4 – 5
- COD: 5,000 – 20,000 mg/l
- TS: 0.5 – 5%
- VS: 50 – 100%
- Rocks, concrete, metal and other debris

Quality data reflects material within the FOG system, not necessarily what is delivered by an individual truck

- Sample location is downstream of the mixing/transfer pump
- Samples collected daily
- Individual trucks are not sampled

Observed conditions upon system shutdown

Laboratory testing of valve seat material

- Two samples tested
  - Tank 2 outlet valve
  - New valve provided by KOR
- Both samples made from nitrile butadiene copolymer (NBR or Buna-N)
- Percent acrylonitrile content
  - Tank 2 outlet valve: 40.4%
  - New valve: 31.8%

NBR Nitrile Classification	Percent Acrylonitrile	Oil Resistance	Cold Flexibility
Low	≤24		
Medium	25-30		
Medium/High	31-35	Better	Better
High	36-42		
Ultra-High	≥43		

Operating Experience at Other FOG Facilities

Investigation of other FOG facilities

Data gathering continues and includes site visits and/or telephone interviews with the following agencies:

EBMUD

Three facilities are located at the EBMUD main WWTP site:

- “Interim” FOG receiving station
- Food waste receiving station
- Newly constructed FOG receiving station

EBMUD

“Interim” FOG Station Components

- Truck connection
- Milliken manual plug valve with NBR seat
- Vogelsang Rotacut grinder/rock trap
- Vogelsang rotary lobe pump with NBR coated rotor
- Goodyear Flexwing® NBR hose to Baker tank

EBMUD

"Interim" FOG Station Operating Conditions

- In service since 2007
- Receive 6-7 trucks/shift (50 - 5,000 gal)
- Operator present at every FOG delivery
- Material received from any permitted hauler (although some permits have been pulled)
- pH ranges from 4 to 7 (5th to 95th percentile)

EBMUD

"Interim" FOG Station Operating Experience

- Vogelsang Rotacut macerator/rock trap
  - Clean once per shift
  - Screen replaced once per year
  - Damaged blades replaced twice per year
- Vogelsang rotary lobe pumps
  - Lobes replaced every 3 to 6 months (failure is reportedly due to abrasion)
  - Replace carbide coated housing every 2 to 3 lobe changes
- No problems reported with plug valve or Flexwing® NBR hose

Newly Constructed FOG Receiving Station

- Operation expected in the next 60-90 days
- Heated recirculation loop with Vaughan chopper pumps
- FOG transfer through Vogelsang Rotacut macerators and rotary lobe pumps
- Pump and valve elastomers are NBR
- Valve, pump, and grinder metals are standard ductile/cast iron or alloy steels

City of Watsonville

Facility Components

- Special fabricated rock trap
- Vogelsang Rotacut macerator
- Vaughan chopper mixing/transfer pump
- 10,000 gal FRP tank
- WEMCO Hidrostal feed pump
- Standard materials/manual valves

City of Watsonville

Operating Conditions

- In service since 2002
- Replaced/modified several facility components
- Typically receive 3 trucks/day (15,000 gal), 5 days/week
- Haulers are permitted, but not sampled
- Minimal maintenance (clean rock trap once per week, general clean up, etc)
  - FOG tank cleaned annually; digesters accumulate more debris (5 year cleaning cycle)

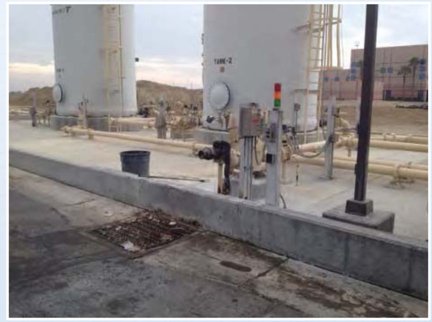
City of FRESNO

Facility Components

- Vogelsang Rotacut macerator (hardened steel components)
- Vaughan chopper mixing/transfer pump (ductile iron casing with cast steel impeller)
- FOG tank (FOG mixed with primary sludge)
- Moyno progressive cavity feed pump (Buna-N stator with steel rotors)
- DeZURIK plug valves with Buna-N

City of FRESNO

Operating Conditions



- In service since May of 2012
- Receive up to 10 trucks/day (1,000 – 5,000 gal loads)
- Primarily FOG (plus chicken blood and sugar waste)
- Operator present at each FOG delivery (sample for pH and VS)
- pH 4 – 5
- Rock traps cleaned once per week
- Replaced valve seats on several valves due to tears and abrasion

LA sewers

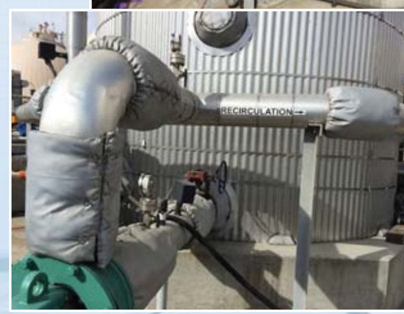
Hyperion Treatment Plant

Facility Components

- Constructed as a pilot facility in 2010
- Stainless steel Vaughan chopper mixing/transfer pumps
- 2-10,000 gal FOG tanks
- Seepex progressive cavity feed pumps (custom silicon stators)
- NIBCO 316 SST ball valves with RTFE seats
- New, larger permanent facility under design by BOE

Operating Conditions

- In operation since August 2010
- Receive FOG from a single hauler who pre-screens material
- pH 3 – 4
- FOG fed directly to digesters without sludge blend



Operating Conditions (cont.)

- Replaced original Milliken Buna-N plug valves with SST ball valves after 2-3 years of service
  - Elastomer swelled and tore when operated
  - SST ball valves in service 6-8 months w/o issue
- Seepex stators experienced same issue – original elastomer EPDM or Buna-N
  - Hyperion staff conducted study of materials in heated FOG, decided to proceed with silicon stators
  - Silicon stators have lasted 6 months, currently being replaced - likely failure due to abrasion
- Original Vaughan pump casing developed hole after 3 yrs; replaced with all stainless steel construction

Hyperion Treatment Plant

Facility Components

- New facility sized for 2 – 27,000 gal FOG tanks under design by BOE
  - In process of developing FOG hauling RFP
  - Will no longer have “clean” FOG
  - Concerned about FOG quality

City of Millbrae

Facility Components

- Custom macerator/rock trap similar to Vogelsang
- Vaughan chopper mixing/transfer pump
- 12,000 gal FOG tank
- Moyno positive displacement feed pump
- DeZURIK plug valves
- Standard materials
- Patented sludge recirculation system

City of Millbrae

Operating Conditions

- In operation for 6.5 years reportedly without issues
- Single hauler (1-2 loads/day)
  - High emphasis on managing hauler
  - Hauler required to photograph each grease trap before and after cleaning

Pinellas County

Facility Components

- Vogelsang rotary lobe mixing/transfer and feed pumps
- Vogelsang Rotocut grinder/rock trap
- DeZURIK plug valves
- Have used both Buna-N and Viton elastomers

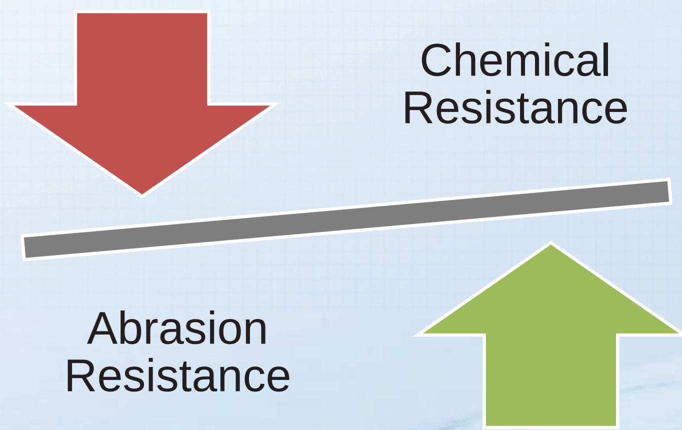
Pinellas County

Operating Conditions

- In service since 2008
- Reported up to 30,000 gpd of FOG processed
- No recommendations on materials… both Buna-N and Viton replaced due to "normal wear and tear"

Materials Selection

Selection of materials exposed to both chemicals and abrasives can be a balancing act



Materials research included the following activities:

- Interviewed/visited other FOG facilities
- Consulted elastomer manufacturer
- Consulted valve manufacturers
- Consulted pump and grinder/rock trap manufacturers
- Reviewed chemical compatibility data

Other FOG Facilities

- Refer to matrix
  - Various materials used – Buna-N, Viton, Stainless Steel, Alloy Steels, Cast/Ductile Iron
  - No material is maintenance-free

Consultation with Elastomer Manufacturer

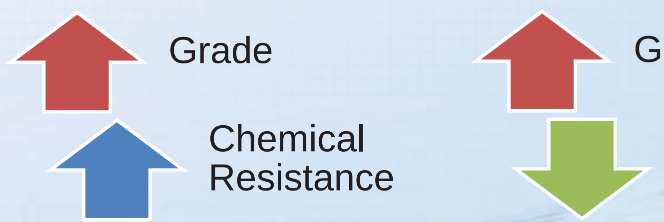
- Minnesota Rubber and Plastics
  - Buna-N typically recommended for use with FOG
  - Viton (FKM) and Teflon (PTFE) generally acceptable for specific equipment components and higher temps

Minnesota Rubber & Plastics
Quadion Corporation

Consultation with Elastomer Manufacturer (cont.)

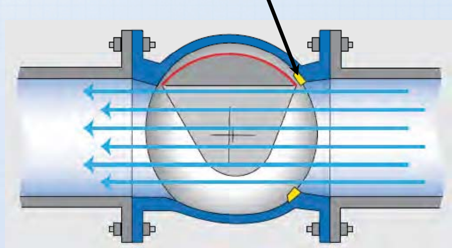
Higher grades of both NBR and FKM may resist chemicals in FOG better, but with reduced abrasion resistance

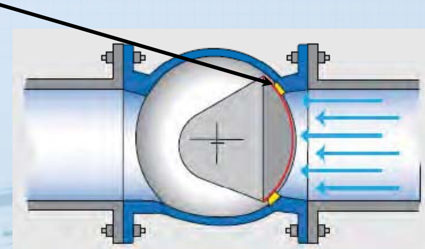
– Grade → Acrylonitrile or fluorine content
– Higher grades not widely available for valves/pumps



Consultation with Valve Manufacturers

- Plug valves
  – Typically, elastomeric encapsulation over metal plug for bubble-tight closure
  – Cast or ductile iron bodies
  – Nickel seat





Consultation with Valve Manufacturers (cont.)

- Elastomers available from both Milliken and KOR
  - Nitrile (NBR, Buna-N)
  - Viton (FKM)
  - EPDM
- Additional elastomers available from Milliken, DeZURIK, and others
  - Neoprene
  - Natural Rubber
- Manufacturers provided material recommendations

Consultation with Valve Manufacturers (cont.)

- KOR – Not responsive to enquiries
- Milliken
  - Recommended NBR – success on other projects
  - Milliken's Elastomer Selection Chart:

Service	Elastomer	Average Useful Temp. Range	Service	Elastomer	Average Useful Temp. Range	Service	Elastomer	Average Useful Temp. Range
Acetone	EPDM	-35°F to 250°F	Caustic Soda	EPDM	-35°F to 250°F	Oil, Animal	Nitrile	-20°F to 212°F
Air	EPDM	-35°F to 250°F	Cement Slurry	EPDM	-35°F to 250°F	Oil, Mobil Therm Light	Viton	10°F to 250°F
Air w/Oil	Nitrile	0°F to 212°F	Copper Sulphate	EPDM	-35°F to 250°F	Oil, Mobil Therm 600	Viton	10°F to 250°F
Alcohol AMYL	EPDM	0°F to 212°F	Creosote (Coal)	Nitrile	-20°F to 212°F	Oil, Mobil Therm 603	Nitrile	-20°F to 212°F
Alcohol Aromatic	Viton	10°F to 250°F	Coal Slurry	Nitrile	-20°F to 212°F	Oil, Lubricating	Nitrile	-20°F to 212°F
Alcohol Butyl	Neoprene	-20°F to 225°F	Diesel Fuel No. 3	Nitrile	-20°F to 212°F	Oil, Vegetable	Nitrile	-20°F to 212°F
Alcohol Denatured	Nitrile	-20°F to 212°F	Diethylene Glycol	EPDM	-35°F to 250°F	Paint, Latex	Nitrile	-20°F to 212°F
Alcohol Ethyl	EPDM	-20°F to 250°F	Ethylene Glycol	EPDM	-35°F to 250°F	Phosphate Ester	EPDM	-35°F to 250°F
Alcohol Grain	Nitrile	-20°F to 212°F	Fatty Acid	Nitrile	-20°F to 212°F	Propane	Nitrile	-20°F to 212°F
Alcohol Isopropyl	Neoprene	-20°F to 225°F	Fuel Oil No. 2	Nitrile	-20°F to 212°F	Rape Seed Oil	EPDM	-35°F to 250°F
Alcohol Methyl	EPDM	-20°F to 250°F	Fertilizer Liquid $H_4N_2O_2$	EPDM	-35°F to 250°F	Sewage with Oils	Nitrile	-20°F to 212°F
Ammonia Anhydrous	Neoprene	-20°F to 225°F	Gasoline Keg	Nitrile	-20°F to 212°F	Sodium Hydroxide 20%	EPDM	-35°F to 250°F
Ammonium Nitrate	EPDM	-20°F to 250°F	Gas Natural	Nitrile	-20°F to 212°F	Starch	EPDM	-35°F to 250°F
Ammonia, water	EPDM	-20°F to 250°F	Glue, Animal	Nitrile	-20°F to 212°F	Steam to 250°F	EPDM	-35°F to 250°F
Animal Fats	Nitrile	-20°F to 212°F	Green Liquor	EPDM	-20°F to 212°F	Stoddard, Solvent	Nitrile	-20°F to 80°F
Black Liquor	EPDM	-20°F to 250°F	Hydraulic Oil (Petro)	Nitrile	-20°F to 212°F	Sulphuric Acid 10% 50%	Neoprene	-20°F to 158°F
Blast Furnace Gas	Neoprene	-20°F to 225°F	Hydrogen	Nitrile	-20°F to 212°F	Sulphuric Acid 100%	Viton	10°F to 300°F
Butane	Nitrile	-20°F to 212°F	JF4, JP5	Viton	-20°F to 212°F	Trichloroethylene Dry	Viton	10°F to 300°F
Bunker Oil "C"	Nitrile	-20°F to 212°F	Kerosene	Nitrile	0°F to 212°F	Triethanol Amine	EPDM	-35°F to 250°F
Calcium Chloride	EPDM	-20°F to 250°F	Ketone	EPDM	-35°F to 250°F	Varnish	Viton	10°F to 300°F
Carbon Dioxide	EPDM	-20°F to 250°F	Lime Slurry	EPDM	-35°F to 250°F	Water, Fresh	EPDM	-35°F to 250°F
Carbon Monoxide (Cold)	Neoprene	-20°F to 150°F	Methane	Nitrile	-20°F to 212°F	Water, Salt	EPDM	-35°F to 250°F
Carbon Monoxide (Hot)	Viton	10°F to 300°F	Methyl Ethyl Ketone	EPDM	-35°F to 250°F	Xylene	Viton	10°F to 300°F
Carbon Tetrachloride	Viton	10°F to 300°F	Naptha (Berzin)	Nitrile	-20°F to 212°F			

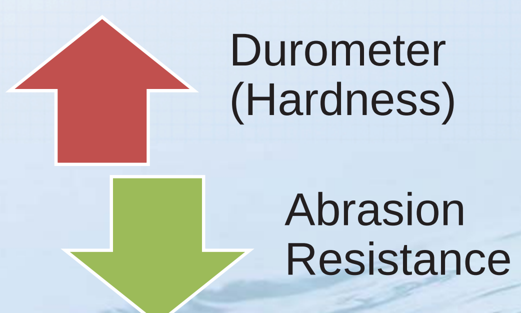
Consultation with Valve Manufacturers (cont.)

DeZURIK

- Recommend NBR for typical food source FOG
  - Offer two grades of NBR
    - Standard NBR – Higher durometer (harder) and ~40% acrylonitrile
    - NBRD – Lower durometer (softer) and <40% acrylonitrile
  - Standard NBR typically used for food source FOG
  - NBRD used in abrasive applications (fly ash or bottom ash slurries in power plants)

Consultation with Valve Manufacturers (cont.)

- DeZURIK
  - Viton recommended if industrial oils/greases and solvents are expected, but at cost of lower abrasion resistance (higher durometer than NBR or NBRD)

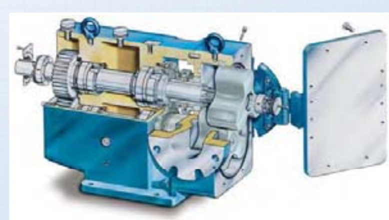


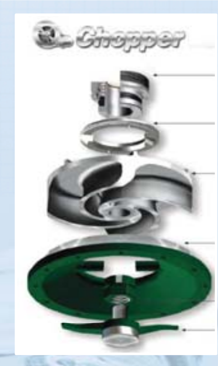
Valve options other than plug valves

- Stainless steel ball valves (full port)
  - Primarily SST with RTFE seats
  - Different lay lengths than plug
- Stainless steel gate valves
  - Primarily SST with various seats
  - Different lay lengths than plug

Consultation with Pump Manufacturers

- Types of pumps
  - Rotary lobe (Swaby, Vogelsang, Boerger, etc.)
    - Ability for suction lift (offloading)
  - Centrifugal chopper (Vaughan, WEMCO)
    - Cannot provide suction lift
    - Limits FOG haulers that don't have pumps or air-assist





Consultation with Pump Manufacturers (cont.)

- Swaby MR Series Lobeline Rotary Lobe Pumps
  - Rotors
    - Urethane
    - Buna-N Encased
    - Ductile Iron
    - 316 SST
  - Optional wear plates
    - Hardened Steel
    - Duplex SST

Consultation with Pump Manufacturers (cont.)

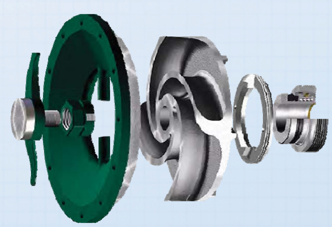
- Swaby MR Series Lobeline Rotary Lobe Pumps
  - Swaby recommends 316 SST rotors for this installation
    - Chemical and abrasion resistant
    - Indicate that lobes should push debris out of cavity and not bind up
    - Carollo cannot verify this
  - Resilient encasement provides some accommodation for debris, but wears and requires replacement
    - Reported condition of District transfer/mixing pump lobes indicated abrasion/tearing

Consultation with Pump Manufacturers (cont.)

- Vogelsang Rotary Lobe Pumps
  - Consulted due to industry experience and installed base
  - Casing Materials: Cast Iron, 316 SST, or Tungsten-coated stainless steel
  - Wear Plates: Various hardened materials available
  - Rotor Encasement Materials: NBR, Viton, or EPDM
    - Recommend NBR for FOG applications
    - Viton good for chemical resistance but more susceptible to abrasion

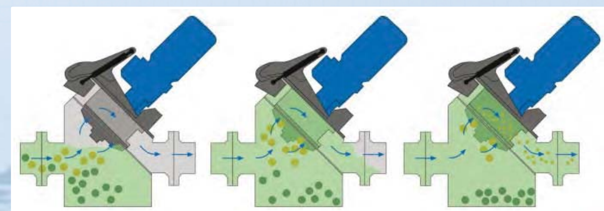
Consultation with Pump Manufacturers (cont.)

- Vaughan Centrifugal Chopper Pumps
  - Standard materials of construction
    - Hardened cast alloy steel impellers/cutters
    - Ductile cast iron casing
    - Buna-N elastomers
  - Stainless Steel Option
    - Hardened cast CD4MCu (duplex) stainless steel impellers/cutters and casing
    - Viton elastomers



Consultation with Grinder/Rock Trap Manufacturer

- Vogelsang Rotacut
  - Standard materials:
    - HDG collection basin, cutter head, lid
    - Hardened steel blade holder and blades
    - CREUSABRO 8000 (wear resistant steel) cutting screen



Consultation with Grinder/Rock Trap Manufacturer (cont.)

- Vogelsang Rotacut
  - Optional materials:
    - Stainless steel collection basin, cutter head, lid
    - Stainless steel blades
    - 420 stainless steel cutting screen

Chemical Compatibility Data

- Many sources of chemical compatibility data are available
- Often produced by valve/pipe manufacturers
- Results can be specific to each manufacturer's experiences and testing
- Not all chemicals included
- FOG is variable and contains unknown quality/chemical composition
  - No "FOG" category
- Chemical compatibility only one piece of puzzle

Chemical Compatibility Data (cont.)

Rating description for Nibco's compatibility chart

MATERIAL RATINGS FOR THERMOPLASTICS & ELASTOMERS

Temp. in °F	=	"A" rating, maximum temperature which is recommended, resistant under normal conditions
B to Temp. in °F	=	Conditional resistance, consult factory
C	=	Not recommended
Blank	=	No data available

MATERIAL RATINGS FOR METALS

A	=	Recommended, resistant under normal conditions
B	=	Conditional, consult factory
C	=	Not recommended
Blank	=	No data available

Chemical compatibility data shows Buna-N and FKM conditionally recommended for food oils

"A" Recommendation for Buna-N up to 200-250F

"A" Recommendation or Conditional "B" for Viton, depending on oil type

CHEM AI FORMULA	CONCE	ABS	CPVC	PP	PVC	PVDF	PEX	PPSU	PTFE	EPDM	NITRILE (Buna-N)	POLYCHLORO-PRENE	FKM	GRAPHITE	BRONZE (8	SI B	A B	B	G	D	C ST	3%	N D	400 SERIES SS	316 SS	630 SS	COPPER
									SEAL MATERIALS MAX TEMPERATURE (°F)																		
Coconut Oil			C	73	140	B to 248	73		400	C	250	C	B to 390		B	B	B	B	C	C	B		C	B	A		
Corn Oil			C	73	140		120		400	C	250	C	B to 400		B	B	B	B	B	B	B	B	B	A	A	A	A
Corn Syrup			185	140	140		140			200	200	C	212														
Cottonseed Oil		120	C	140	140		B to 140		400	B to 70	200	C	B to 400		B	B	B	B	B	B	B		B	A	A	A	
Olive Oil		160	C	73	140	B to 248	B to 68		350	C	250	C	250		A	A	A	A	A	A	A	A	A		A	A	A
Palm Oil				73			140		200	C	250	C	250		C	C			C	C	C		C		A		
Peanut Oil			C	140		B to 248			250	C	250	C	400		A	A			A	A			A		A		
Soybean Oil				73			140		400	C	250	250	B to 400		A	A	B		A	A	B	A	A	A	A	A	
Vegetable Oil			C	140	140	B to 248	B to 140		300	C	200	C	200		A	A				A	A			A	A	A	

Chemical compatibility data shows differing levels of acceptability for Buna-N and FKM when exposed to hydrolyzed compounds

CHEMICALS AND FORMULA	CONCENTRATION	ABS	CPVC	PP	PVC	PVDF	PEX	PPSU	PTFE	EPDM	NITRILE (Buna-N)	POLYCHLORO-PRENE	FKM	GRAPHITE	BRONZE (85% Cu)	SILICON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES SS	316 SS	630 SS	COPPER
		PLASTICS MAX TEMPERATURE (°F)							SEAL MATERIALS MAX TEMPERATURE (°F)						METALS												
Fatty Acids R-COOH		160	73	120	140		120		400	C	B to 250	C	250	A	C	C	C	C	C	C	C		C		A		
Oleic Acid		160	180	73	140	B to 248	C		250	C	B to 225	C	B to 212	A	B	B	A		B	B	C			B	A	A	A
Propionic Acid $CH_3CH_2CO_2H$		C	C	140		B to 140	140			200		C	C												A		A
Starch			180	140	140		140		300	176	B to 176	212	212		B	B	B	B	B	B	B		B	A	A	A	
Stearic Acid $CH_3(CH_2)_{16}COOH$			180	73	140		120		350	C	B to 70	C	140	A	A	A	C	B	C	C	C	B	C	A	A	A	A
Sugar $C_6H_{12}O_6$			180		140		140		350						C	C				B	C		B	A	A	A	

Chemical Compatibility Data (cont.)

- Buna-N, Viton, and PTFE are reported to be acceptable for some compounds that may be in FOG
- For other compounds, these same elastomers were not recommended, unknown, or conditionally acceptable
  - No silver bullet
  - PTFE recommended more often and to higher temps, but is a thermoplastic rather than an elastomer and has limited functionality
- 316 Stainless Steel showed good chemical resistance to many compounds
- Abrasion resistance not included in charts

Summary of Findings and Next Steps

Summary of Findings

1. NBR/Buna-N is commonly used for FOG applications and recommended by equipment manufacturers
2. Use of other materials to significantly improve system performance is yet to be demonstrated
3. Abrasion of NBR/Buna-N is common, although chemical impacts occur less frequently
4. Large systems require significant maintenance, although smaller plants fair better
5. Factors which contribute to reasonable operating success at other facilities include:
   - System simplicity
   - Reduced material residence time/flushing
   - Oversite/monitoring of FOG haulers
   - High degree of agency commitment

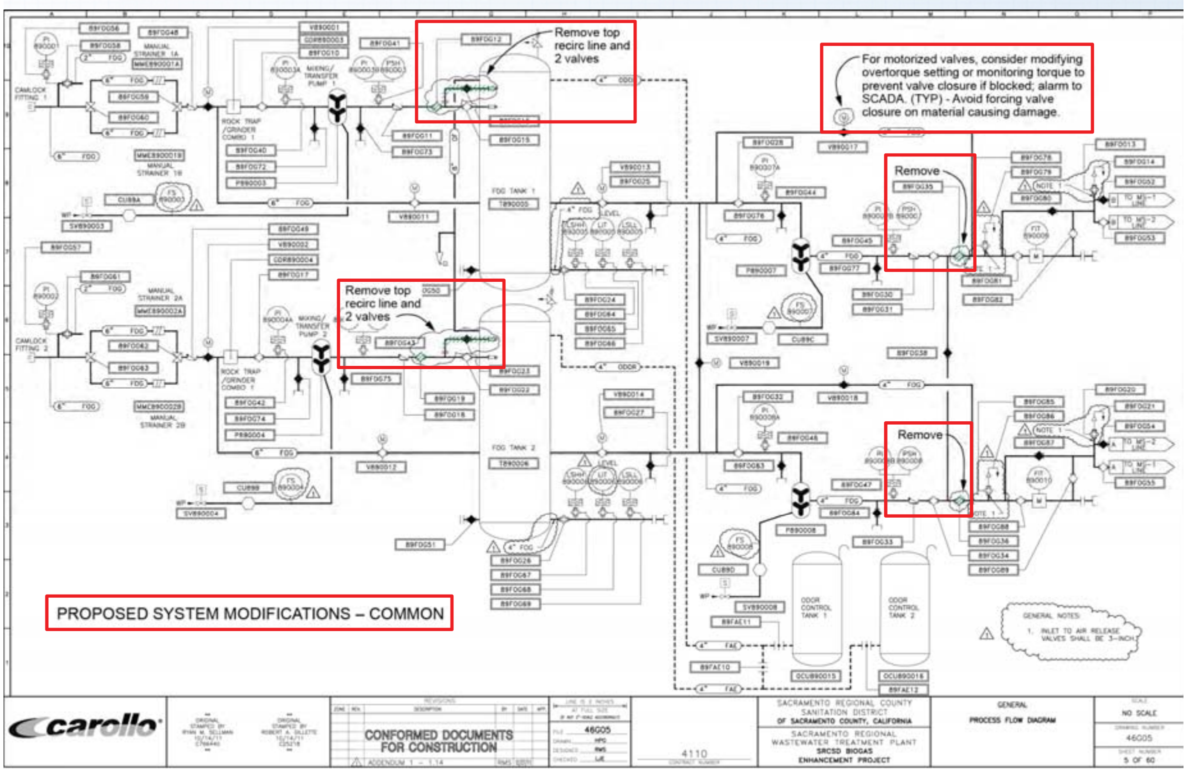
Next Steps

1. Simplify system to reduce number of components requiring monitoring and maintenance
2. Implement additional recirculation with MS and manual or automated flushing with WRH
3. Replace internals on Rotacut that does not yet have stainless steel internals
4. Consider alternative approaches to FOG testing and acceptance
5. Initiate regular monitoring and maintenance program for system components
6. Consider system modifications

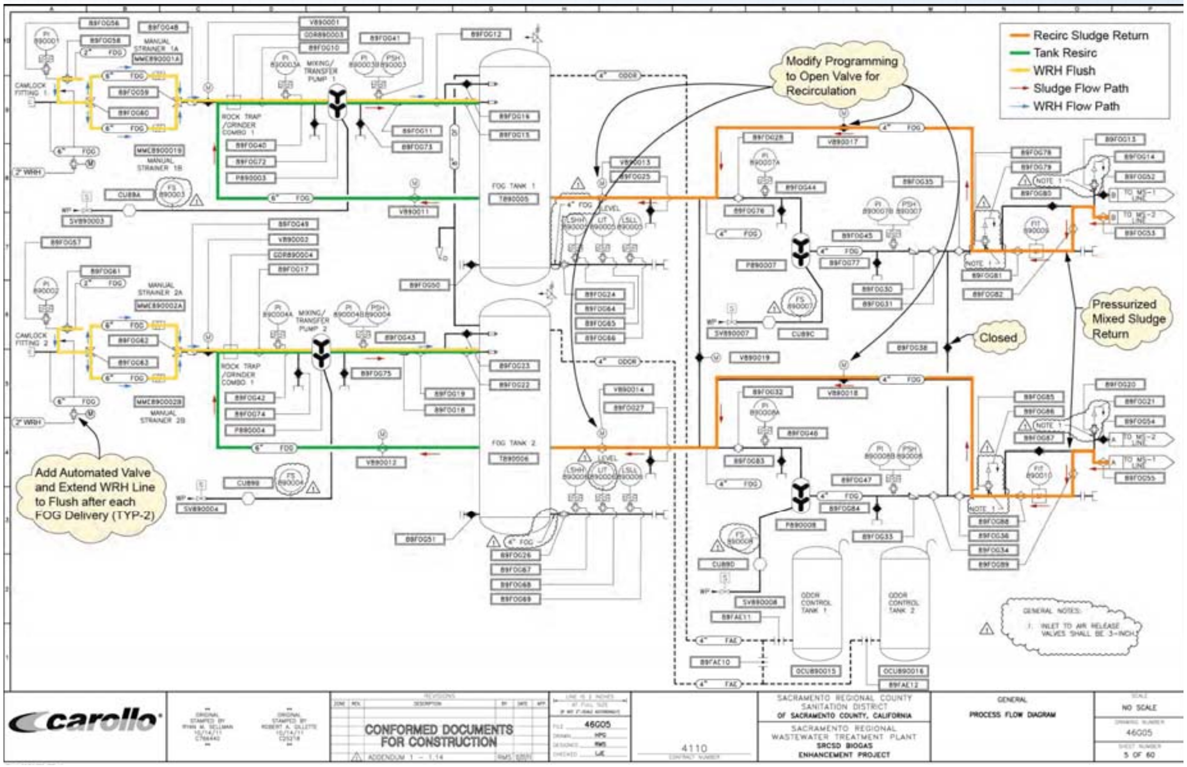
A range of alternatives for system modifications are available. Four have been developed for discussion.

Alternative	Description	Budget Cost
1	Replace damaged components in-kind	$200,000
2	Replace damaged components in one train in-kind. Use 2nd train to test alternate materials and manufacturers.	$220,000
3	Replace component elastomers with Viton and SST	$340,000
4	Replace all 4”/6” valves and mixing/transfer pump lobes with SST	$390,000

Simplify system before modifying components



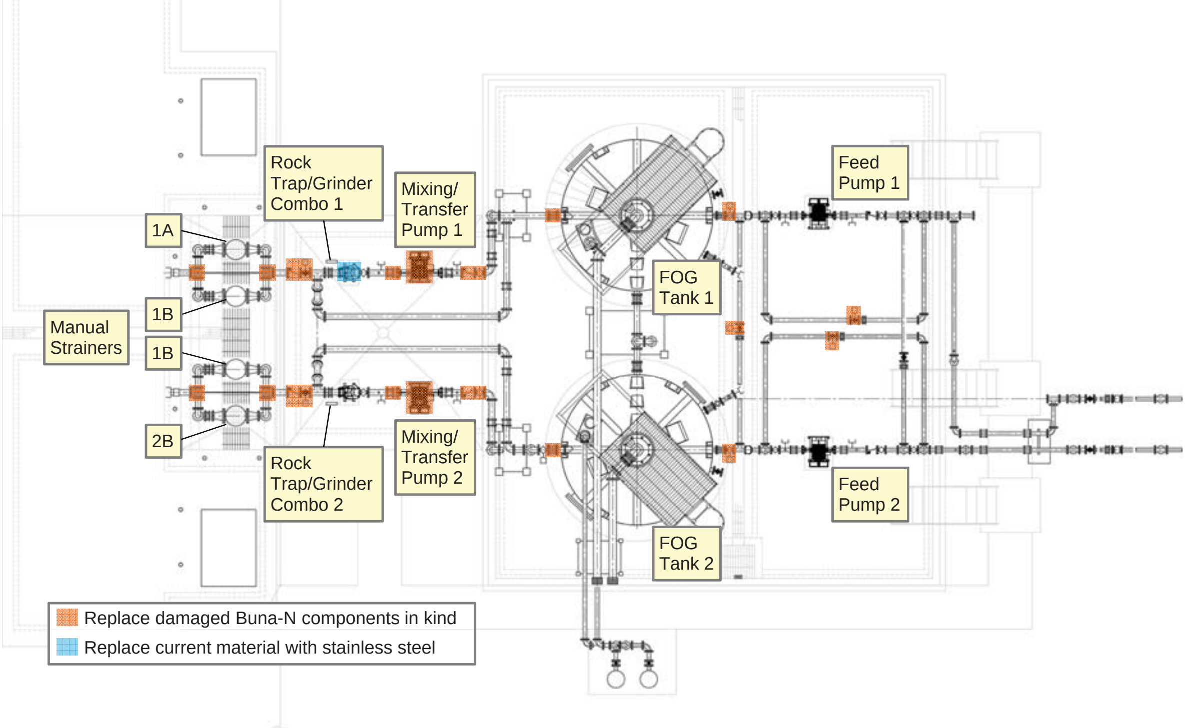
Implement recirculation/flushing



Modifications – Alternative 1

- Alternative 1
  - Replace damaged plugs, lobes, seals, flappers in kind (Buna-N)
  - Inspect remaining components and replace in kind if necessary

Modifications – Alternative 1



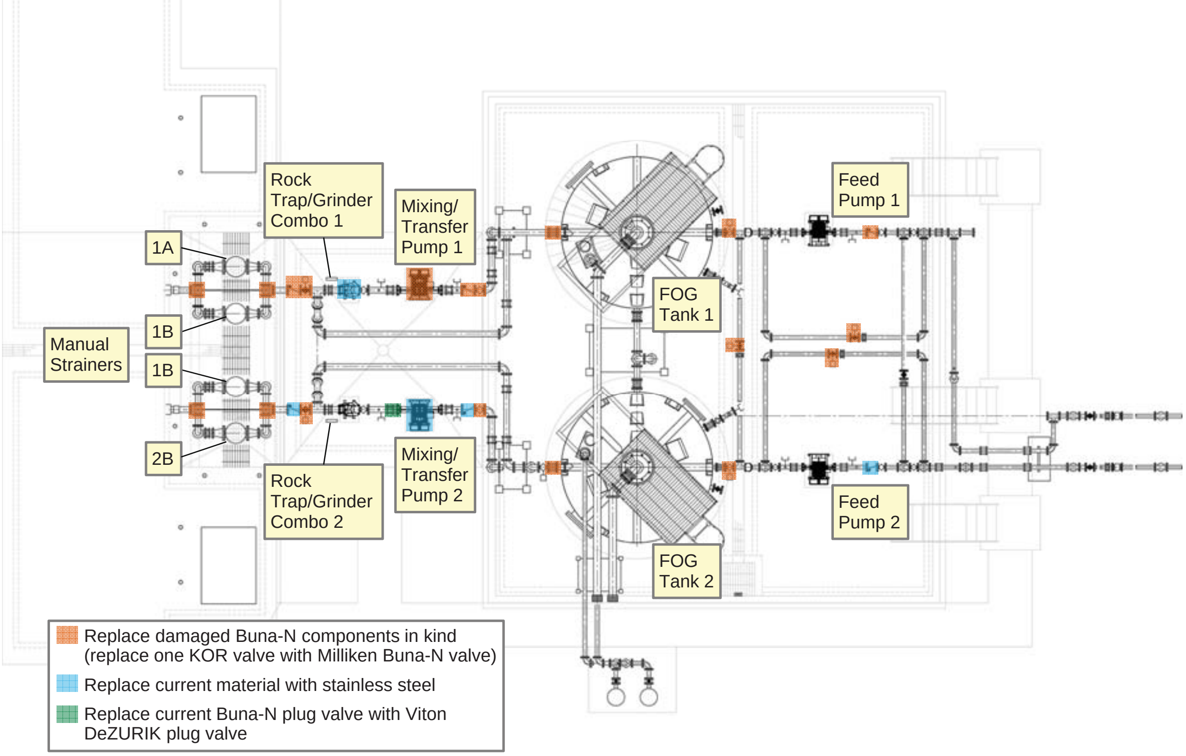
Modifications – Alternative 1

- Alternative 1
  - Estimated Material Cost (District purchase): $120,000
  - Estimated Contractor Cost: $80,000
  - Total Estimated Construction Cost: $200,000
- Lead Times
  - KOR Replacement Plugs: Awaiting Response
  - Vogelsang SST Internals: Awaiting Response
  - Swaby Buna-N Rotors: 8-12 weeks if not in stock
  - APCO Flapper Discs: 4-5 weeks

Modifications – Alternative 2

- Alternative 2
  - Replace damaged plugs, lobes, seals, flappers in one train in kind (Buna-N)
  - Replace some damaged components in second train with different items
    - SST lobes in one transfer/mixing pump
    - One Milliken plug valve with Buna-N
    - One DeZURIK plug valve with Viton
    - SST seated check valves
    - Replace remaining, damaged plug valves in kind
  - Inspect remaining components and replace in kind if necessary

Modifications – Alternative 2



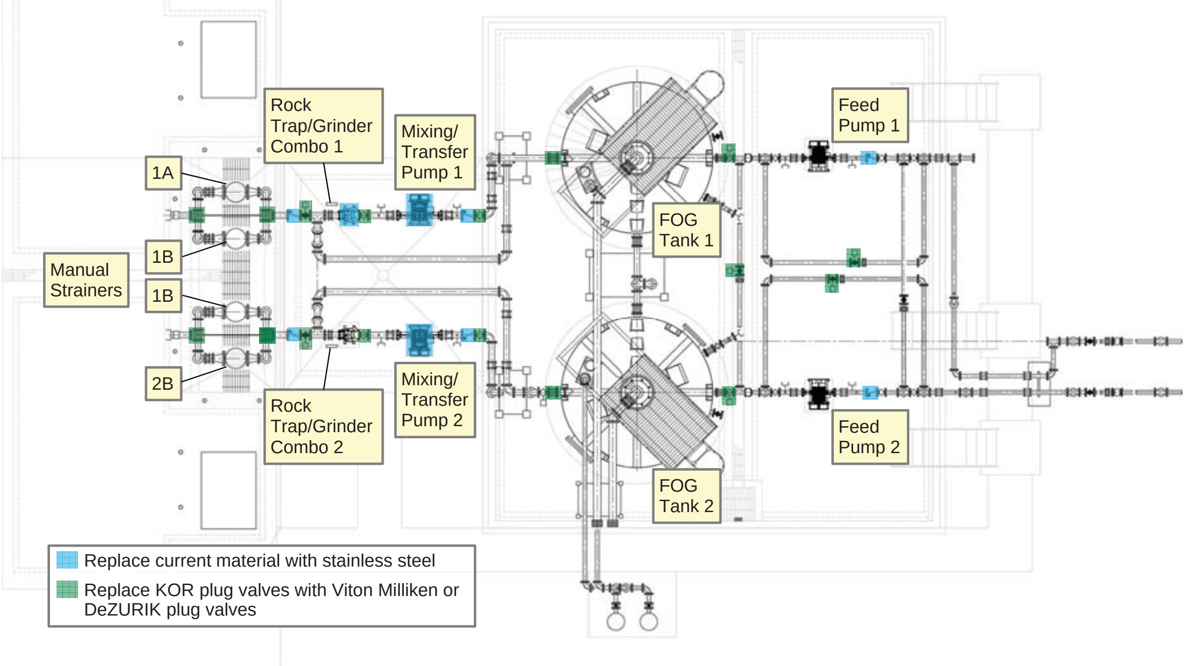
Modifications – Alternative 2

- Alternative 2
  - Estimated Material Cost: $130,000
  - Estimated Contractor Cost: $90,000
  - Total Estimated Cost: $220,000
- Lead Times
  - KOR Replacement Plugs: Awaiting Response
  - Vogelsang SST Internals: Awaiting Response
  - Swaby Buna-N and SST Rotors: 8-12 weeks if not in stock
  - DeZURIK Plug Valve with Viton: Awaiting Response
  - Milliken Plug Valve with Buna-N: Minimal. In Stock Item
  - Neway SST Check Valves: Minimal. In Stock Item
  - APCO Flapper Discs: 4-5 Weeks

Modifications – Alternative 3

- Alternative 3
  - Replace all 4" and 6" plug valves in both trains, upstream of tanks, with Viton plug valves (Milliken or DeZURIK)
  - Replace all motorized plug valves downstream of tanks with Viton plug valves and new actuators
  - SST lobes in both mixing/transfer pumps
  - SST seated check valves
  - Inspect remaining components and replace plug valves with Viton and feed pump lobes with SST, if damaged

Modifications – Alternative 3



Modifications – Alternative 3

- Alternative 3
  - Estimated Material Cost: $240,000
  - Estimated Contractor Cost: $100,000
  - Total Estimated Cost: $340,000
- Lead Times
  - Vogelsang SST Internals: Awaiting Response
  - Swaby SST Rotors: 8-12 weeks if not in stock
  - Milliken Plug Valve with Viton: Minimal. In stock item
  - Milliken 3-Way Plug Valve with Viton: 4 weeks
  - Neway SST Check Valves: Minimal. In Stock Item

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Modifications – Alternative 4

- Alternative 4
  - Replace all plug valves in both trains with either 4” SST ball valves or 6” SST gate valves, modify piping
  - Replace actuators for motorized valves
  - SST lobes in both mixing/transfer pumps
  - SST seated check valves
  - Inspect feed pump lobes and replace with SST, if failed

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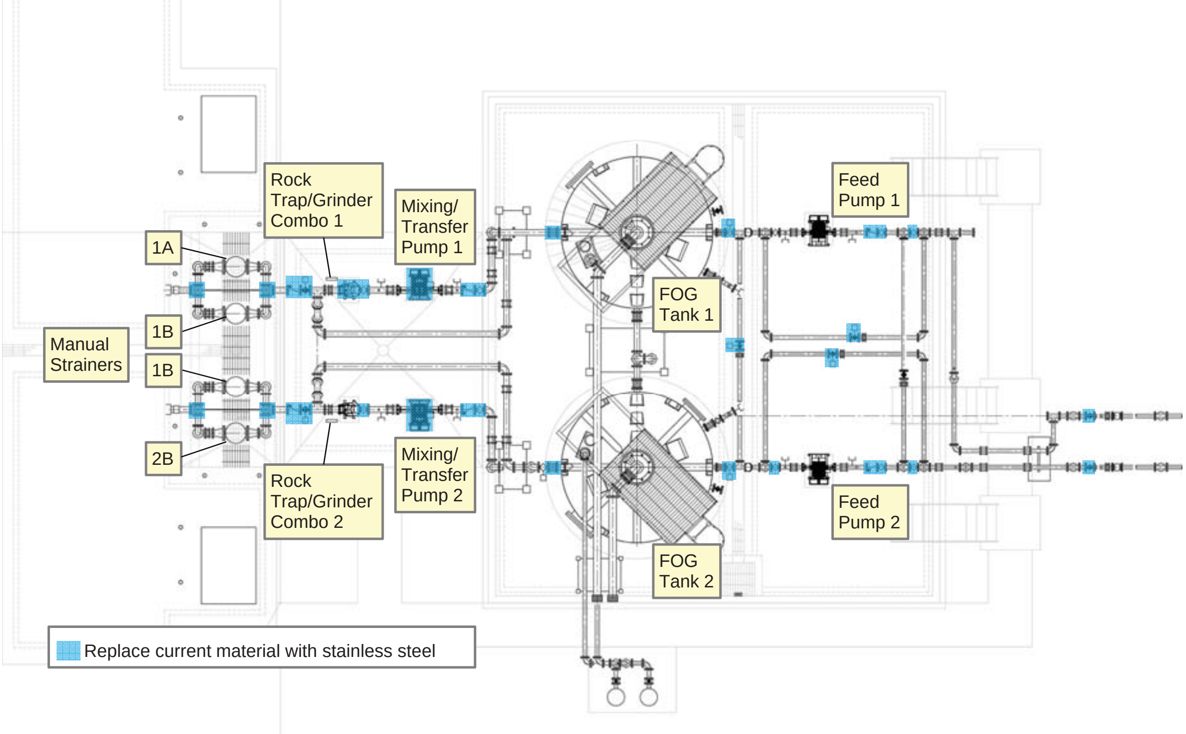
Modifications – Alternative 4



Modifications – Alternative 4

- Alternative 4
  - Estimated Material Cost: $280,000
  - Estimated Contractor Cost: $110,000
  - Total Estimated Cost: $390,000
- Lead Times
  - Vogelsang SST Internals: Awaiting Response
  - Swaby SST Rotors: 8-12 weeks if not in stock
  - Wey Model VL SST Knife Gate Valve: Few days for manual actuation, 4-6 weeks for motorized valves
  - Apollo SST Full Port Ball Valve: 2-4 weeks if not in stock
  - Neway SST Check Valves: Minimal. In Stock Item
  - Glass-lined Pipe: 14 weeks

APPENDIX C:
New Hope Dairy Digester Report

Plugging dairies into a renewable future.

Final Report: New Hope Dairy Digester and Engine-Generator

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SMUD CRED Contract Number: 4500072275

Table of Contents

1. Introduction

Under Grant Agreement ARRA Grant # DE-EE0003070, a team led by California Bioenergy LLC has developed and demonstrated the application of an anaerobic digester and engine-generator system to a 1,200 milk cow dairy farm, New Hope Dairy LLC, located west of Galt in the Southern part of the Sacramento County. New Hope uses a newly installed scrape system to collect manure from most of the stalls and deliver it to the anaerobic digester. The project, developed by California Bioenergy LLC, uses a CSTR (complete stirred tank reactor) digester operating at mesophilic temperatures, designed by MT-Energie and built by RECM. The collected manure along with some dilution water (cooling misters during hot weather) is retained in the tank digester for 30 to 40 days. As the manure decomposes, biogas is produced and accumulates in the tank. The gas is then collected, cleaned and sent to a 450 kW engine-generator made by 2G-Cenergy. California Bioenergy LLC (CalBio), through its special purpose company, ABEC New Hope LLC, is the developer of New Hope Dairy digester. MT-Energie, through its special purpose company, RECM, LLC completed the design in 2011 and construction started in December 2012 and was completed in the first quarter of 2013. Commissioning was completed in the second and third quarters of 2013.

The first phase of start-up and commissioning of the digester and engine-generator was described in the earlier report: Test Plan for Start-up and Commissioning. A test plan for operating the digester and engine-generator through a field demonstration period was submitted, and subsequently, a report summarizing the data collected during this field demonstration period in August 2013 was also submitted.

This final report includes data collected through one full year of operation of the New Hope digester, from July, 2013 through June, 2014, along with analysis, discussions and conclusions.

2. Digester System Components and Testing

2.1 Manure Collection System Description

New Hope Dairy has installed a new automatic manure scraping system to collect manure from most of the stalls and deliver it to the anaerobic digesters. This system, shown in Figure 1, continuously scrapes the fresh manure from three free stall barns into two slurry collection tanks with influent pumps as shown in Figure 2. As the tanks fill with manure, the pumps transfer the manure to the digester through the influent pipes shown in Figure 3. Also shown is the ferric chloride dosing system for controlling H_2S in the digester gas.

Figure 1. Automatic manure scraping system.

Figure 2. Manure slurry collection tank.

Figure 3 Ferric Chloride dosing system and Influent pipes entering digester.

2.2 Digester System Description

The tank digester is a reinforced concrete structure 85 feet in diameter and 26 feet deep with a volume of approximately 1 million gallons, with a reinforced concrete floor as well as a leak detection system underneath the slab. Figure 4 shows the tank digester. This digester is heated using the water jacket and exhaust heat from 2G Cenergy engine generator. As shown in Figure 5, hot water from engine-generator is circulated in pipes that maintain the digester temperature in the mesophillic range, 95-104 ^{o}F.

In order to collect the produced biogas the tank is equipped with a flexible double membrane roof. The outer cover is a protective cover being held up through air inflation. The inner membrane can move freely between the top of the tank and the outer membrane allowing for gas storage capacity. Also included in the tank digester is an air injection system, shown in Figure 6, that injects a small amount of air (<5%) under the inner gas storage membrane in order to oxidize and reduce the hydrogen sulfide levels. The effluent from the digester is pumped to a storage pond for solids separation and afterwards used for crop irrigation as a liquid fertilizer.

Figure 4. 1-million gallon tank digester at New Hope Dairy.

Figure 5. Hot water pipes for digester heating in control room

Figure 6. Air Injection System for H_2S Reduction in Control Room

2.3 Engine-Generator Description

The engine-generator is a 2G-Cenergy and MAN Combined Heat and Power (CHP) package with a rated capacity of 450 kW and utilizing a Selective Catalytic Reduction (SCR) emissions control system. The installation was performed in 2012 with switchgear allowing interconnection to the grid. Specifications for the engine are given in Table 1.

Specification	
Engine type	V12
Bore and Stroke, mm (in)	129 X 142 (5.04 X 5.59)
Displacement, L (CID)	21.93 (1338)
Compression ratio	14.8:1
Net weight, kg (lb)	14,991
Ignition system	Coil on Plug
Electrical output, kW	450
Thermal output, kW	500
Electrical Efficiency, %	39.1
Generator type	Synchronous electronic governor control
Generator power kV(kVA)	480(562)
Generator Output, amps	677
Generator speed, rpm	1800
Generator frequency, hZ	60

Table 1. 2G-Cenergy and MAN CHP 450 ekW 60hz a312

This engine was chosen because of its suitability for biogas, its efficiency and its emissions capabilities. The size was chosen for its fit with the digester output and for its ability to generate power during the peak hours of the day. Figure 5 shows the completed installation of this unit.

Figure 7. New Hope Dairy 450 kW engine-generator

2.4 Test Objectives and Technical Approach

The objectives and technical approach of the year-long digester testing are as follows:

2.4.1 The manure collection system utilizing mechanical scrapers was subjected to periodic testing during its first year of operation to demonstrate its effectiveness at removing manure from the free stall lanes and delivering influent to the digester at the appropriate quantity and quality. The technical approach for evaluating the scraping system is to measure volumes of manure slurry collected by the scraping system along with the TS and VS characteristics and compare with the total manure production from the cows housed on the scraping system free stalls.

2.4.2 The tank-type digester system was subjected to continuous testing to determine its gas production rates, influent loading rates as well as digester operational parameters such as temperature and mixing rates. The technical approach is to utilize the data collection system included as part of the MT-Energie CSTR tank digester installation, which continuously collects the important digester data which is listed in the data matrix below.

2.4.3 The CHP engine-generator was subjected to year-long continuous testing for its electrical output and overall efficiency based on the biogas energy input as well as the thermal heat output and its effectiveness for digester heating. The technical approach is to utilize the data collection system included as part of the 2G Cenergy engine-generator installation, which continuously collects the important engine and generator data which is listed in the data matrix below.

2.4.4 Perform cash flow economic calculation and levelized cost analysis for the project.

2.4.5 Document job creation during construction and actual operation of the integrated digester and CHP engine-generator system

2.4.6 Perform actual and projection of GHG benefits for the New Hope Dairy digester project.

2.4.7 Perform exhaust emissions testing to compare with the allowable limits for the various pollutants.

3. One-year Test Results

3.1 Test Measurements and Data

3.1.1 The manure scraping system data matrix is shown in Table 2. Manure flow data were collected and summarized for four distinct time intervals; August 2013, September 2013, March 2014 and June 2014, corresponding with the varying climatic seasons of the year. Regarding the data shown in Table 2, The main reason for Pre-tank 1 having a lower TS and VS content than Pre-tank 2, is that there was some extra flush water that was used to clean the freestalls in the barns feeding Pre-tank 1, whereas the barns feeding Pre-tank 2 did not have this extra flush water, only the scraped manure.

Table 2. Manure scraping system data matrix selected months 2013-2014

Parameter	Pre-Tank #1	Pre-tank #2	Total Influent	Average Effluent	Theoretical Manure production from 1200 cows[1.]	Percent Collected
August 2013						
Volume, gal/day	25,777	9,123	34,900	30,742	17,000	NA
TS, %	4.57%	4.14%	4.46%	1.78%	13.30%	
TS,lb/day	9,825	3,150	12,975	4,564	18,857	69%
VS, %	3.55%	3.16	3.45%	1.12%	11.30%	NA
VS,lb/day	7,632	2,404	10,036	2,872	16,021	63%
September 2013						
Volume, gal/day	26,563	11,830	38,393	37,360	17,000	NA
TS, %	3.68%	5.26%	4.14%	2.71%	13.30%	
TS,lb/day	8,106	5,155	13,261	8,444	18,857	70%
VS, %	2.68%	3.91%	3.04%	1.7%	11.30%	NA
VS,lb/day	5,904	3,831	9,735	5,297	16,021	61%
March 2014						
Volume, gal/day	18,978	10,774	29,752	30,445	17,000	NA
TS,%	6.80%	8.39%	7.38%	4.72%	13.30%	
TS,lb/day	10,763	7,539	18,302	11,985	18,857	97%
VS,%	5.49%	6.86%	5.99%	3.30%	11.30%	NA
VS,lb/day	8,689	6,164	14,853	8,379	16,021	93%
June 2014						
Volume, gal/day	20,353	11,803	32,156	32,292	17,000	NA
TS,%	6.0%	7.59%	6.58%	3.99%	13.30%	
TS,lb/day	10,185	7,471	17,656	10,746	18,857	94%
VS,%	4.74%	6.08%	5.23%	2.68%	11.30%	NA
VS,lb/day	8,046	5,985	14,031	7,218	16,021	88%

[1.] ASABE D384.2 MAR2005, Manure Production and Characteristics: 1200 cows

3.1.2 The CSTR digester system data matrix is shown in Table 3. The data are for August 2013, September 2013 March 2014 and June 2014, corresponding to the months when influent and effluent lab analyses were performed. The total solids and volatile solids data were collected at these time intervals to correspond with the flow data. These particular data, total solids and volatile solids of the influent and effluent were collected at these particular times due to the time limitations in being able to collect this data and have it analyzed. All the other data in this report - biogas, kWh, etc, are monitored continuously by the digester instrument and control system; the TS and VS are not part of this system. It is believed that the data collected, although not for all the months of the year, did show important trends in differences between summer and winter months.

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Table 3. Digester system data matrix selected months 2013-2014

Parameter	Units	Aug. 2013	Sept. 2013	March 2014	June 2014
Total Influent	Gallons/day	34,900	38,393	29,751	32,156
Influent VS	Pounds/day	10,036	9,735	14,853	14,031
Effluent to lagoons	Gallons/day	30,742	37,360	30,445	32.292
Effluent VS	Pounds/day	2,872	5,297	8,379	7,218
Digester Mixer times	Minutes/day	387	300	305	261
Digester Temperature	Degrees F.	105	103	104	105
Air injection for H2S control	SCFM	5	5	4	5
Biogas production	Cubic Feet/day	79,071	71,536	94,929	83,131
Biogas conversion of VS	Cubic feet/lb influent VS/day	7.88	7.33	6.39	5.92
Gas composition:					
CH4	% Volume	56	56	54	55%
CO2	% Volume	39	38	43	42%
O_2	% Volume	1	1	0.4	.5%
N_2	% Volume	4	5	2.1	2%
H_2S	ppmv	.61	10	1.65	.8
Digester Operating time	Cumulative hours	4,110	4,828	9,185	11,363
Operating time of digester	hours/day	24	24	24	24
Internal power consumption	kWhrs/day	413	326	287	218
Internal power consumption	average kW	9	14	12	9

3.1.3 The evaluation of the CHP engine-generator includes the parameters shown in the Table 4 matrix. The data are for August 2013, September 2013 March 2014 and June 2014, corresponding to the months when influent and effluent lab analyses were performed.

Table 4. CHP engine-generator data matrix, selected months 2013-204

Parameters	Units	Aug. 2013	Sept 2013	March 2014	June 2014
Biogas Consumption (equal to biogas production w/o flare)	Cumulative cubic feet	5,899,018	8,045,110	23,349,220	30,757,240
	cubic feet/day	79,071	71,536	94,929	83,131
Biogas Energy Input*	Btu/day	40,186,650	36,265,962	46,751,773	41,818,880
Cumulative Electrical work output	kWhrs	341,638	464,854	1,363,983	1,788,715
Electrical work daily output	kWhrs/day	4,482	4,107	5460	4,732
Electrical average power output	kW	420	417	439	436
Electrical Efficiency, %	%	38%	39%	40%	36%
Operating time	Cumulative hours	894	1,178	3,241	4,216
Operating time	hours/day	10.68	9.47	12.42	10.87
% Utilization of the CHP**	%	77.8%	71.3%	94.78	82%

* Based on methane content from Table 3 and LHV of methane = 910 Btu/cu ft

** % Utilization of CHP =(Daily electrical production/5761)*100, where 5761kWh/day is the design basis electrical production. Thermal heat utilization was calculated and these results are shown in Tables 8 and 9.

3.1.4 Job creation as a result of this digester project was calculated to be 0.86 Full-time equivalents (FTE), and the basis for this calculation is shown in Table 5 which is for the continued operation of the digester The average number of people on site during construction of the New Hope digester was calculated as follows: based on the total number of hours worked divided by 2040 hrs/year (assuming FT Employee status) which comes to 6.1 FTE. Since almost all the workforce was part-time, the actual number of employees was estimated to be 20. Based on the information in Table 5, almost $230,000 is added annually to the local economy in terms of direct wages as well as additional indirect benefits of materials purchased.

Table 5. Basis for calculation of job creation of the New Hope dairy digester project, in Full-time Equivalents (FTE) and overall operating cost metrics.

Expense Category	Expense per Year	Materials	Labor	Est. Labor Rate $/Hr	FTE Hours per Year	FTE
State Property Taxes	$46,222	80%	20%	$100	92.4	0.05
Generation O&M Expenses	$45,571	20%	80%	$75	486.1	0.24
Farmer Feedstock and Lease	$41,706	0%	100%	$100	417.1	0.21
Digester O&M Expenses	$40,054	15%	85%	$75	453.9	0.23
Administrative Expenses	$27,898	0%	100%	$150	186.0	0.09
Property Insurance	$21,319	90%	10%	$100	21.3	0.01
SMUD Interconnection Maintenance	$6,488	10%	90%	$100	58.4	0.03
Unlevered Operating Cost	$229,257				1,715.2	0.86
Interest Expense	$31,982					
Levered Operating Cost	$261,239					

3.1.5 GHG Reduction. This section includes a calculation of the GHG credits that can be assigned to the performance of the CSTR digester and CHP engine –generator in capturing and combusting methane emissions from the dairy manure. The Climate Action protocols will be used for this calculation. Based on the assumptions used in the CAR Livestock calculation tool, assuming 1000 milking cows and 200 dry cows and assuming operation beginning in July, 2013 through June 2014 the estimated GHG credits for the full calendar year of 12 months would be 2697 metric tons of CO2 equivalents per the year. The summary table from the CAR calculation is shown in Table 6 below.

Table 6. Comparison of modeled methane reductions to total quantity of destroyed methane for New Hope dairy, 12-months.

Description	Quantity	Unit
BECH4 (MT) - PECH4 (MT) =	128.424	tonnes CH4
CH4,destroyed (MT) =	363.175	tonnes CH4
Total Actual Methane Reductions (MT) =	128.424	tonnes CH4
Total Actual Methane Reductions (CO2e) =	2696.906	tonnes CO2e
Note: The Total Methane Reductions (below) will be equal to the lesser of the two values above.		
Total Emission Reductions (CH4 and CO2)		
Total Emission Reductions (MT CO2e/yr) =	2,696.91	tonnes CO2e

3.1.7 Engine Emissions. Testing was performed in June, 2013 to determine the levels of exhaust emissions from the 2G-Cenergy and MAN CHP engine-generator while running at from 73% to 100% of the load of 450 KW. The result of this testing are listed below in Table 7.

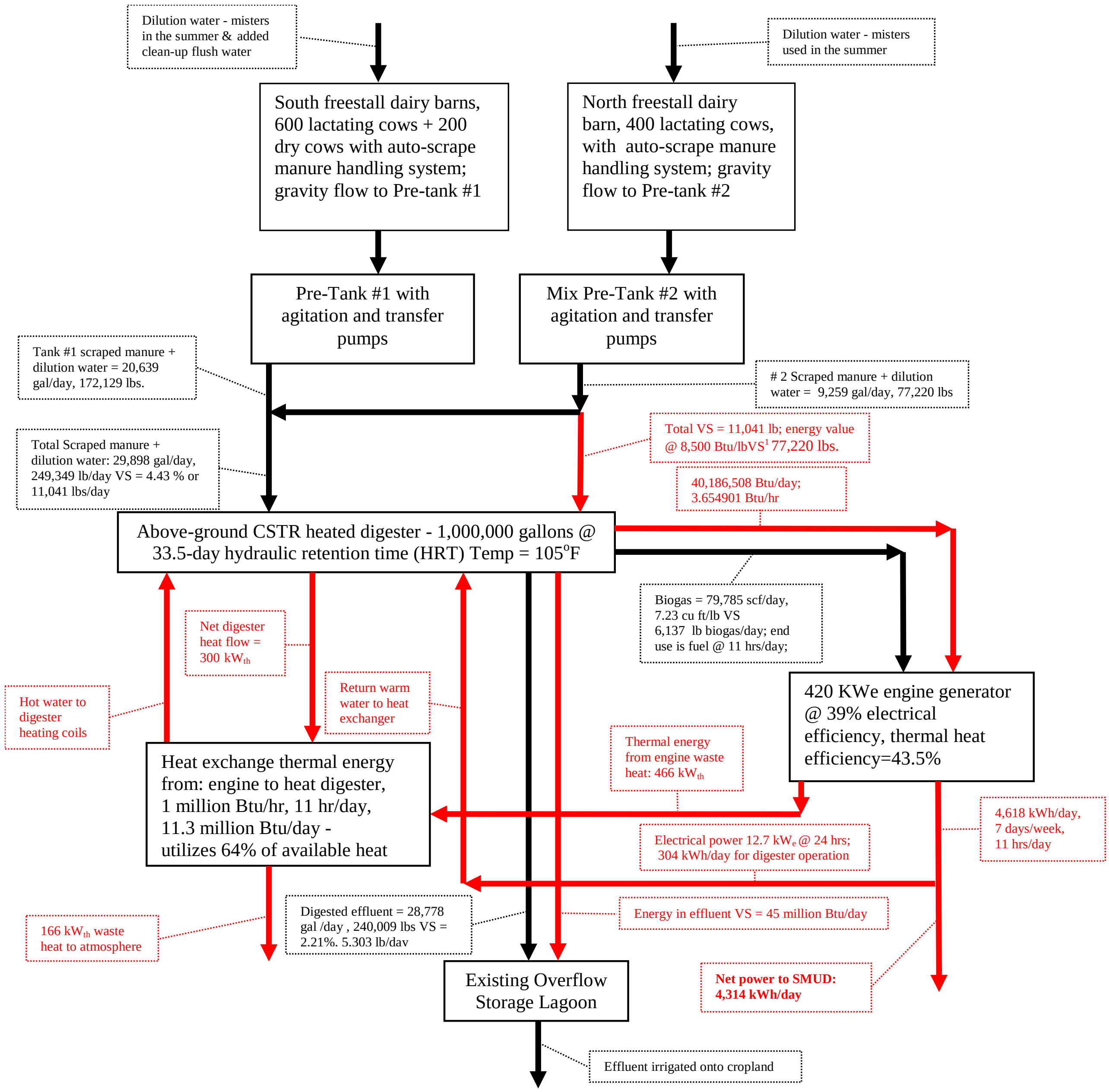
Table 7. Results of exhaust emissions testing of the 2G-Cenergy and MAN CHP engine-generator.

Test Parameters:	Carbon Monoxide (CO), Oxides of Nitrogen (NO_X), Volatile Organic Compounds (VOC), Ammonia (NH_3), Particulate Matter (PM) and Hydrogen Sulfide (H_2S)	
Emission Limits:	*CO:*	*329.6 ppmvd@15% O_2*
	NO_X:	*24.1 ppmvd@15% O_2*
	VOC:	*79.1 ppmvd@15% O_2*
	NH_3:	*10 ppmvd@15% O_2*
	PM:	*9.6 lb/day*
	H_2S:	*350 ppmvd (fuel)*
Test Results:	*CO:*	*24.6 ppmv@3%O_2*
	NO_X:	*11.2 ppmv@3%O_2*
	VOC:	*13.0 ppmv@3%O_2*
	NH_3:	*0.06 ppmv@3%O_2*
	PM:	*0.08 lb/day*
	H_2S:	*0.06 ppmvd (fuel)*
Test Company:	Air Science Technologies, Inc. 247 Rodeo Avenue Rodeo, CA 94572	

3.2 Mass and Energy Flow Diagram for New Hope Dairy.

The below diagram, Figure 8, is based on the average data collected over the first full year of operation. The heat balance calculations for the 450 kW CHP engine-generator are shown in Table 9, and the results of these calculations are used to determine the overall efficiency of the CHP shown in Table 8.

The unaccounted mass flow of over 3,000 lb/day (~1%) was probably due to measurement errors in the flow meters and possibly some accumulation in the digester tank. The unaccounted energy flow of almost 9 million Btu/day is mostly due to the mass flow difference and the reduced energy contained in the effluent VS. There may also be errors in measurement, primarily the VS measurement being only four total samples compared with one full year of data shown in Table 8.



Mass(↓) and Energy(↓) Flow Diagram: New Hope Digester System: One Year average. July 2013-June 2014

[1.] http://www.extension.org/pages/43790/what-is-the-energy-value-btulb-of-livestock-manure-our-manure-source-is-dairy-solids-that-are-separate

Figure 8. Mass and energy flow Diagram for New Hope Dairy: average daily flows during first year of operation July 2013-June-2014

Table 8 shows a spreadsheet form of the mass and energy balance illustrated above and Table 9 shows the result of the heat balance calculation for the New Hope digester and CHP system.

MASS AND ENERGY BALANCE AT NEW HOPE DIGESTER AND CHP ENGINE GENERATOR			
		MASS	ENERGY
PARAMETER	UNITS	Average July 2013-June 2014	
PRE-TANK #1 MANURE +MIST AND FLUSH WATER	GAL/DAY	20,639.00	
PRE-TANK #1 MANURE +MIST AND FLUSH WATER	LB/DAY	172,129	
PRE-TANK #2 MANURE +MIST AND FLUSH WATER	GAL/DAY	9,259.00	
PRE-TANK #2 MANURE +MIST AND FLUSH WATER	LB/DAY	77,220	
TOTAL MANURE + MIST AND FLUSH WATER	GAL/DAY	29,898.00	
HYDRAULIC RETENTION TIME, DIGESTER VOLUME = 1 MILLION GALLONS	DAYS	33.45	
TOTAL MANURE + MIST AND FLUSH WATER	LB/DAY	249,349.32	
MANURE VOLATILE SOLIDS(VS)	%	4.43%	
MANURE VOLATILE SOLIDS(VS)	LB/DAY	11,041.00	
ENERGY CONTENT OF VS INPUT TO DIGESTER	BTU/LB	8,500.00	93,848,500.00
BIOGAS PRODUCTION PER DAY	CU FT/DAY		79,785.00
BIOGAS ENERGY CONVERSION OF VS	CU FT/LB VS		7.23
CH4 CONTENT OF BIOGAS	%		0.55
LLHV OF CH4	BTU/CU FT		910
BIOGAS ENERGY OUTPUT FROM DIGESTER/INPUT TO CHP	BTU/DAY		40,186,508
HOURLY ELECTRICAL ENERGY OUTPUT FROM CHP	KW		420.00
HOURLY OPERATION OF DIGESTER	HRS/DAY		11.00
DAILY ELECTRICAL OUTPUR FROM CHP	KWHR/DAY		4,618.0
ELECTRICAL EFFICIENCY OF CHP	%		39%
PARASITIC ELECTRICAL POWER TO OPERATE DIGESTER	Kwe		12.67
HOURS PER DAY TO OPERATE DIGESTER	HRS/DAY		24
PARASITIC ELECTRICAL ENERGY TO OPERATE DIGESTER	KWHRS/DAY		304
NET ELECTRICAL ENERGY TO SMUD	KWHRS/DAY		4,314
THEMAL HEAT EFFICIENCY OF CHP	%		43.5%
MAXIMUM HEAT FLOW	KWth		466
TOTAL HEAT FLOW AVAILABLE	BTU/DAY	-	17,481,130.86
DIGESTER HEATING:INFLUENT HEATING: SEE HEAT BALANCE CALCULATION			10,909,033
DIGESTER HEATING:WALL HEAT LOSS : SEE HEAT BALANCE CALCULATION			364,503.29
TOTAL DIGESTER HEAT LOSS	BTU/DAY		11,273,536
DIGESTER HEAT LOSS % OF TOTAL HEAT AVAILABLE	%		64%
NET DIGESTER THERMAL ENERGY FLOW	KWth		300
EXCESS THERMAL ENERGY FLOW TO ATMOSPHERE	KWth		166
MASS FLOW OUT OF DIGESTER:			
BIOGAS @ 13 CUBIC FEET/LB	LB/DAY	6,137	
EFFL;UENT	GAL/DAY	28,778	
TOTAL EFFLUENT	LB/DAY	240,008.52	
VS CONTENT	%	2.21%	
EFFLUENT VS	LB/DAY	5303	45,075,500
UNACCOUNTED FOR MASS FLOW:INFLUENT-EFFLUENT-BIOGAS	LB/DAY	3,203	
UNACCOUNTED FOR ENERGY FLOW:INFLUENT VS-EFFLUENT VS-BIOGAS ENERGY	BTU/DAY		8,586,492

Table 8. Mass and energy balance for Digester and CHP engine-generator

HEAT BALANCE CALCULATION: NEW HOPE DIGESTER AND 2G CENERGY 450 KW CHP ENGINE				
			DESIGN BASIS	AVERAGE: JULY 2013 -JUNE 2014
PARAMETER		UNITS		
FUEL INPUT		CU FT/DAY	92,893.00	79,785.00
CH4 CONTENT		%	0.55	0.55
CH4 ENERGY		BTU/CU FT	910.00	910.00
BIOGAS FUEL ENERGY INPUT, PER DAY		BTU/DAY	46,492,947	40,186,508
BIOGAS FUEL ENERGY INPUT, PER HOUR		BTU/HR	3,822,735	3,654,901
HOURLY ELECTRICAL		KW	450.00	420.00
DAILY ELECTRICAL		KWHR/DAY	5,473.00	4,618.00
CHP ENGINE DAILY OPERATION		HOURS/DAY	12.16	11.00
ELECTRICAL EFFICIENCY		%	40.2%	39.2%
MAXIMUM HEAT EFFICIENCY		%	43.5%	43.5%
MAXIMUM HEAT FLOW		KW	487	466
TOTAL HEAT FLOW AVAILABLE		BTU/DAY	20,224,432	17,481,131
DIGESTER HEATING: INFLUENT HEATING				
	INFLUENT VOLUME FLOW	GAL/DAY	19,404.00	29,898.00
	INFLUENT MASS FLOW	LB/DAY	161,829.36	249,349.32
	INFLUENT TEMPERATURE	^{O} F	70.00	70.00
	DIGESTER TEMPERATURE	^{O} F	105.00	105.00
	NET INFLUENT HEAT REQUIRED	BTU/DAY	5,664,028	8,727,226
	EFFICIENCY OF HEAT EXCHANGER	%	0.80	0.80
	GROSS INFLUENT HEAT	BTU/DAY	7,080,035	10,909,033
DIGESTER HEATING: WALL HEAT LOSS				
	AREA OF WALLS	SQ FT	6,942.92	6,942.92
	R VALUE OF WALLS	hr-Btu^{-1}sq ft	20.00	20.00
	AVERAGE OUTSIDE TEMPERATURE	^{O} F	70.00	70.00
	DIGESTER TEMPERATURE	^{O} F	105.00	105.00
	NET HEAT LOSS THROUGH WALLS	BTU/DAY	291,603	291,603
	HEAT EXCHANGER EFFICIENCY	%	80%	80%
	GROSS HEAT LOSS THROUGH WALLS	BTU/DAY	364,503.29	364,503.29
TOTAL DIGESTER HEAT LOSS		BTU/DAY	7,444,538	11,273,536
HEAT LOSS % OF TOTAL HEAT AVALABLE		%	37%	64%
	Digester Diameter, ft	85	Digester height,ft	26
[1]Wall area = pi(dia)(height)		6,942.92	sq. ft.	
Insulation R-value of 4" foam insulation: 20 hr-Btu^{-1} sq ft^{-1} ^{o}F^{-1}				
Reference: http://building.dow.com/na/en/products/insulation/highload60.htm				

Table 9. Heat balance calculation: New Hope digester and CHP engine-generator

3.3 Analysis, Discussion and Conclusions

The following are combined analysis, discussion and conclusions from the data collected over a one-year period for the New Hope digester. Table 10 contains the summarized operating data for the one-year of operation and a comparison with the original design basis. Figures 9,10,11,12 and 13 then illustrate the trends of the various performance parameters of the New Hope dairy digester and CHP system.

3.3.1 The performance of the new continuous scrape system is characterized in the following bullet points:

- The gallons per day of manure influent was compared with the total estimated manure production by the 1200 cows from which the manure is scraped, and the percent collection efficiency was calculated on a total solids and volatile solids basis. Table 10 shows that during the first year of operation from July 2013 to June 2014 the average VS collected was over 11,000 pounds/day or 70% of the design VS indicating that a significant amount of manure was not collected due to the time the cows spend on the dirt lot adjacent to the free stall barn. However, in March 2014, the VS collection was almost 15,000 pounds per day or 95% of the design basis VS. Figure 9 shows the trend of the VS collection over the first year during the months when VS analysis was performed. As shown the VS collection improved from the early months of August and September 2013 to the later months of March and June 2014.

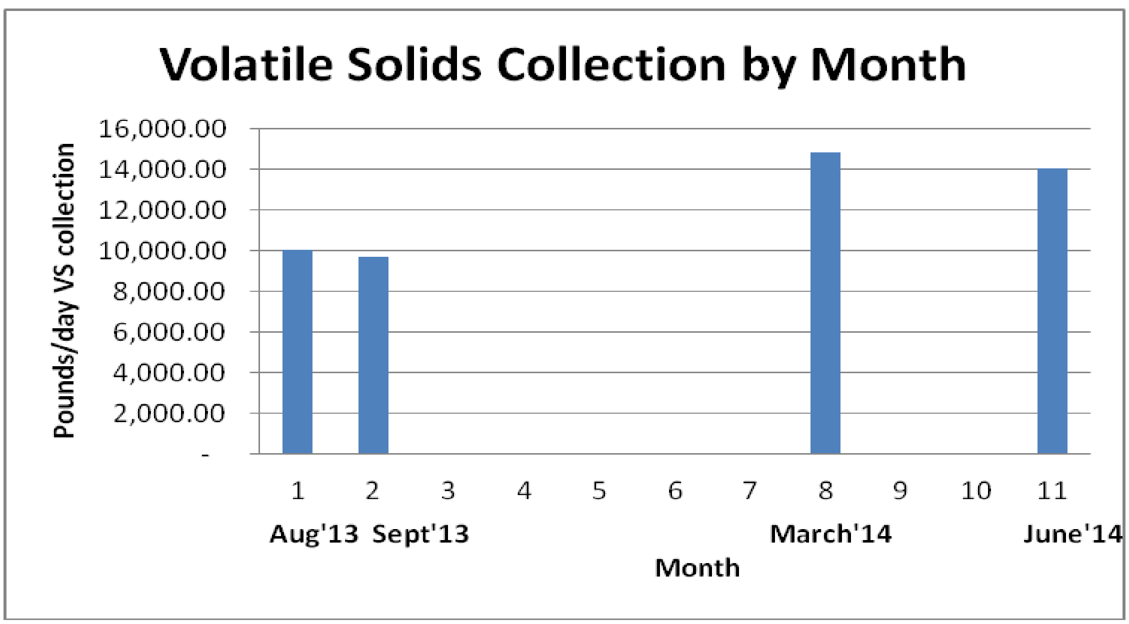


Figure 9. Volatile solids collection for New Hope Dairy: selected months during first year of operation July 2013-June-2014

- The average VS content of the influent also varied depending on the time of year ranging from 3% to 6%, with an average of 4.4%, which is significantly lower than the design VS content of 9.7%. These numbers indicated the presence of significant dilution water in the influent, primarily from misters operated during the hot days in the late summer and fall. Figure 10 shows the trend of total effluent input through the first year of digester operation, averaging about 30,000 gallons/day as compared with the design basis of just under 20,000 gallons/day.

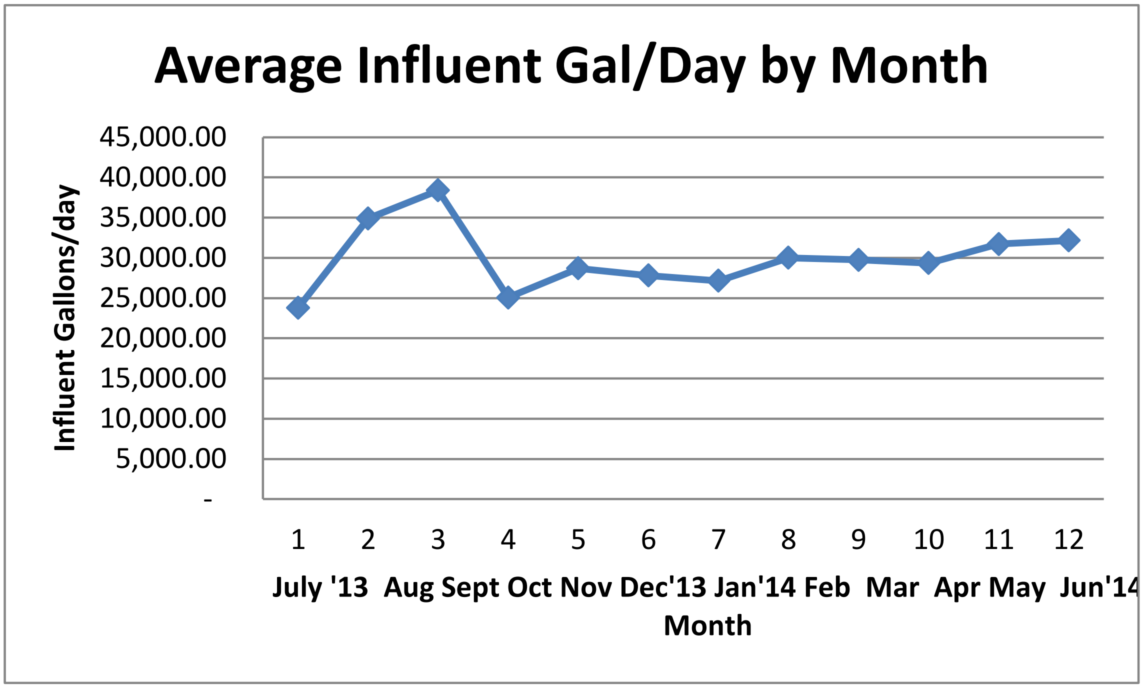


Figure 10. Average daily influent loading for New Hope digester during first year of operation July 2013-June-2014

3.3.2 The digester performance consisted of the following parameters listed in Table 10 and compared with the design basis as explained in the following bullet points:

- Biogas production varied from just under 60,000 cubic feet per day in July 2013 to a maximum of almost 95,000 cubic feet in March 2014 averaging about 80,000 cubic feet/day over one-year's operation. The design basis of 92,000 cubic feet was equaled and exceeded during the spring of 2014, with the trend showed increasing gas production as the digester operation progressed through the first year, as shown in Figure 11.

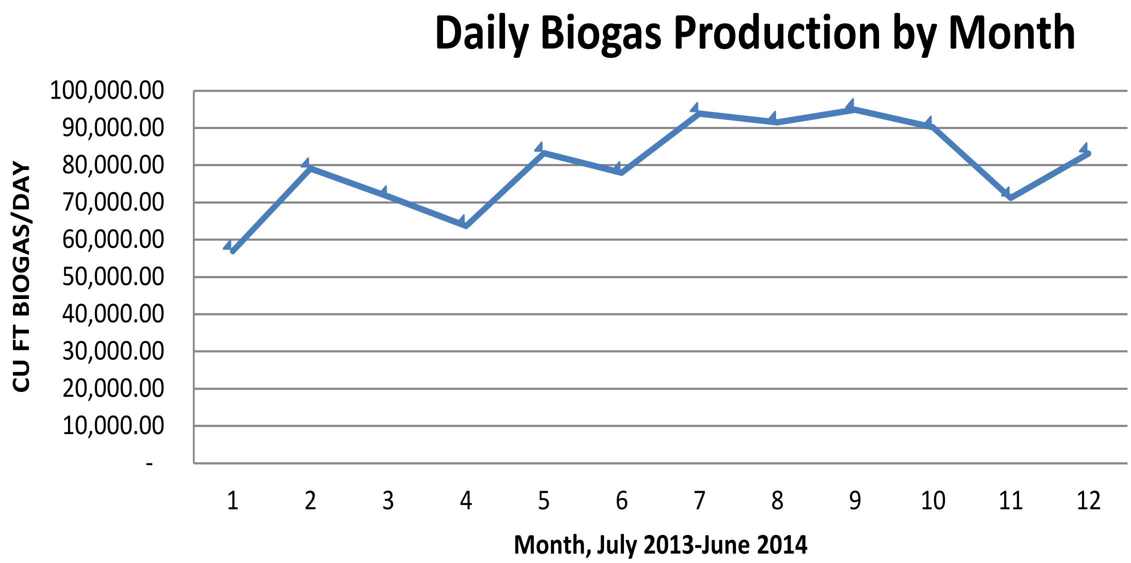


Figure 11. Average daily biogas production for New Hope digester during first year of operation July 2013-June-2014

- The average hydraulic retention time of 35 days was lower than the design basis of 54 days due primarily to the higher influent loading rate of 30,000 gallons/day which in turn was due to the extra water added by misters and supplemental flushing of some of the free stall lanes.

- The average volumetric efficiency was 0.6 cubic feet of biogas/cubic feet of digester volume, approximately 90% of the design basis of 0.66 cubic feet of biogas/cubic feet of digester volume.

- The average specific biogas production was 7.2 cubic feet of biogas per pound of volatile solids fed per day, significantly higher than the design basis of 5.9. This was due in part to the lower average biological loading rate of 0.8 lb VS/cu ft/day compared with the design loading rate of 0 .11 lb VS/cu ft/day.

- The methane percentage was very consistent averaging 55% which is equal to the design basis.

- Hydrogen sulfide levels were very effectively controlled by the combination of ferric chloride dosing, air injection and activated carbon polishing filter. The H2S levels in the biogas delivered to the engines was at or less than 1 ppmv during the first year of operation.

- The volatile solids reduction by the digester average 52% over the first year of operation, slightly higher than the design basis of 48%.

3.3.3 The engine generator performance parameters are also shown in Table 10 and compared with the design basis as explained in the following bullet points:

- The electrical efficiency of the engine in converting the Btu's in the biogas into kWhrs of electricity averaged 39%, slightly lower than the design of 40%.

- The electrical output of 420 KW was over 93% of the design basis CHP capacity of 450 KW. The average daily operating time of 11 hours resulted in gross electrical production of almost 4,620 kWhrs/day, about 82% of the design basis production. This design basis of almost 5,500 kWh of gross electrical production was achieved in March 2014, with the trend over the first year of operation shown in Figure 12.

- The parasitic loads are those mixing and pumping electrical needs of the digester, and these loads averaged just over 300 kWh resulting in a net average electrical production delivered to SMUD of just over 4300 kWh/day. Figure 13 then show the net electrical production delivered each month of the first year of operation.

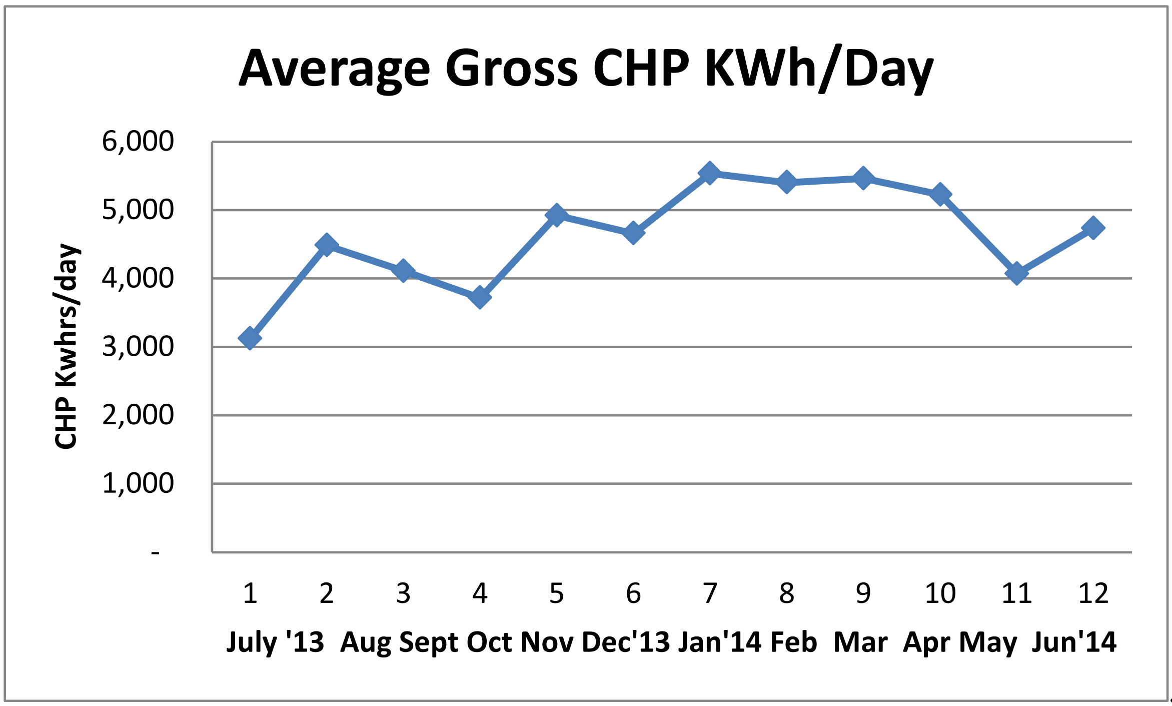


Figure 12. Average daily gross electrical production from the New Hope digester CHP during first year of operation July 2013-June-2014

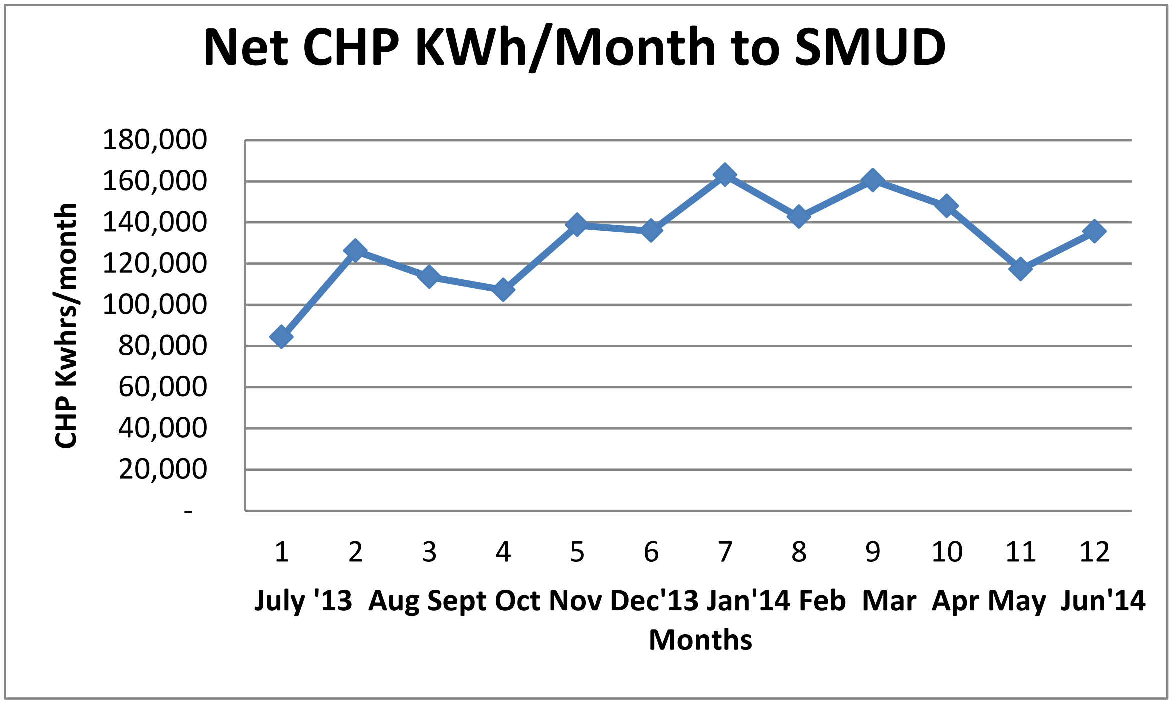


Figure 13. Net monthly electrical production from the New Hope digester CHP during first year of operation July 2013-June-2014

- The thermal energy captured from the CHP for heating the digester were calculated to be just over 217 million Btus per day, or about 64 % of the available thermal energy as shown in Table 10. This then resulted in an overall efficiency of the CHP engine generator of 67 % including both the electrical production and utilized thermal energy for digester heating.

NEW HOPE DAIRY DIGESTER		DESIGN BASIS	AVERAGE	MAXIMUM
DESCRIPTION	UNITS		July 2103-June 2014	MARCH 2014
INFLUENT VOLUME	GAL/DAY	19,404	29,898	29,752
INFLUENT TS	%	11.60%	5.64%	7.38%
INFLUENT VS	%	9.70%	4.43%	5.99%
INFLUENT VS	LB/DAY	15,697	11,038	14,853
BIOGAS PRODUCTION	FT^3/DAY	92,893	79,785	94,929
VOLUMETIC BIOGAS PRODUCTION	FT^3BIOGAS/ FT^3DIG VOL	0.66	0.60	0.68
SPECIFIC GAS PRODUCTION	FT^3/LB VS	5.9	7.2	6.39
METHANE CONCENTRATION	%	55%	55%	54%
H2S CONCENTRATION	PPMV	2000	<1	1.65
VS DESTRUCTION RATE	%	48%	52%	44%
NET DIGESTER VOLUME	FT^3	140,622	140,622	140,622
NET DIGESTER VOLUME	GAL	1,050,000	1,050,000	1,050,000
HYDRAULIC RETENTION TIME	DAYS	54	35	35
EFFLUENT VOLUME	GALLONS	18,561	28,778	30,445
ORGANIC LOADING RATE	LB VS/FT^3 VOL	0.11	0.08	0.11
BIOGAS ENERGY CONTENT	BTU/DAY	46,492,947	40,186,508	46,751,773
ENGINE SIZE	KW	450	420	439
DAILY RUNTIME	HOURS	12.2	11.0	12.4
DAILY ENERGY PRODUCTION	KWHRS/DAY	5,473	4,618	5,460
ENGINE ELECTRICAL EFFICIENCY	%	40%	39%	40%
MAXIMUM ENGINE THERMAL EFFICIENCY	%	43.50%	43.50%	44%
TOTAL THERMAL ENERGY AVAILABLE FOR DIGESTER HEATING	BTU/DAY	20,224,432	17,481,131	20,337,021
THERMAL ENERGY REQUIRED FOR DIGESTER HEATING	BTU/DAY	7,444,538	11,273,536	11,273,536
% OF TOTAL THERMAL ENERGY REQUIRED FOR HEATING	%	37%	64%	55%
ACTUAL THERMAL AS % OF TOTAL BIOGAS ENERGY	%	16%	28%	24%
OVERALL EFFICIENCY OF CHP (ELECTRICAL PLUS THERMAL)	%	56%	67%	64%

Table 10. Digester and engine design basis compared with one-year's data for New Hope digester project.

4. Economic Evaluation of the New Hope Digester Project

4.1 Operational costs

Listed below in Table 11 are the actual operating expenses for the project through the middle of 2014 and projected for the balance of the year. Based on the nature of the expense, we have estimated how much of each operating expense is fixed per year and independent of the number of MWh generated. These are the fixed expenses such as insurance and property taxes. All these costs will generally increase each year with inflation except property taxes which will slowly decrease according to the county's schedules. Total fixed costs per year are $121,954 per year and are estimated to increase on average at 50% of inflation rate given the average annual decline in property taxes. Variable operating costs are estimated at $121,954 per year which when divided by annual estimated electric production of 1,774 MWh equals $60.5 per MWh. This cost per MWh will generally increase with inflation each year.

Expense Category	Expense per Year	Fixed/Year	Variable/kWh
State Property Taxes	$46,222	$46,222	
Generation O&M Expenses	$45,571		$45,571
Farmer Feedstock and Lease	$41,706		$41,706
Digester O&M Expenses	$40,054	$20,026.87	$20,026.87
Administrative Expenses	$27,898	$27,898	
Property Insurance	$21,319	$21,319	
SMUD Interconnect Maintenance	$6,488	$6,488	
Unlevered Operating Cost	$229,257	$121,954	$107,303
	$0.1292 /kWh	**$271.01 /kW**	**$0.0605 /kWh**
Interest Expense	$31,982		
Levered Operating Cost	$261,239		
	$0.1473 /kWh		

Table 11. Average Operational Costs for New Hope Digester through June 2014

The project is delivering approximately 1,774 MWh per year in electrical sales to SMUD. Thus this year's total average unlevered (not including any cost of equity or debt capital) operating cost per kWh of the plan is estimated to be $129.20 per MWh.

4.2 Revenue Estimates and Financial Feasibility

4.2.1 Capital costs

See Table 12 below for a breakdown for the project's capital cost to construct and commission. The total cost of constructing this project before taking into account any grant funding was $3.9 million, not including one time training costs for teaching US sub-contractors how to use and deploy the special concrete slip forming technology used to continuously pour the CSTR concrete tank digester.

DOE ($802,166), CEC ($250,000) and USDA/EQIP ($125,000) grants provided $1.177 million of this total cost. After achieving commercial operation, the project was successful in receiving an ARRA Treasury 1603 Grant in the amount of $1.24 million. The balance of project cost was provided by California Bioenergy LLC and MT-Energie USA, Inc. as project equity and from a secured bank loan in the amount of approximately $400,000.

ABEC New Hope LLC	
9547 New Hope Road, Galt, California 95632	
System Design: Covered Lagoon Anaerobic Digester + 0.45 2G Engine Generator	
DETAILED COST BREAKDOWN	
Description	**Cost**
Biogas Plant:	
Preliminary design	$50,400
Detailed engineering and construction documents	$74,880
Procurement - materials and equipment	$1,522,485
Construction	$1,531,789
Sales Tax	$42,425
Grid Interconnection, Power and CO2 Purchase Agreements	$117,115
Permits	$17,042
Financing cost	$42,150
Capitalized Interest expense - construction loan	$50,239
Field Demonstration, Operation and Monitoring	$9,500
Commissioning	$16,000
Developer Fees	$241,938
Other Direct Project Costs:	$0
General project administration	$33,407
Project management services	$72,795
Legal and accounting	$49,923
Travel	$3,666
Feedstock, site control and lease Agreement	$23,918
Miscellaneous	$3,840
Total Capital Cost	**$3,903,512**
Total Capital Cost per MW	**$8,674,472**

Table 12. Total Capital Costs for New Hope Digester

4.2.2 Revenues

- **Existing Electricity Production:** The available manure generates sufficient gas to generate 1,774,000 kWh per year. Net of station load the project exports approximately 1,570,925 kWh to the grid (90% of the generated kWh) annually. The 0.45MW generator is operating at only 45% capacity factor and spends much of the day powered off. The generator powers up twice per day as needed to burn the biogas accumulated under the CSTR cover. The programming optimizes as much time as possible to be in the higher shoulder and peak hours when the SMUD tariff pays a higher rate for the electricity. Annual average distribution of production by period has been: Off-Peak: 18.7%, On-Peak: 40.4% and Super-Peak: 40.9%. As a result the project earns on an annual average $0.1414 per kWh, generating $222,116.38 per year in electricity sales.

- **Upside Potential for Additional Electricity Production:** This project's CSTR digester has significant spare capacity, as does the engine, and with addition of substrates could produce up to twice as much biogas and thus operate at a 90% or higher capacity factor. To perform at this higher level, acceptable farm friendly substrates would need to be sourced and loaded into the CSTR as part of a co-digestion program. Permitting of co-digestion on a dairy is a complicated and challenging process. A significant opportunity for this project lies in its ability to be a research platform to develop co-digestion in California and thus bring a much more efficient and lower cost dairy biogas solution to the industry. Co-digestion in addition, recycles organic waste, such as food waste, back to the land and away from landfills as required by recent legislation.

- **Carbon Credits:** The project is expected to generate 2,696 Air Resource Board California Climate Offsets ("CCOs") per year. We assume an average value of $10 per tonne over the life of the project. It is hard to predict future CCO pricing and some estimates project a value substantially higher. With verification every second year at a cost of $8,000 per verification, this nets to $8.52 per tonne thus CCO sales are expected to generate an annual revenue of approximately $23,000.

- **Levelized Cost of Energy ("LCOE"):** For bioenergy projects, the California Energy Commission often references the LCOE model developed by Black and Veatch for the Califoirnia PUC's SMALL-SCALE BIOENERGY: RESOURCE POTENTIAL, COSTS, AND FEED-IN TARIFF IMPLEMENTATION ASSESSMENT. This Small-Scale Bioenergy LCOE calculator is accessible at: http://www.cpuc.ca.gov/NR/rdonlyres/69848D0B-9EA3-466B-8B8F-CE1E0EEF1894/0/PublicDRAFTLCOEModelCPUCSB1122.xlsx.

  We use this LCOE calculator to report on the economics of the project. The results are shown below for four different cases, for which the model results are listed in Attachment 1.

  Case 1 is current economics: manure only, low capacity factor and assumes there is no 30% investment tax credit ("ITC") i.e. the ITC remains unavailable for biogas projects. Under this scenario,, the LCOE = $41.2 cents per kWh

  Case 2 is economics of manure PLUS co-digestion: We assume co-digestion of a farm friendly substrate that generates additional biogas sufficient to fully utilize the plant at a 95% capacity factor. It assumes the substrate generates a $10 per wet ton tipping fee, is 25%dry matter and generates gas at 9,500 scf of CH_4 per dry matter ton. Like Case 1, it assumes the 30% ITC remains unavailable for biogas projects. The LCOE = $21.1 cents per kWh.

  Case 3 is the same as Case 2 but we assume the Federal Government adopts the Extend Act or equivalent and the 30% Investment Tax Credit is reinstated for biogas projects to give them similar treatment to Solar projects. The LCOE = $14.0 cents per kWh.

Case 4 is the same as Case 3 but we assume that the New Hope farmers would be willing to sell the fiber solids output of 112 tons per day x 8% dry matter ("DM") or screw pressed to 30,000 pounds per day at 70% DM. It is assumed the project could net, after processing and drying costs, $10 per ton dry matter or $32,589 per year, approximately $90 per day. With this additional revenue the LCOE = 12.8 cents per kWh.

Some other interesting cases can be run with higher carbon CCO prices to generate LCOEs in the 10 cent per kWh range. Similarly lower O&M per kWh and lower Capital Cost per MW which will come with industry scale are alternative and additional pathways to a 10 cent per kWh biogas electricity LCOE. This seems like a worthy goal of the dairy biogas industry to be able to produce this high value, predictable and reliable, electricity at a competitive price through co-digestion and fiber sales.

Clearly one of the most important issues is for biogas to regain it tax parity with solar on the investment tax credit. This has a huge impact on the LCOE.

ABEC New Hope is very grateful for the DOE, CEC and EQIP funding which when combined and contributed to this project reduced the manure only LCOE to $145 per MWh, approximately equal to the current price the project is receiving from SMUD. The project owners look forward to exploring additional ways to leverage this digester as a platform for further research into co-digestion and digested solids and effluent marketing.

Attachment 1: Levelized Cost of Energy ("LCOE") Model

SB1122 Levelized Cost of Electricity Calculator

Developed for the California Public Utilities Commission
by Black & Veatch

Selected Case		
Technology	Dairy Manure	<==Select
Cost Scenario	Low	<==Select

CASE:	Case 1: As Built, No Grants, No ITC	Case 2: As Built + Co-Digest No Grants, No ITC	Case 3: As Built + Co-Digest No Grants, + 30% ITC	Case 4: As Built + Co-Digest + Fiber sales, No Grants, + 30% ITC
Technical Entries				
Project Capacity (MW)	0.45	0.45	0.45	0.45
Capital Cost ($/kW)	8674.5	8674.5	8674.5	8674.5
Fixed O&M ($000/kW/Yr)	271	271	271	271
Fixed O&M Escalation	1%	1%	1%	1%
Variable O&M ($/MWh)	60.5	60.5	60.5	60.5
Variable O&M Escalation	2%	2%	2%	2%
Fuel Cost ($/MBtu)	0.00	-2.22	-2.22	-2.22
Fuel Cost Escalation	0%	0%	0%	0%
Heat Rate (Btu/kWh)	8751	8751	8751	8751
Capacity Factor	45%	95%	95%	95%
Financial Entries				
Debt Percentage	60%	60%	60%	60%
Debt Rate	7%	7%	7%	7%
Debt Term (years)	10	10	10	10
Economic Life (years)	20	20	20	20
Depreciation Term (years)	5 MACRS	5 MACRS	5 MACRS	5 MACRS
Percent Depreciated	100%	100%	100%	100%
Cost of Generation Escalation	0%	0%	0%	0%
Tax Rate	39.23%	39.23%	39.23%	39.23%
Cost of Equity	15%	15%	15%	15%
Discount Rate	15%	15%	15%	15%
Incentives				
PTC ($/MWh)	0	0	0	0
PTC Escalation	0%	0%	0%	0%
PTC Term (years)	0	0	0	0
ITC	0%	0%	30%	30%
Other Incentives ($/year)	$22,960	$22,960	$22,960	$55,549
Incentive Escalation (%)	5%	5%	5%	5%
Calculated LCOE	**$412 per MWh**	**$211 per MWh**	**$140 per MWh**	**$128 per MWh**

***Co-Digest Fuel Cost Calculators (Manual)**				
Biogas Feedstocks				
$/wet ton tipping fee	-10			
Percent Solids	25%			
Methane Yield (ft3/dry ton)	9500			
Fuel Cost ($/MBTU)	($4.21)			
Fuel Mix	kWh per Year (MBTU Proxy)	kWh per Year (MBTU Proxy)	kWh per Year (MBTU Proxy)	kWh per Year (MBTU Proxy)
Substrate Fuel for Co-Digest	0	1,971,000	1,971,000	1,971,000
Manure Fuel ($0/MBTU)*	1,773,900	1,773,900	1,773,900	1,773,900
* Included in Farmer Lease	1,773,900	3,744,900	3,744,900	3,744,900
Weighted Average Fuel Cost	$0.00	($2.22)	($2.22)	($2.22)

Cost of Generation Calculator

All inputs are in blue.

BLACK & VEATCH
Building a world of difference.

Technology Assumptions	
Project Capacity (MW)	0.45
Capital Cost ($/kW)	$8,675
Fixed O&M ($/kW)	$271
Fixed O&M Escalation	1%
Variable O&M ($/MWh)	60.5
Variable O&M Escalation	0.02
Fuel Cost ($/MBtu)	-$2.22
Fuel Cost Escalation	0%
Heat Rate (Btu/kWh)	8751
Capacity Factor	95%

Financial/Economic Asumptions	
Debt Percentage	60%
Debt Rate	7%
Debt Term (years)	10
Economic Life (years)	20
Depreciation Term (years)	5
Percent Depreciated	100%
Cost of Generation Escalation	0%
Tax Rate	39%
Cost of Equity	15%
Discount Rate	15%

Incentives	
PTC ($/MWh)	$0
PTC Escalation	0%
PTC Term (years)	$0
ITC	30%
Other Incentives ($/year)	$55,549
Incentive Escalation	5%

Outputs	
NPV for Equity Return	$0
Levelized Cost of Generation	$128.06

Year		1	2	3	4	5	6	7	8	9	10
Annual Generation (MWh)		3,745	3,745	3,745	3,745	3,745	3,745	3,745	3,745	3,745	3,745
Cost of Generation		$128.06	$128.06	$128.06	$128.06	$128.06	$128.06	$128.06	$128.06	$128.06	$128.06
Operating Revenues		**$479,559**	**$479,559**	**$479,559**	**$479,559**	**$479,559**	**$479,559**	**$479,559**	**$479,559**	**$479,559**	**$479,559**
Fixed O&M		$121,950	$123,170	$124,401	$125,645	$126,902	$128,171	$129,452	$130,747	$132,054	$133,375
Variable O&M		$226,566	$231,098	$235,720	$240,434	$245,243	$250,148	$255,151	$260,254	$265,459	$270,768
Fuel Cost		-$72,624	-$72,624	-$72,624	-$72,624	-$72,624	-$72,624	-$72,624	-$72,624	-$72,624	-$72,624
Incentives		$55,549	$58,326	$61,243	$64,305	$67,520	$70,896	$74,441	$78,163	$82,071	$86,175
Operating Expenses		**$220,343**	**$223,317**	**$226,254**	**$229,150**	**$232,000**	**$234,798**	**$237,538**	**$240,213**	**$242,818**	**$245,344**
Interest Payment		$163,948	$152,082	$139,385	$125,800	$111,263	$95,709	$79,066	$61,258	$42,204	$21,815
Principal Payment		$169,516	$181,383	$194,079	$207,665	$222,201	$237,756	$254,398	$272,206	$291,261	$311,649
Debt Service		**$333,464**	**$333,464**	**$333,464**	**$333,464**	**$333,464**	**$333,464**	**$333,464**	**$333,464**	**$333,464**	**$333,464**
Tax Depreciation		$780,705	$1,249,128	$749,477	$449,686	$449,686	$224,843	$0	$0	$0	$0
Taxable Income		($685,438)	($1,144,968)	($635,557)	($325,077)	($313,390)	($75,791)	$162,955	$178,087	$194,537	$212,399
PTC		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
ITC		$1,171,058									
Taxes		**($1,439,920)**	**($449,114)**	**($249,297)**	**($127,511)**	**($122,927)**	**($29,729)**	**$63,919**	**$69,855**	**$76,307**	**$83,314**
Total	***(1,561,410)***	***1,365,671***	***371,891***	***169,138***	***44,456***	***37,022***	***(58,975)***	***(155,363)***	***(163,974)***	***(173,031)***	***(182,563)***

APPENDIX D:
Van Warmerdam Dairy Digester Report

Van Warmerdam Dairy Digester

Final Report

Including

Technology Transfer Report

Prepared by: Daryl Maas, Maas Energy Works Inc.

daryl@maasenergy.com

210-527-7631

Table Contents

CHAPTER 1: Introduction

1.1 Executive Summary The Van Warmerdam Dairy digester is a covered lagoon anaerobic digester installed on a 1,000 cow dairy farm near Galt, California in 2012-2013. The project is privately developed, owned, and operated by Maas Energy Works, Inc, (MEW) with significant financial and development support from SMUD, who also purchases the power generated by the facility.

The digester operates solely on manure collected on the Van Warmerdam Dairy. Biogas from digester is routed to a containerized internal combustion engine capable of generating 600 kW of electricity for delivery back onto the SMUD distribution grid. The engine is oversized to allow the facility to generate most of its power during peak demand periods. In addition to producing renewable energy, the facility also reduces significant greenhouse gas emissions by destroying methane.

As this report will detail, the project was a development success, being built for less than the original budget of ~$1,700,000, and going online less than 18 months from initial contact between SMUD and the developer. Operationally, the project has performed consistently and efficiently, although total electrical production is slightly below initial estimates. The project demonstrated successful compliance with stringent emissions standards and, more broadly, demonstrated a cost-effective, reliable model for developing digesters in the SMUD service territory.

1.2 List of Figures

1.3 List of Tables

1.4 Report Organization Chapter 2 provides a project overview and details on the project design, down to the individual system level. It also provides a history of the permitting, financing, and some of the major steps in development and startup. Chapter 3 speaks to the project objectives and the approach taken by MEW in developing the project and creating valuable data for technology transfer. Chapter 4 contains the Technology Transfer Report, which is a comprehensive listing of useful data gathered during development and operations. Finally, Chapter 5 presents summaries, conclusions and lessons learned.

CHAPTER 2: Project Description

2.1 Overview

Project Name: Van Warmerdam Dairy Digester

Site Address: 12127 McKenzie Road, Galt, CA 95632

Project Owner: Maas Energy Works Inc.

Project Operator: Maas Energy Works Inc.

Owner/Operator Point of Contact: Daryl Maas, 210-527-7631

SMUD Project Managers: Valentino Tiangco 916-732-6795 and Marco Lemes 916-732-5871

2.2 Project Description

Digester: The digester is an earthen pond approximately 525' by 125', with a total operational fluid volume of about 8,000,000 gallons. The pond is covered with a 80/1000" high density poly-ethylene (HDPE) membrane to contain the biogas. The cover is designed to allow directional flow through the digester to ensure retention time, and mixers in the digester improve biogas production. The digester operates at ambient temperatures and is supplemented by engine waste heat. The digester's flexible cover enables biogas storage, allowing the engine to run during peak power periods when prices paid for electricity are highest, and store gas during lower prices. The effluent from the digester is used as a liquid fertilizer for crop irrigation. The biogas is conveyed underground to the engine generator system (600 kW engine-generator (genset) made by Martin Machinery). Figure 1 shows the covered lagoon and genset container.

Figure 1: Genset Container and Covered Lagoon

Biogas Cleaning or Treatment Description: The project uses two systems to remove hydrogen sulfide (H_2S) from the biogas. First, a small amount of air is injected under the cover at multiple points. This very small injection of air, spread across the cover, induces naturally-occurring bacteria to grow on the slurry surface and digester cover. Via a process known as biological fixation, these bacteria metabolize H_2S back into elemental sulfur, which collects on the surface rather than entering the biogas stream. The biological fixation system reduces H_2S significantly, but may not consistently meet the project's air permit's 50 parts per million (ppm) limit on H_2S. For that reason, the biogas can be routed through a canister containing approximately 80 gallons of activated carbon media. This media (which must be replaced on a periodic basis) absorbs the remaining sulfur and ensures continuous permit compliance.

Engine-Generator Description: The project's power plant is a Guascor SFGLD-560 1,800 RMP, 12-cylinder internal combustion engine rated at over 900 horsepower and operating on biogas fuel from the co-located covered lagoon anaerobic manure digester. The engine is mated to a Stamford HCI 534F 600 kW synchronous generator, generating at 480 V (See Figures 2 & 3), which is connected to SMUD's distribution feeder via a 750 kVA interconnection transformer (see one-line diagram, Figure 4)

Figure 2: Genset Schematic

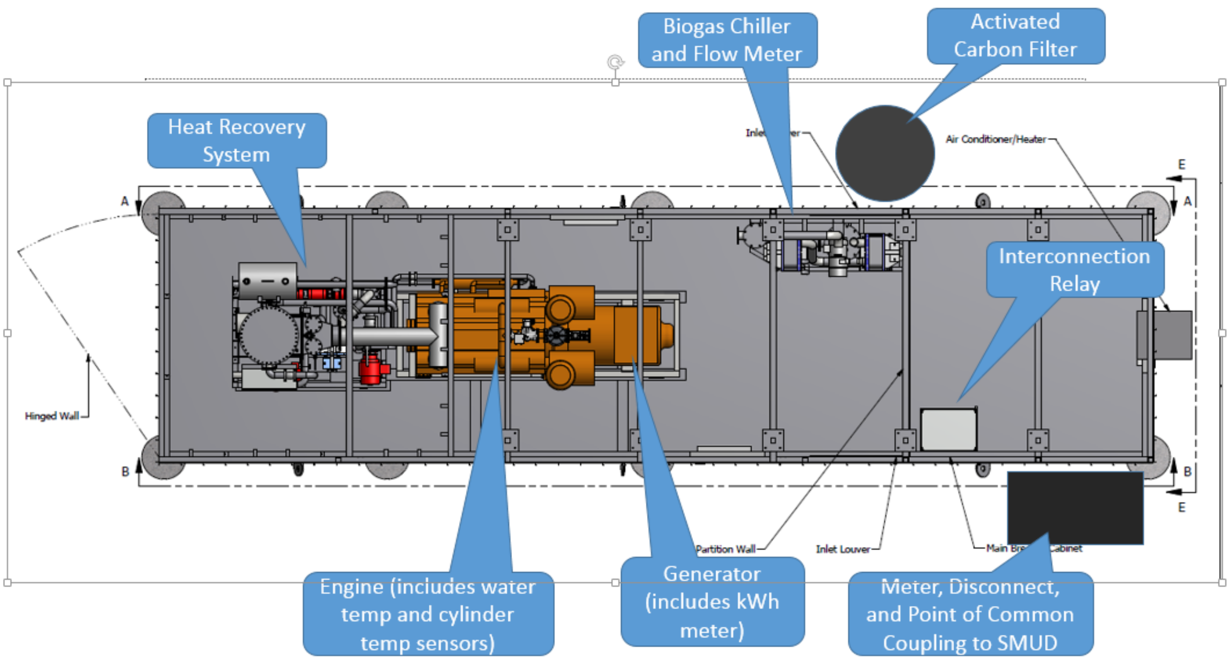
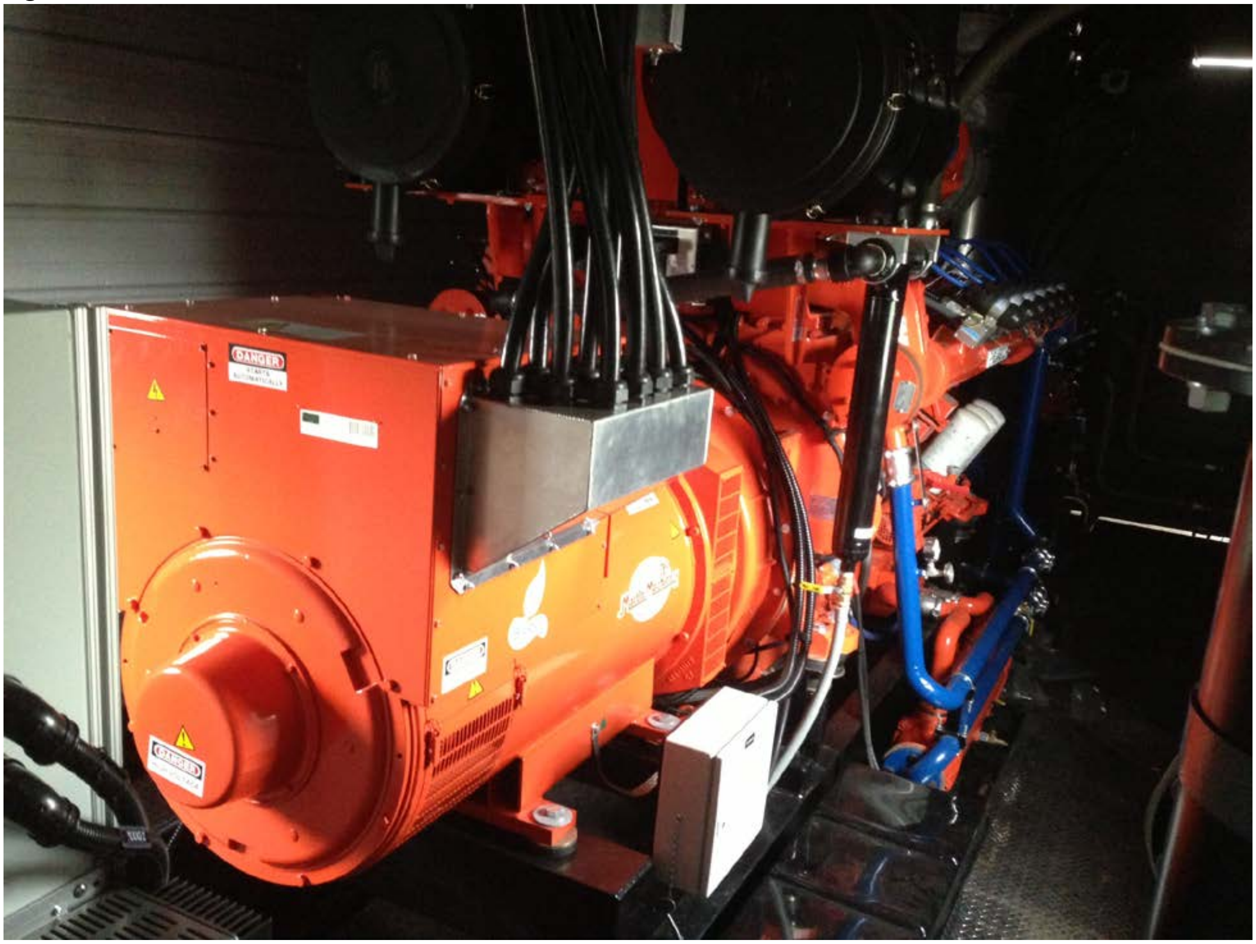


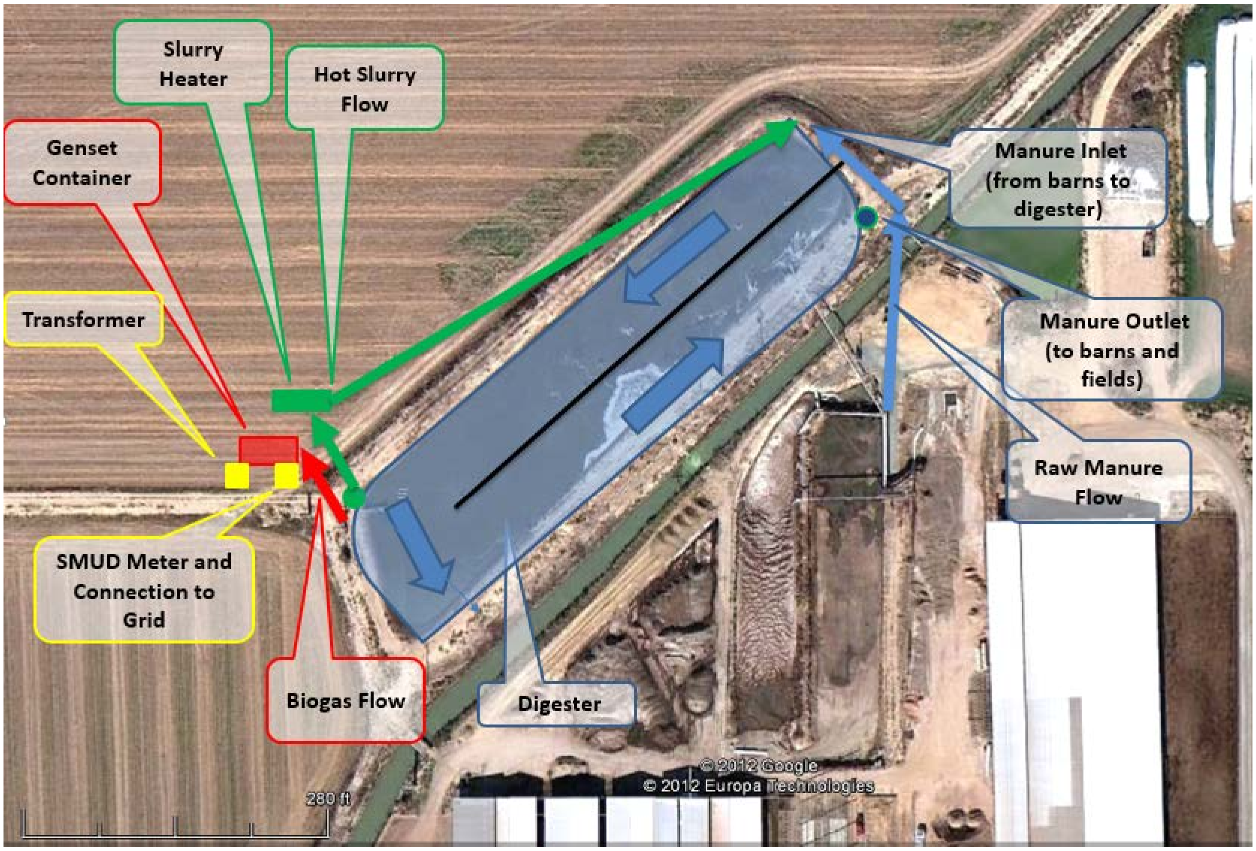
Figure 3: SFGLD-360 Genset



<u>Heat Recovery Description:</u>

The genset recovers heat from three sources. The engine block's jacket water is pumped out via the engine water pump. Additionally, the exhaust from the engine is routed through a series of parallel pipes where a heat exchanger extracts energy from the exhaust in the form of more hot water. Finally, the engine's intercooler loop coolant is pumped out to catch more hot water. Together, these three sources allow the system to recover hot water for a total well in excess of 40% of the engine's energy input. After collection, the hot water is transferred to a pipe-in-pipe heat exchanger where the heat is transferred to manure pumped from the covered lagoon. With its large volume, the lagoon can supply essentially unlimited cooling potential to the engine. The heated manure in the heat exchanger is then dumped back into the lagoon so as to increase the overall lagoon temperature and thus improve biogas production.

Figure 4: Project Conceptual Diagram



2.3 Grid Interconnection

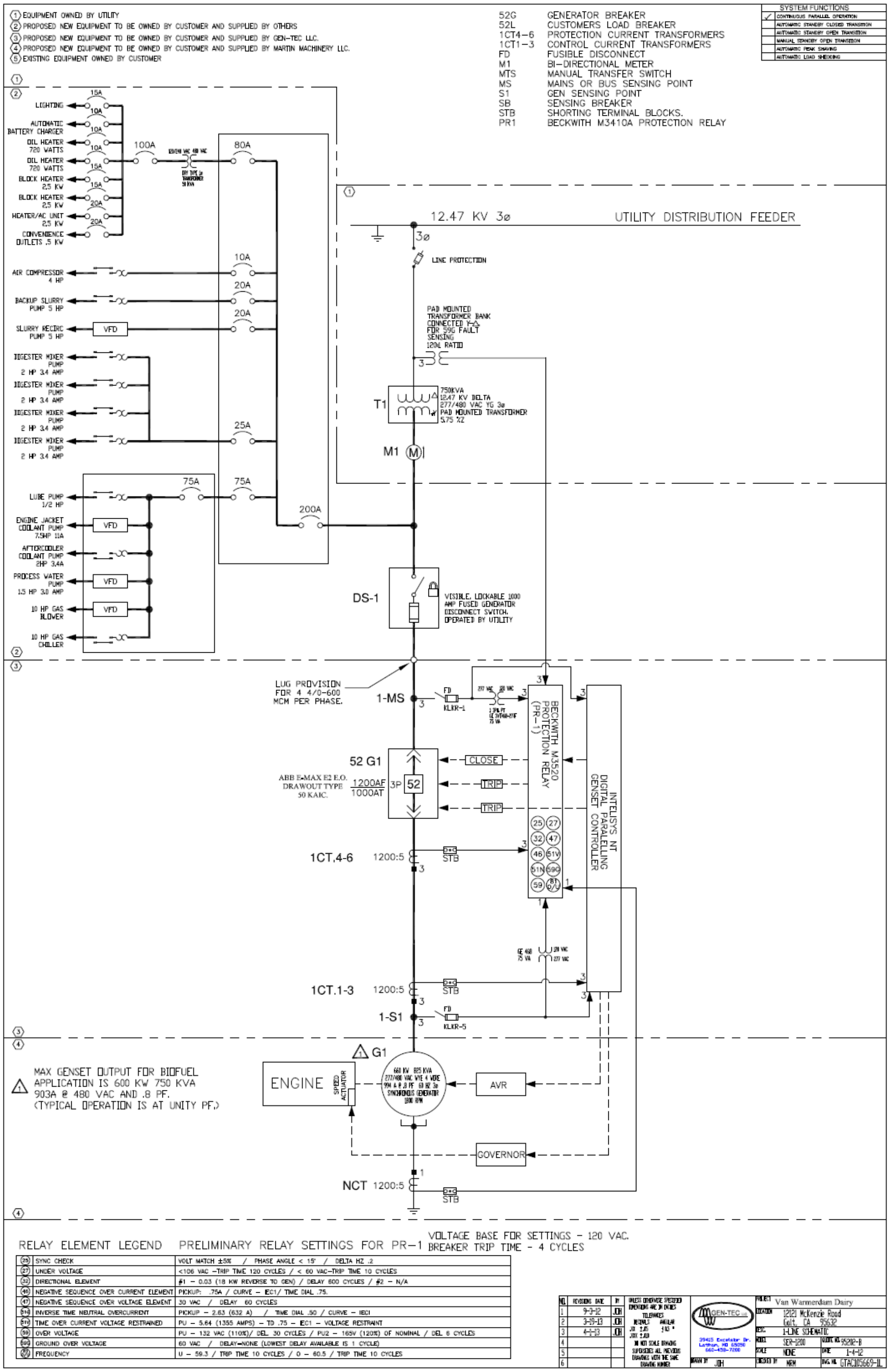
The facility was connected to SMUD's 12.47 kV distribution feeder that serves the host dairy. Interconnection improvements included the installation of a pad mounted Delta-Y 750 kVA transformer, and two new poles, one of which included a new broken delta bank. These installations were accomplished by SMUD for an initial cost of $160,000 estimate, although the final cost was approximately $80,000. Additionally, SMUD required the project owner to install a visible, lockable 800 amp disconnect and a Beckwith M3520 protective relay on the project's site of the transformer. The estimated cost of this equipment was $25,000 not including conductors.

Grid interconnection was hampered by the slowness of the county's electrical inspection approval process. First, Sacramento County approved the project electrical design months in advance. However, as inspectors visited the site each added more requirements on top of the original approved design. Once the additional requirements were met, the next inspector would levy new requirements. Even though the errors appear to have been the fault of the County plan checker, there was no way around this process and MEW had to simply push office staff and inspectors repeatedly, while paying various expedite fees and making trips to County offices. This was highly inefficient, but MEW's continuous efforts on the site for 1-2 weeks eventually completed the process.

The second source of interconnection delay was the SMUD approval process for connecting electrical service. MEW personnel had spoken with various SMUD personnel about the planned schedule for service in advance. As soon as MEW had county approval, we tried to start up the SMUD connection process and submitted an expedited request for connection. However, we found that various offices at SMUD needed to sign off on this connection. Some of these offices we had prior contact with, and others we had had no prior contact with. This could have created significant delays. Thankfully, SMUD's project engineer and some of their senior staff were on site on the day in question. They were willing to stay extra time on site, to come back late in the evening, and to make dozens of phone calls to various offices in SMUD to get the appropriate approvals. Without this intervention, the startup could have been delayed days or weeks.

Also note that the third party relay testing had to be accomplished two times. We had originally assumed SMUD would attend the third party relay testing we had scheduled in advance of the startup week. However, we found that SMUD wanted the third party relay tester to come out a second time so that SMUD could witness the testing. This could have created delays, however our relay tester was able to come out on short notice and SMUD's engineer was also able to stay on site to wait for the tester and witness the relay testing.

Figure 5: One-Line Electrical Diagram



RELAY ELEMENT LEGEND — PRELIMINARY RELAY SETTINGS FOR PR-1

25	SYNC CHECK	VOLT MATCH ±5% / PHASE ANGLE < 15° / DELTA HZ .2
27	UNDER VOLTAGE	<106 VAC -TRIP TIME 120 CYCLES / < 60 VAC-TRIP TIME 10 CYCLES
32	DIRECTIONAL ELEMENT	#1 - 0.03 (18 KW REVERSE TO GEN) / DELAY 600 CYCLES / #2 - N/A
46	NEGATIVE SEQUENCE OVER CURRENT ELEMENT	PICKUP: .75A / CURVE - IEC1/ TIME DIAL .75.
47	NEGATIVE SEQUENCE OVER VOLTAGE ELEMENT	30 VAC / DELAY 60 CYCLES
51N	INVERSE TIME NEUTRAL OVERCURRENT	PICKUP - 2.63 (632 A) / TIME DIAL .50 / CURVE - IECI
51V	TIME OVER CURRENT VOLTAGE RESTRAINED	PU - 5.64 (1355 AMPS) - TD .75 - IEC1 - VOLTAGE RESTRAINT
59	OVER VOLTAGE	PU - 132 VAC (110%)/ DEL. 30 CYCLES / PU2 - 165V (120%) OF NOMINAL / DEL 6 CYCLES
59G	GROUND OVER VOLTAGE	60 VAC / DELAY-NONE (LOWEST DELAY AVAILABLE IS 1 CYCLE)
81 O/U	FREQUENCY	U - 59.3 / TRIP TIME 10 CYCLES / O - 60.5 / TRIP TIME 10 CYCLES

2.4 Permitting Process

The facility required three separate permits.

Air Permit: The facility required an Authority to Construct from the Sacramento Air Quality Management District (SMAQMD). This was obtained in a reasonable period of three months at a cost of less than $10,000 including preparation of the application. The permit contained very stringent limits on emissions, requiring the installation of a selective catalytic reducer (SCR) system including an oxidation catalyst at a cost of approximately $90,000. Once installed and fully integrated, this system was capable of meeting the permit limitations. Details on the permit standards and site testing results may be found in Chapter 4 Technology Transfer Report.

Building Permit: A Sacramento County building permit was required. This permit was relatively easy to obtain at a cost of approximately $7,000. However the county unexpectedly required that the prefabricated container be engineered by a California structural engineer as if it were a structure. This added approximately $8,000 of unnecessary project costs. Additionally, the county had additional flood plain restrictions over and above the published FEMA flood plain. This forced us to increase the elevation of the project's equipment by over two feet, at a total cost of approximately $15,000. The permits themselves were reasonable; although the final inspection process was extremely tedious especially with regard to electrical connections (see 2.3). The fire department also required an expanded access road. There were no CEQA actions required for this project.

Water Board: The water board did not require a Work Plan or modifications to the dairy's existing Waste Discharge Requirements because this project did not involve any significant changes to the existing manure handling or storage structures at the host dairy. Simply covering a pond does not impact its function as a manure storage container. However, the project is limited to taking only manure from one dairy, and may not add manure or organic waste from other sources since this would involve a change to the waste handling at the host dairy. The Water Board did require the installation of three monitoring wells to ensure the existing lagoon is not leaking. These wells must be sampled quarterly and annual reports must be submitted to the Water Board. The total cost of installing these wells was $29,064 and the annual sampling and reporting costs is estimated at $8,000.

2.5 Project Finance

The initial budget for the project was set at $1,700,000. This amount does not include certain development, insurance, rent, and financing costs that were not eligible for inclusion in the SMUD project cost basis.

The project was awarded a total of $880,852 in funding from SMUD, including $125,000 from the California Energy Commission (CEC) and $755,852 from the US Department of Energy. In addition to these funds, the project secured a $900,000 construction loan from New Resource Bank. The project working capital and other funds were supplied out of company cash.

The project's overall financial approach was to reduce project cost and complexity as a means of reducing financial risk. The project achieved a very low installation cost both in terms of capital expense and manpower expended. This structure enabled a simplified financial package whereby a single owner and a single bank, together with SMUD, financed the project. Many other projects require additional grants, loans, or investors, which slows down project development, increases costs, and reduces the likelihood of successful project duplication.

CHAPTER 3: Project Approach

3.1 Objectives The project's stated objectives are

1. Improve knowledge of and promote the acceleration of market adoption of renewable energy technologies.

2. Support implementation of California Energy Commission and the Recovery Act by creating jobs, promote economic recovery, and investing in renewable energy infrastructure.

3. Provide energy-related and other benefits to SMUD customers, state of California, and the Nation.

An earlier version of this project was previously attempted by a different developer whose contract with SMUD was terminated. For that reason, the project plan included an additional objective of rapid, reliable execution in order meet the summer 2013 sunset date for grant funds awarded to this effort.

3.2 Procedure The procedure used was a design-build-operate model headed by project owner Maas Energy Works (MEW). MEW designed the project using reliable technologies common to the digester industry—including a lean burn piston engine build by industry leader Martin Machinery LLC, and covered lagoon digester installed by industry leader Environmental Fabrics Inc. This approach promised the most amount of energy and economic benefit for the smallest capital investment in the shortest possible time with the highest degree of reliability. The overall approach to the project involved a simplified management structure at MEW, with only two main fixed price, design-build contracts. Martin Machinery supplied the genset and ancillary equipment. Environmental Fabrics Inc. supplied and installed the lagoon cover. MEW coordinated a small number of local contractors and suppliers for additional services.

3.3 Measurement and Data The following data sets were included in the Technology Transfer Plan, and the results are including in Chapter 4, Technology Transfer Report.

Technical Data
Biogas production
Biogas CH_4 content
Electricity Production
Electricity Consumption
Lagoon Temperature
Biogas H_2S
Stack Emissions
Greenhouse Gas Impacts

Financial Data:
Construction Costs
Operational Costs
Estimated Revenue
Job Creation
Development Timeline

3.4 Data Analysis Procedures

See the Technology Transfer Report in Chapter 4

CHAPTER 4: Technology Transfer Report

This report details the data collected under the project's Technology Transfer Plan. For each data set recorded, the report contains the following three elements:

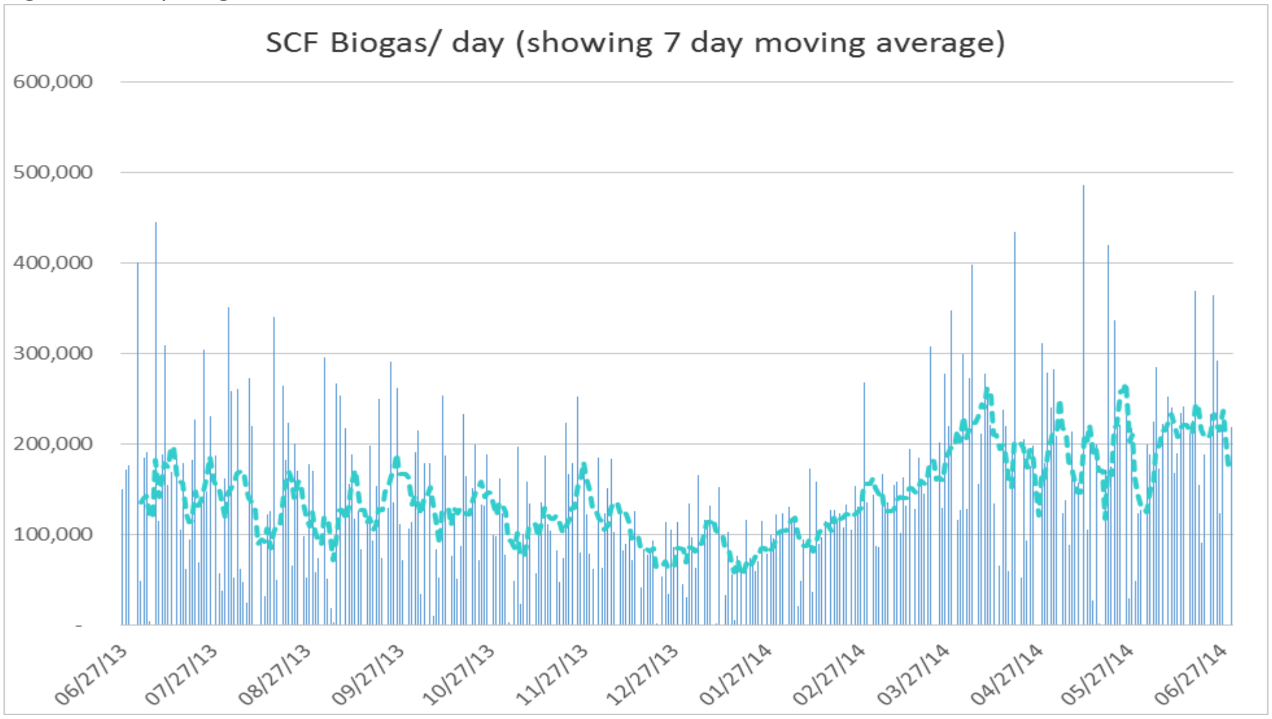
- Collection Procedures
- Data Collected
- Analysis and Discussion

4.1 Biogas Production:

Collection Procedures: The total standard cubic feet (SCF) of biogas combusted was recorded each day using a Sage SIP-05-10-DC24-DIG GAS biogas flow meter installed in the biogas feed pipe upstream of the genset. The results were recorded by MEW personnel in an onsite log and backup up weekly off site. The flow meter used for this application automatically adjusts for standard temperature and pressure, and MEW personnel perform calibrations on this unit once per quarter.

Data Collected: The table below depicts daily biogas metered in scf. The dotted line in the center is a seven day running average. The biogas is metered only when it is combusted in the genset. Therefore on days when the genset is off (nearly every Sunday, and other days when maintenance is occurring), there is no biogas metered. Likewise on days where the genset is run longer than usual, then large volumes of biogas are metered. Furthermore, there is considerable variability in the time of day when the biogas is sampled, creating daily swings. Consequently, the weekly trend is the best indicator of overall biogas production at the facility.

Figure 6: Daily Biogas Production



Analysis and Discussion: The project's biogas production was at or near pre-project estimates in June and July. Several factors contributed to a lower output towards the end of August, including farm changes in manure handling that upset digester conditions. In particular, the farm added an excessive volume of fresh water to the digester. The farm added this water to make more water available for irrigation and to dilute the manure flush liquids. However, the farmer was not aware that such large additions of water will rapidly change the temperature and pH of the digester, upsetting the methane-producing bacteria in the digester. These errors are not likely to be repeated and gas production has recovered substantially.

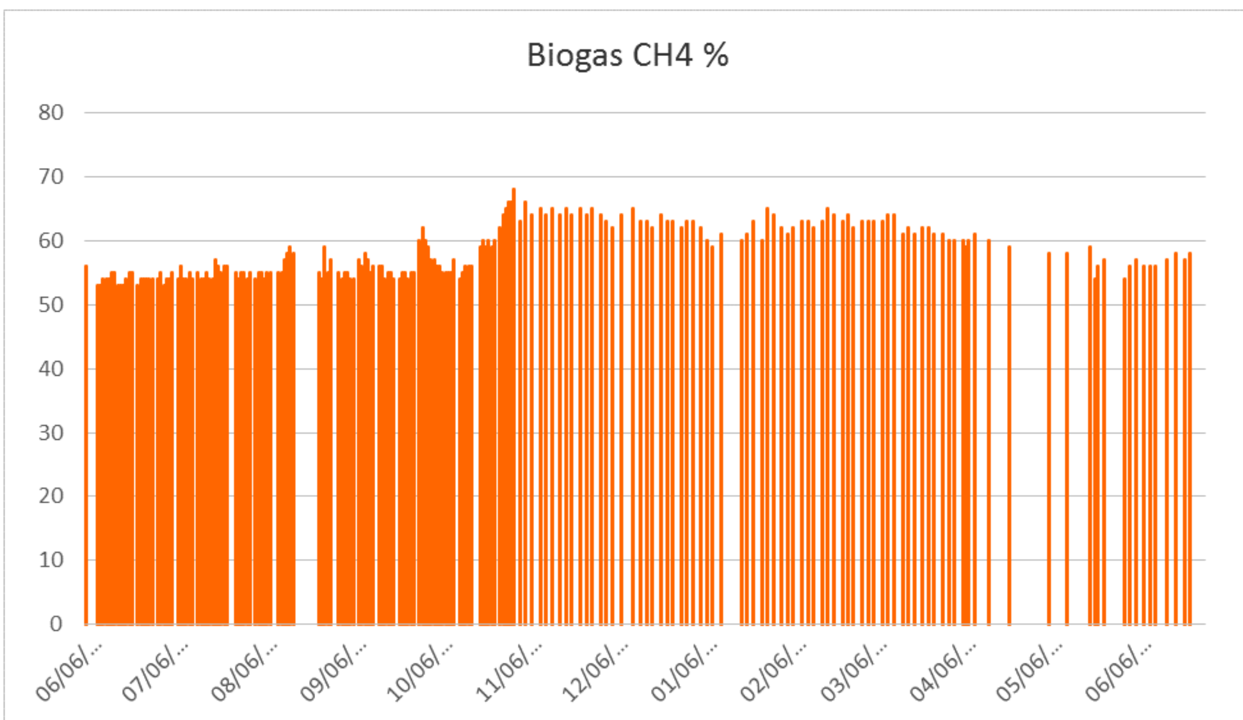
Average daily biogas metered from 6/27/13 to 6/30/2014 was 144,513 scf, or 100.4 scfm. Throughout the period covered, the dairy hosted approximately 1,100 milking cow equivalents. The resulting average biogas production of 131.4 scf per milk cow equivalent per day compares favorably with even the more expensive and complicated digester systems on the market. It remains to be seen how biogas production will be impacted by lower ambient temperatures during the winter months (see Section 4.4).

4.2 Biogas CH4 Content

Collection Procedures: MEW recorded the CH4 content of the biogas produced by the digester using a ERE GX-2012 gas analyzer on a nearly daily basis. The sample was taken from a port in the digester cover prior to the carbon filter or chiller. The results were recorded by MEW personnel in an onsite log. The results were audited quarterly by a Landtech GEM-2000 professional grade gas analyzer.

Data Collected: The table below depicts biogas percent CH4 content by date.

Figure 7: Biogas CH4 Content



Analysis and Discussion: Average biogas CH4 content during the period of observations was 58.2%. Overall, CH4 content was remarkably stable as would be expected from a large covered lagoon digester fed only by manure. As detailed later in this report, genset performance on this biogas was steady and reliable. The only significant spike occurred around the time of the partial digester upset described in 4.1.

4.3 Electricity Production

Collection Procedures: SMUD's monthly statements of power generation were used to create a record of net power delivered by the project. This information was broken down into off-peak, on-peak, and super-peak portions. MEW used its own CoMap Intellimonitor metering equipment to audit the SMUD monthly statements.

Data Collected: As of July 22, 2014, the genset has logged 3,829 operating hours, for an average of 9.0 run-hours per day since startup on May 23, 2013. Total gross generation (numbers in the table show generation net of site loads) as of July 22, 2014 is 2,159,762 kWh. Consequently, the average electrical output of the generator while running is 564 kW or 94% of capacity, including periods of startup and shutdown. The table below shows net generation recorded by SMUD's meter, broken down by month and Time of Use period.

Table 1: Electricity Production

	May 2013 (pre COD)	**May 2013**	**Jun 2013**	**Jul 2013**	**Aug 2013**	**Sep 2013**	**Oct 2013**	**Nov 2013**
# Days	5	4	30	31	31	30	31	30
Off Peak kWh	1,840	233	8,370	1,345	75	5,754	0	0
Peak kWh	9,757	13,427	78,793	81,871	67,837	50,569	54,159	46,262
Super Peak kWh	6,569	6,013	78,534	82,232	76,798	74,036	84,277	67,840
Total kWh	18,168	19,674	165,698	165,449	144,710	130,360	138,437	114,102
	Dec 2013	**Jan 2014**	**Feb 2014**	**Mar 2014**	**Apr 2014**	**May 2014**	**Jun 2014**	
# Days	31	31	28	31	30	31	30	
Off Peak kWh	0	66	0	2,634	1	8,476	3,020	
Peak kWh	23,806	17,663	34,151	79,545	112,984	84,871	96,259	
Super Peak kWh	77,407	71,882	76,870	82,991	82,512	77,158	80,886	
Total kWh	101,213	89,611	111,021	165,170	195,497	170,506	180,166	

Analysis and Discussion: The project's genset was intentionally oversized to allow peaking operational of the facility. Consequently, net super-peak generation made up 47.5%.of total net generation from May 1 to August 31, 2013. So far, the project has not detected any negative equipment impacts from the frequent startup and shutdown of the genset. Such negative impacts may appear over time, however the larger genset not only increases revenue due to time of day pricing, it also reduces total run hours on the engine and thus may lengthen maintenance cycles.

4.4 Electricity Consumption

Collection Procedures: The site's electrical consumption for periods when the genset was not running was calculated using the monthly power consumption bills received from SMUD. During periods where the genset was running, we calculated site electrical consumption by subtracting the net power metered by SMUD from the gross power generation logged on the CoMap intellimonitor, assuming the difference to be site load.

Data Collected: The total site (parasitic) load is shown below. Note that the broadest possible definition of parasitic load is employed here, since the numbers below include loads that occurred while the generator was not running, and also include manure handling loads such as mixers which are not directly associated with biogas generation. A more narrow definition of parasitic load would have yielded lower percentages.

Table 2: Electricity Consumption

	Jun 2013	**Jul 2013**	**Aug 2013**	**Sep 2013**	**Oct 2013**	**Nov 2013**	**Dec 2013**
Total Site Load (kWh)	10,532	10,939,	8,462	7,775	3,672	9,614	4,658
As a Percentage of Gross Generation	8.1%	9.1%	7.2%	7.0%	4.1%	9.1%	7.2%
	Jan 2014	**Feb 2014**	**Mar 2014**	**Apr 2014**	**May 2014**	**Jun 2014**	
Total Site Load (kWh)	5,136	3,425	6,702	9,941	9,563	11,375	
As a Percentage of Gross Generation	8.2%	4.5%	4.8%	5.5%	6.5%	5.9%	

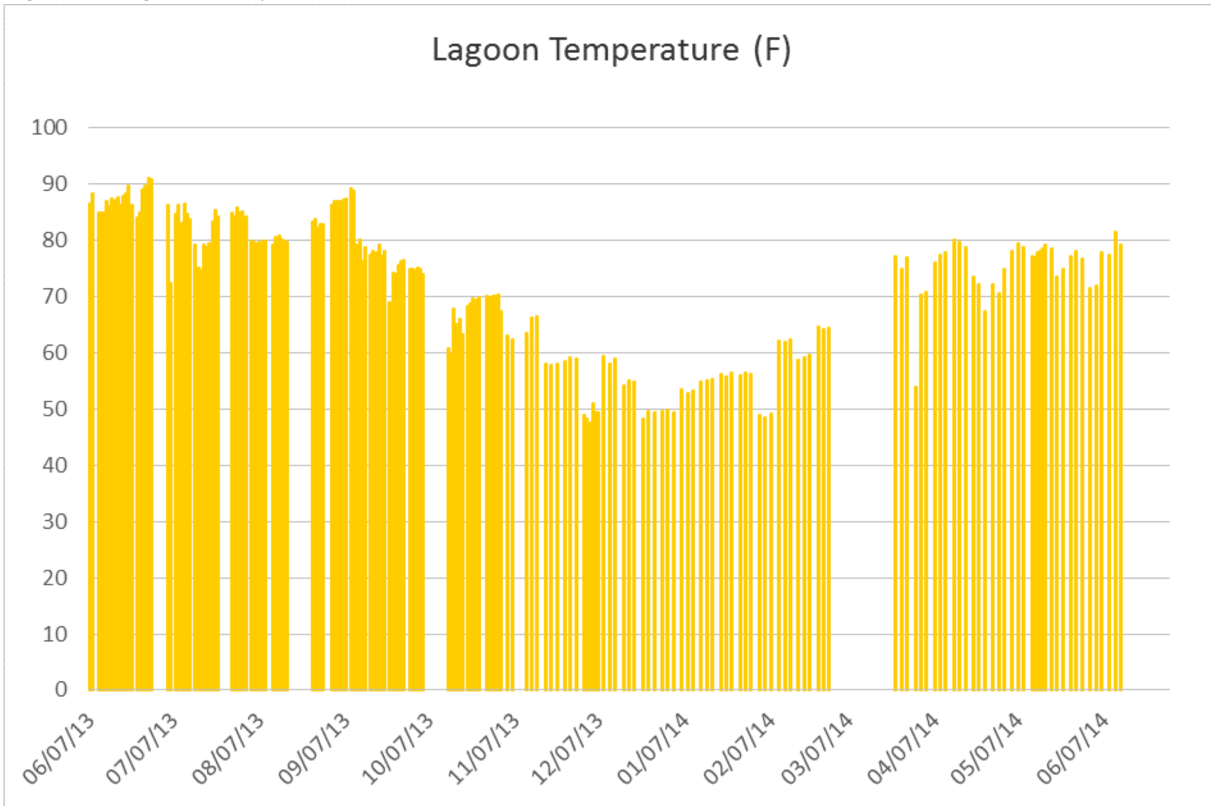
Analysis and Discussion: Total parasitic load was kept low due to the streamlined project design. Additional power savings were created by adding automation of certain components after startup. This site load is quite low by industry standards and owes to the simplicity of the project design.

4.5 Lagoon Temperature

Collection Procedures: The temperature of the fluid in the covered lagoon digester was measured using a Fluke infrared thermometer periodically to evaluate seasonal warming trends, and also the impact of sending engine heat into the digester. The heat was measured in the wet well nearest the genset building, which is also the source of cooling water for the genset.

Data Collected: Daily temperatures are shown on the figure below:

Figure 8: Lagoon Temperature



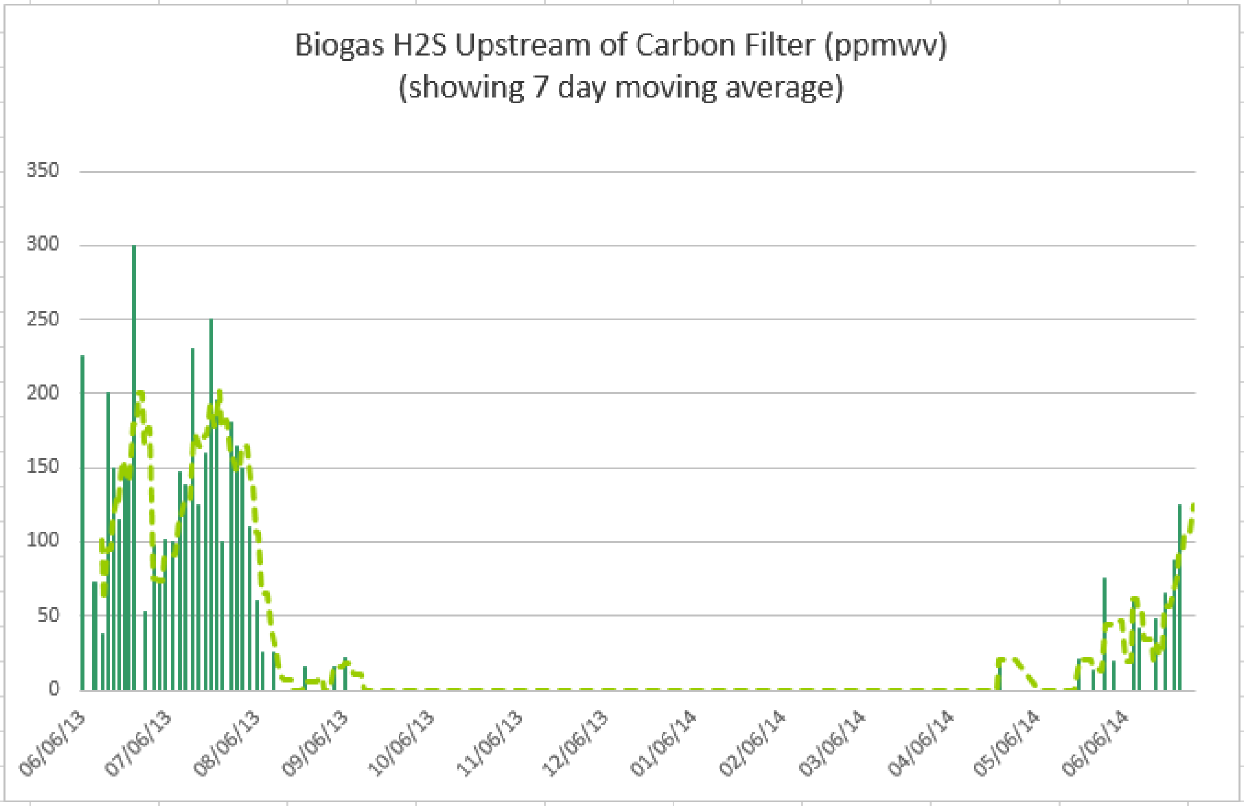
Analysis and Discussion: Although the period of sampling is too long to make a strong determination, it appears that lagoon temperature is generally correlated with outside temperature—showing a decline in September as the outside temperatures cooled. Further analysis will reveal whether or not supplemental heating from the genset's waste heat will allow the lagoon to consistently operate at a temperature above ambient levels, especially in winter (see description of heat recovery system in 2.2).

4.6 Biogas H2S

Collection Procedures: The hydrogen sulfide content of the biogas in the digester was tested 2-7 times per week depending on variability using a Mattheson Kittagawa toxic detector gas system. The test was taken directly from the lagoon cover, prior to the biogas passing through the activated carbon filter.

Data Collected: The collected biogas H2S data are represented below. The dotted line depicts a 7 day moving average.

Figure 9: Biogas H2S



Analysis and Discussion: As the data makes clear, the H2S level fell consistently after startup. The air injection system needed frequently adjustments and modifications into July, and the spikes in H2S frequently correspond to periods of air injection system alternations. Thereafter, the H2S levels fell consistently and no use of the active carbon filter was necessary for the majority of operations.

4.7 Stack Emissions

Collection Procedures: MEW contracted a licensed third party emissions tester to check for air permit compliance. The test was performed on August 22, 2013 with the engine running at full load.

Data Collected: The data collected during the test is presented below, along with the permit limits for this system.

Table 3: Emissions Results

	Measured	Limit
NO_x, ppm @ 15% O_2	8.8	12
CO, ppm @ 15% O_2	34.5	236.2
VOC, ppm @ 15% O_2	11.2	45.9
NH_3, ppm @ 15% O_2	6.8	10

Analysis and Discussion: The genset passed the test in all categories. These results prove the effectiveness of the engines's lean burn control systems, as well as the effectiveness of the Selective Catalytic Reduction emissions control system installed on the engine. Biogas engines have historically had a very difficult time meeting California emissions in prior years, but these results show that modern emissions controls have finally met the challenge. The necessary SCR emissions controls cost approximately $83,188 and also consume approximately $2,000 per year of expendables and one $20,000 catalyst every 10 years or so, so financially marginal projects probably cannot afford the required emission control system.

4.8 Greenhouse Gas Impacts

Collection Procedures: Greenhouse gas emissions impacts from the project were estimated using cow population numbers procured during the technology transfer period. These numbers, as well as historic weather patterns, site manure handling history, EPA data, site power generation, and other data estimate were evaluated using the Climate Action Reserve Livestock Protocol 3.0 tool for avoided methane emissions. Greenhouse gas offsets from displacement of conventional fuel sources were calculated uses EPA averages for SMUD generation.

Data Collected:

Table 4: Greenhouse Gas Impacts

Annual GHG Reductions from Avoided Methane Emissions	
(in MT CO-2e as calculated by CAR Tool)	**7,241**
Annual GHG Reductions from Renewable Electricity	
Estimated Annual Net MWh Generated	2,000
lbs CO-2 per MWh according to EPA eGRID 2009 for SMUD	659
MT CO-2	**598**
Total Annual GHG Reduction (MT CO-2e)	**7,839**

Analysis and Discussion: As the table clearly illustrates, nearly all of the greenhouse gas benefits from the project are generated by the avoided methane emissions component. This benefit is unique to digester projects versus other renewables such as solar or wind. Actual power generation may be slightly less than 2,000 MWh (see 4.11), but this would have only minimal impact on total GHG reduction.

4.9 Construction Costs

Collection Procedures: Construction costs were collected via the project's monthly invoices to SMUD.

Data Collected: The total construction costs in the table below are broken down by category, and separately, by project phase.

Table 5: Construction Costs

	Total			
Direct Labor	$ 29,421.25		Project Administration	$ 61,719.60
Fringe Benefits	$ -		Lease Agreement	$ 2,769.88
Materials	$ 88,252.98		Preliminary Design	$ 2,172.19
Travel	$ 2,036.58		Engineering and Construction Documents	$ 14,564.21
Misc. (includes interconnection and permitting)	$ 236,074.01		Procurement	$ 680,665.04
Minor Subcontractors	$ 98,624.48		Construction	$ 508,675.77
Major Subcontractors	$ 339,235.16		Grid Connection	$ 161,432.00
Equipment	$ 677,343.37		Commissioning	$ 20,706.38
			Field Demonstration	$ 15,801.95
			Technology Transfer	$ 2,480.81
Total	**$ 1,470,987.83**		**Total**	**$ 1,470,987.83**

Analysis and Discussion: The table above does not include certain non-SMUD eligible costs such as insurance, financing, leases, and other expenses not meeting SMUD's eligibility criteria. These expenses would add approximately $150,000 in additional costs to the project, bringing the total cost to slightly over $1,600,000. Even at this level, the project construction cost less than the original estimate of $1,700,000. Cost efficiencies were achieved primarily through simplification of project design. Some examples of simplified design include the project's use of an existing pond, purchase of the genset pre-installed in a container, and the use of local vendors and non-specialized equipment wherever possible. Another cost-limited factor was the project developer's highly lean management and overhead costs relative to other digester developers. These results could not normally be achieved by hiring an outside firm at consultants/contractors rates, but an in-house development team such as that employed by MEW can capture efficiencies in this manner.

4.10 Operational Costs:

Collection Procedures: MEW staff tracked operational costs by summing the labor, rents, taxes, insurance, consumables, and other costs incurred during operations. In many cases, these costs had to be estimated since the project did not operate long enough to establish clear, steady state operational cost trends.

Data Collected: The table below shows estimates of annual operating costs for the facility. Annual power production for the Levelized Cost of Electricity calculation was set at 1,800 MWh.

Table 6: Operating Costs

Genset Maintenance (parts and labor)	$27,000
Interconnection Maintenance	$10,044
SCR Maintenance	$9,000
H2S Media	$2,750
Lease Payment	$24,000
Digester Repairs (parts)	$10,000
Digester Repairs and Operations (labor)	$14,000
Insurance	$11,000
Utilities	$8,000
Consulting and Testing	$27,000
Property Taxes	$6,000
SG&A	$18,000
Total Operating Costs	**$166,794**
~~**LCOE/MWh @ 1,800 MWH/yr**~~	~~**$92.66**~~

Analysis and Discussion:
The largest costs involved are in engine maintenance, which is to be expected. Another large cost comes from lease and manure payments to the farmers. There are also significant costs involved in complying with various regulations and protocols, which require outside consultants. Some examples include air permit emissions testing, carbon offset verification, and water board well sampling. All of these costs are not related to project size, and consequently they absorb a larger percentage of the project budget as projects get smaller. Some variables costs such as repairs and SG&A may decrease over time. The LCOE for 1,800 MWh/yr should be regarded as a relatively conservative (high) number, which future efficiencies may reduce.

4.11 Revenue Estimates, Financial Feasibility and Levelized Cost of Electricity

Collection Procedures: The project's electrical production revenue was estimated based on historical production rates and estimated winter temperature impacts. For this calculation, total estimated power was set to 1,800 MWh.

Data Collected: Revenues from electricity were calculated at the estimated **levelized Power Purchase Agreement price of $146.45/MWh** based on estimated seasonal and time of day power generation. Without access to peak pricing, the effective Power Purchase Agreement price received by the project and would be significantly lower and the project would not be economically feasible as designed. The carbon revenue was estimated based on a predicted market price of $9 per ton CO-2e. The loan payment was calculated based on a $900,000 loan at 6% interest fully amortized over 10 years.

Table 6a: Revenue and Earnings

Total MWh	$/MWh	Revenue
1,800	146.45	$ 263,610.00
Tons CO-2	$/ton	Revenue
6,000	9	$ 54,000.00
Total Revenue		**$ 317,610.00**
Operating Costs		$ 166,794.00
Loan Payment		$ 119,902.20
Before-Tax Earnings		**$ 30,913.80**

The project has adequate revenue to pay anticipated operating costs and debt service. If power output can be increased to 2,000 MWh, per year, the project will generate additional earnings. The project debt of $900,000 represents 61% of the project's $1,470,987 in SMUD eligible costs. After including construction and development costs not eligible for SMUD reimbursement, the total buildout costs increases to over $1,600,000. Add in working capital costs and bank-required payment reserves, and the total financing required for the project is approximately $1,800,000, making the $900,000 loan approximately 50% of total project financing. This 50% ratio is probably a good upper estimate of how much of total project cost can be serviced by a small digester project. If project costs had been any higher, MEW would have needed to make up the difference with additional company cash. In summary, the project was financially feasible only due to the relatively modest project budget. A larger project cost would have required significant equity infusions in order to be financially feasible.

Levelized Cost of Electricity

Using the above cost and performance data, the levelized cost of electricity (LCOE) using the revenue requirement approach was calculated for Van Warmerdam dairy digester. The results of different LCOE cases and other assumptions such as taxes and other technical and financing assumptions are shown in Table 6b below.

The LCOE of generating electricity from anaerobic digestion of dairy wastes depends mainly on capital and operating expenses.

Case 1. Using the capital cost = $1.8 Million, operating expenses = $166,794, with no investment tax credit (ITC), no CO_2 payment, no grants, 50% debt ratio, cost of debt = 6%, debt term = 10 years, return on equity = 15%, and economic life = 20 years. The LCOE in this scenario is equal to 25.59 cents/kWh (nominal $2013)

Case 2. Using the capital cost = $1.8 Million, operating expenses = $166,794, with 30% ITC, with $9/MT CO2 payment, no grants, 50% debt ratio, cost of debt = 6%, debt term = 10 years, return on equity = 15%, economic life = 20 years, the LCOE= 19.28 cents/kWh (nominal $2013).

Case 3. With 30% ITC, with $9/MT CO2 payment, with grants from DOE and CEC=$880,852
50% debt ratio, cost of debt = 6%, debt term = 10 years, return on equity = 15%, Economic life = 20 years, the LCOE yields to 9.29 cents/kWh (nominal $2013).

Case 4. This scenario mimics the real case for Maas Energy Works with 30% ITC, With $9/MT CO2 payment, with grants from DOE and CEC=$880,852, the capital cost is about $919,148 (or about $900,00), 94% debt ratio, cost of debt = 6%, debt term = 10 years, with 6% equity contribution, return on equity = 15%, economic life = 20 years. The LCOE= 7.85 cents/kWh (nominal $2013). The levelized PPA price = $14.645, which is significantly higher than LCOE in this scenario.

Case 5. With 30% ITC, With $9/MT CO2 payment, with grants from DOE and CEC=$880,852
100% debt ratio, cost of debt = 6%, debt term = 10 years, return on equity = 15%, economic life = 20 years. The LCOE= 7.67 cents/kWh (nominal $2013)

Table 6b. LCOE cases

Warmerdam Dairy Digester					
Case:	Case 1	Case 2	Case 3	Case 4	Case 5
Technical Entries			With grants = $880,852	With grants = $880,852	With grants = $880,852
Total Facility Capital Cost ($)	1,800,000	1,800,000	919,148	919,148	919,148
Electrical and Biogas Fuel--base year					
Gross Electrical Capacity (kWe)	600	600	600	600	600
Net Electrical Capacity (kWe)	570	570	570	570	570
Capacity Factor (%)	36	36	36	36	36
Net Efficiency--Biogas to Electricity (%)	38.9	38.9	38.9	38.9	38.9
Methane Concentration in Biogas (% by volume)	59.0	59.0	59.0	59.0	59.0
Heat--base year					
Total heat production rate (kWth)	865	865	865	865	865
Aggregate fraction of heat recovered (%)	50	50	50	50	50
Recovered heat (kWth)	433	433	433	433	433
Overall CHP Efficiency--Gross (%)	70.5	70.5	70.5	70.5	70.5
Overall CHP Efficiency--Net (%)	68.4	68.4	68.4	68.4	68.4
Carbon Offset (tons CO2e)	6,000	6,000	6,000	6,000	6,000
Expenses--base year					
Operating Expenses ($)	166,794	166,794	166,794	166,794	166,794
Taxes					
Federal Tax Rate (%)	34.00	34.00	34.00	34.00	34.00
State Tax Rate (%)	6.65	6.65	6.65	6.65	6.65
IvestmentTax Credit (% of Total Capital Cost)	0.000	0.300	0.300	0.300	0.300
Combined Tax Rate (%)	38.39	38.39	38.39	38.39	38.39
Income other than energy					
Carbon Payment ($/tons)	0	9	9	9	9
Sales price for solids ($/t)	0.00	0.00	0.00	0.00	0.00
Escalation/Inflation					
General Inflation (%/y)	2.50	2.50	2.50	2.50	2.50
Escalation--for all parameters (%/y)	2.50	2.50	2.50	2.50	2.50
Financing					
Debt ratio (%)	50.00	50.00	50.00	96.00	100.00
Equity ratio (%)	50.00	50.00	50.00	4.00	0.00
Interest Rate on Debt (%/y)	6.00	6.00	6.00	6.00	6.00
Life of loan or debt term (y)	10	10	10	10	10
Economic Life (y)	20	20	20	20	20
Cost of equity (%/y)	15.00	15.00	15.00	15.00	15.00
Cost of Money (%/y)	10.50	10.50	10.50	6.36	6.00
Depreciation Schedule	MACRS 5-yr	MACRS 5-yr	MACRS 5-yr	MACRS 5-yr	MACRS 5-y
Current $ LCOE ($/kWh) 2013	0.2559	0.1928	0.0929	0.0785	0.0767
Constant $ LCOE ($/kWh) 2013	0.2114	0.1593	0.0767	0.0630	0.0614

Sensitivity Analysis and Sustainability

LCOE is particularly sensitive to capital cost, operating expenses, capacity factor, return on equity and price of carbon. Sensitivity to these and other factors is illustrated in Figure 10 showing the full LCOE as each parameter is varied over the indicative relative range, all other values held constant at their reference or base –case values (in this case LCOE=19.28 cents/kWh (2013 nominal $)). If capital cost is lowered by 50% (or with grants about $900,000), LCOE reduces to about 9 cents/kWh (2013 nominal $) similar to LCOE in Case 3 above. Lowering operating expenses by 50%, LCOE reduces to 14 cents/kWh. Increasing the capacity factor by 50%, LCOE reduces to about 13 cents/kWh. And as price of carbon increases, LCOE decreases.

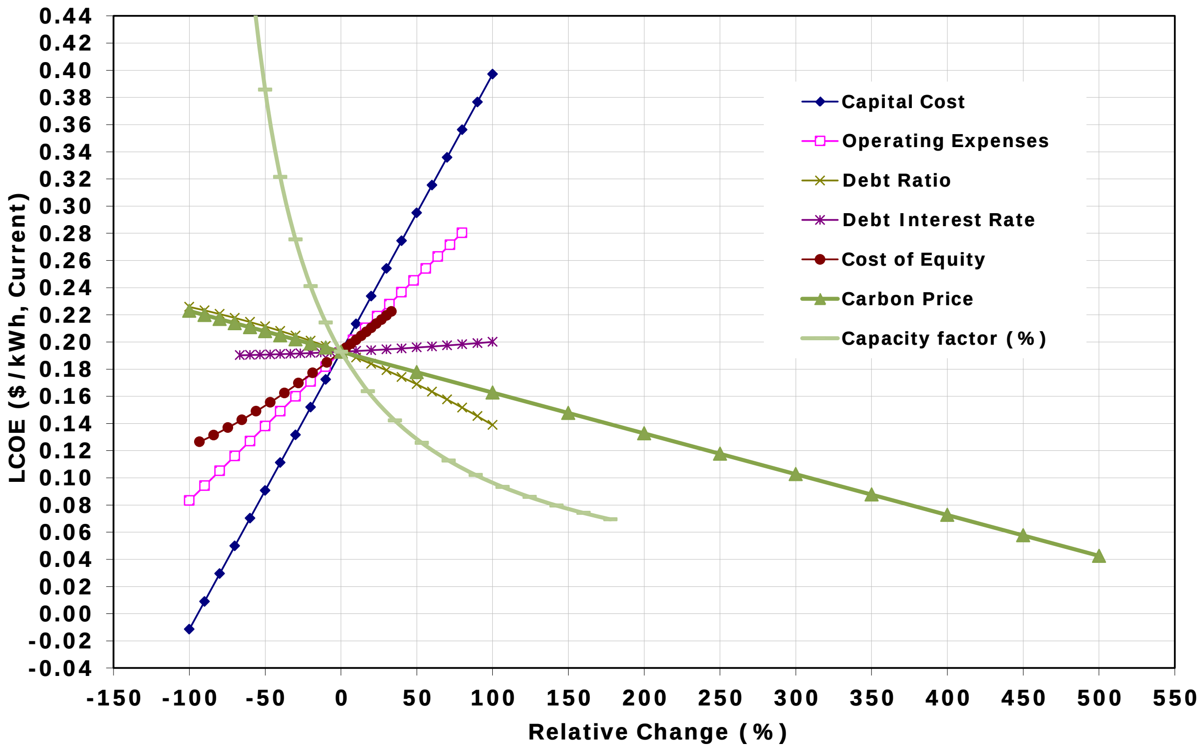


Figure 10. Sensitivity of LCOE (2013 Current $/kWh) to technical and financial factors for covered lagoon digesters at Warmerdam Dairy Farm and assumptions as shown:

Capital cost = $1.8 Million	Operating expenses = $166,794/year	ITC = 30%
Price of Carbon = $9/MT	Debt ratio = 50%	Cost of debt = 6%/year
Debt term = 10 years	Return on equity = 15% /year	Economic life = 20 years
MACRS Depreciation = 5-year	General Inflation = 2.5%	Federal tax Rate = 34%
State Tax rate = 6.65%	Gross electrical capacity = 600 kW	Capacity Factor = 36%

So, the significant drivers for economic sustainability of covered lagoon digesters for widespread deployment include:

- Increased carbon value from methane destruction
- Reduction in capital cost, and
- Reduction in operating expenses.

Co-digestion can boost biogas production and increase revenues with minimal capital investment. Where feasible, this technique should be employed.

4.12 Job Creation Estimates

Collection Procedures Project financial records were used to estimate total spending on manufactured equipment during construction and also to calculate hours of labor billed by MEW and other contractors. Estimates of operational purchases and labor were generated based on expected operations and maintenance schedules.

Data Collected: The table below shows job estimates for the project.

Table 7: Job Creation Estimates

Estimate of Jobs Created by Van Warmderdam Dairy Digester Project					
		Construction			
	Number		Rate		Jobs
MEW Direct Labor	554	hours	2,000	hours per job	0.28
Contracted On-Site Labor	1,600	hours	2,000	hours per job	0.80
Manufactured Equipment purchased	715,000	dollars	100,000	dollars per job	7.15
				Total Construction	8.23
		Operations			
	Number/yr		Rate		Jobs
Contracted On Site Labor	240	hours	2,000	hours per job	0.12
MEW On-Site Labor	600	hours	2,000	hours per job	0.30
MEW Off-Site Labor	240	hours	2,000	hours per job	0.12
Equipment and Supplies Purchased	80,000	dollars	100,000	dollars per job	0.80
				Total Operations	1.34
				Total Construction and Operations	
				9.57	

Analysis and Discussion: As with most renewable energy facilities, the project created most of its jobs during construction. Lean operations are essential to making the project financially sustainable over the long term, and so the estimated amount of operational jobs is appropriate to the project size.

4.12 Development Timeline

Collection Procedures: Completion dates of the major development milestones were logged by MEW staff.

Data Collected: Milestones and dates are depicted in the table below.

Table 7: Development Timeline

SMUD Request of Statements of Interest	November 27, 2011
Maas Energy Works initial concept response to SMUD	December 7, 2011
Grant Agreement signed between MEW and SMUD	December 27, 2011
Air Permit Application Submitted	April 24, 2012
Interconnection Application Submitted	April 26, 2012
Air Permit Received	June 11, 2012
Interconnection Agreement and PPA Signed	June 27, 2012
Building Permit Application Submitted	September 17, 2012
Building Permit Received	October 24, 2012
Begin Excavation	January 11, 2013
Genset Delivered	March 5, 2013
County Electrical Signoff	May 16, 2013
First Power Generated	May 23, 2013
SMUD-Approved Commercial Operations Date	May 28, 2013
Total Time from Initial Concept to Commercial Operations	**17.7 Months**

Analysis and Discussion: The project was completed 17.7 months from the initial concept proposal. Development could have been shortened by several months under better circumstances. The primary delay in the timeline was due to financing, which delayed initial excavation by 2-3 months and delayed genset delivery by another 2-3 months. On-site construction activities lasted only five months, and could have been shortened to as little as three months if financing were available sooner. The containerized genset design greatly simplified installation complexity reduced timeline. SMUD's interconnection agreement turnaround was exceptionally fast, which also helped the project timeline.

CHAPTER 5: Results and Discussion

Objectives The project met its objective of demonstrating a cost-efficient, timely, and reliable digester project, so as to promote market adoption of renewable technologies. In many ways, the project represents a “best case” design showing the simplest, fastest, and most efficient way to get a reliable digester built. If there are more digesters that can be financially feasible in the SMUD territory and elsewhere, they will most likely follow a similar design model, or at least major components of the Van Warmerdam model. The project did not generate a large number of jobs, but at approximately $92,000 dollars of SMUD grant funds per job created (see Chapter 4), it compares favorably to other Recovery Act projects. The project demonstrated several critical industry technologies such as hydrogen sulfide reduction, generator peaking operation and selective catalytic reduction of biogas engine exhaust.

Levelized Cost of Electricity At $83-$93/ MWh levelized operating cost of electricity, these projects remain a relatively expensive means of generating electricity. Developer experience may reduce these costs slightly in the future. For example, MEW has identified some minor savings that could lower the cost of the Van Wamerdam design in areas such as excavation and digester anchor design. However, it is more likely that new entrants into the market will use more expensive technology, and spend far more money developing new projects. For that reason SMUD’s current strategy of working directly with experienced, established developers (instead of requiring farmers to own the projects) is likely to bear fruit in lowering LCOE. Developer expertise can make digester projects more efficient and reliable. However, the danger with developers is that the allure of grant funding can draw in overly complex or expensive projects that are not likely to be successful in the long term—especially on the relatively small farms in the SMUD service territory. SMUD has devised a novel solution by individually selecting farmers and then separately selecting developers based on SMUD’s previous experience. The ability of the Van Warmerdam facility to store biogas and then generate power during peak periods is a key to maximizing the project revenue and creating an economically viable digester. Without peak pricing, small projects similar to Van Warmerdam would be economically infeasible.

Digester Performance The overall digester performance has been more than satisfactory. The system has required minimal repairs and has performed very reliably. Parasitic load of ~5% is reasonable. This operational simplicity is a major benefit of the covered lagoon design. A major drawback of the covered lagoon design include lower winter power production. Our data show a drop in digester temperature and a drop in power output during the winter, to as low as 54% of peak summer output. However this drop was brief and the rest of the winter the digester created biogas of at least 60% of peak summer output. We believe this tradeoff is worthwhile, considering the lower capital and operational costs of the covered lagoon. The digester also performed well regarding H_2S reduction and biogas storage, enabling the peaking operation that was discussed earlier in this document.

Renewable Electricity Due to the up-sized 600 kW generator, the project has an excellent capacity to provide electricity during super-peak demand periods. This timing of deliveries eases SMUD’s generation and transmission burden. In this case, the extra capital cost incurred by MEW was justified since SMUD offered higher prices for on-peak delivery. Now that SMUD’s Feed in Tariff has expired and there is no advantageous Time of Use pricing to incentivize the project. The only remaining option is to produce baseload power at a single, low rate, which will effectively raise the Levelized Cost of Electricity since digesters do not “scale down” well. The main positive attribute of digesters—the ability to store gas and generate maximum power during super-peak periods—is only effective if time-of-use pricing is available. Otherwise, small digesters are not highly efficient producers of renewable electricity.

Greenhouse Gas Impacts Digesters' ability to create large volumes of greenhouse gas reductions gives these projects an additional benefit over and above their power production. The project's greenhouse gas impact is impressive due to the avoided methane benefits combined with the renewable energy generation benefits. This allows the digester to generate greenhouse gas benefits normally associated with a project many times its size. However, it can be difficult to verify and market greenhouse gas credits at such a small scale. This difficulty can be mitigated if the developer has a streamlined process for verifying greenhouse gas offsets, or if the purchaser of the offsets is willing to wait up to two years, to lengthen the verification cycles and then lower costs.

Permitting as discussed in Chapter 2, the project required three separate permits. Although none of the permits was excessively difficult to procure, all of these permits increased the project cost by tens of thousands of dollars and delayed project implementation. Since the cost of securing permits is a relatively fixed cost, the percentage of project budget spend on permits will increase as the size of the project decreases. For that reason, projects must be designed with as small of a regulatory footprint as possible. Also, project developers must be willing to invest the necessary capital to purchase state of the art engines and emissions controls in order to meet air emissions standards. Thankfully, the existing emission controls appear to be adequate to meet current air permitting rules.

Financing MEW was able to secure the necessary construction loan, thanks in a large part to SMUD's provision of grant funds and also due to MEW's prior industry experience. Without SMUD financing, most projects of this small size would not be financially feasible without large injections of equity from developers. Developers, in turn, are not likely to invest large amounts of private funds in digester projects unless the revenue prospect is positive—either due to a high feed in tariff rates with time of day pricing, or else due to a rise in carbon offsets, or due to grant financing to offset capital costs. However, with sufficient financial incentives in place, the Van Warmerdam project has clearly demonstrated that stable, long term financial performance is possible for projects of this type and scale.