Commonwealth Energy Biogas/PV Mini-Grid Renewable Resources Program

Making Renewables Part of an Affordable and Diverse Electric System in California

Contract No. 500-00-036

First Quarterly Data Report

Data for the Period June 1 – August 31, 2004

Project 2.2 Enhanced Energy Recovery through Optimization of Anaerobic Digestion and Microturbines

Task 2.2.5a Collect and Analyze Data for Optimized Anaerobic Digestion System

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The Site Selection and Test Plan Report, delivered under Task 2.2.2 (Project 2.2) of this PIER program, carried forward the conclusions from the above-mentioned reports and provided specific site recommendations, further definition of the processes and their integration into the host facility at the recommended site, and the test plan for the recommended processes.

The ultrasound process selected in Task 2.2.1 was recommended for testing at the City of Riverside Water Quality Control Plant. A specific location on the south side of digesters #1 and #2 at that plant was recommended and described on a plant layout. Two vendors of ultrasound systems, IWE Tec and Sonico, were selected to provide equipment.

The recommended test plan was broken down in to four phases, pretest phase (preparing for the test), baseline phase (with no ultrasound system installation), ultrasound phase (with ultrasound system installation) and continuation phase (after the shut down of the ultrasound systems).

This first quarterly data report summarizes the baseline test results obtained from June 1 to August 31 2004. Two quarterly reports will be issued during the testing phase, and the fourth report will be provided after completion of the continuation phase. The baseline performance provides site-specific digester performance with regard to gas production and biosolids production and various other parameters based on the known amount of primary sludge (PS) and thickened waste activated sludge (TWAS) fed to digesters. The data will be used later for comparing digester improvements with the ultrasound systems installed.

The scope for Task 2.2.5 also includes testing and reporting for microturbine and gas cleaning systems. That pilot equipment was installed IEUA's RP-1 facility. Due to the different timing of these two separate installations, the testing for the microturbine and gas cleaning systems pilot equipment was started later than the equipment at Riverside. Therefore, data from the microturbine and gas cleaning systems pilot testing in not included in this 1st Quarterly Report, and will be included starting with the 2nd Quarterly Report. To complete the reporting, a total of six (6) Quarterly Reports will be done instead of the originally-planned four.

Baseline Performance

Riverside WWTP Digester Baseline Performance

During the baseline period, the digesters were monitored for a number of key performance parameters, such as gas production and volatile solids reduction (VSR). The two test digesters, Digesters 1 and 2 were the main focus. Digester 3, being a smaller digester, is operated slightly differently, however monitoring of this digester is used to verify trends seen in the other two digesters. The digesters did see some process interruptions, such as Digester 3 feed being stopped for installation of the new gas meter on July 9 through 13 and Digester 2 being overfed during that time, becoming unstable and requiring feed to that digester be stopped for two days.

The baseline data showed that VSR in the digesters was normally in the range of 53 to 56-percent. Low 50 percent VSR is fairly typical of conventional mesophilic digestion in California. Biogas yield, or the amount of gas generated per unit mass of solids destroyed, averaged 16.5 cf/lb VSR in Digester 1 and 14 cf/lb VSR in Digester 2. This is within the expected range, where 16 cf/lb VSR is normally taken as the theoretical value. The baseline period digester data did show that Digester 2 had a slightly lower performance than Digester 1 in terms of VSR and gas production. Excluding the period when Digester 2 process was unstable due to overfeeding, the average VSR in this digester was 54 percent, compared with 56 percent in Digester 1. Tracer tests conducted showed that Digester 2 had approximately 23 percent more dead volume than Digester 1. Subsequent to the tracer tests, the mixing on both digesters was changed in the latter part of July to provide more complete mixing with all the mixing pumps being operated continuously. Tracer tests will need to be repeated to verify comparative mixing in the two digesters under the new mixing mode. The gas meters on Digesters 1 and 2 were also interchanged on August 4th to ascertain whether there was a difference in the meters, but no change in gas production was seen. The gas methane was similar between the digesters, averaging 65 percent, with a heating value of 657 BTU/cf. The VSR trend in Digester 3 was seen to follow similar trends to Digesters 1 and 2, confirming it's use as a point of comparison for changes that might be seen with the ultrasound installation.

Riverside WWTP Digester Baseline Installation and Operating Costs

The total installation cost for the ultrasound system at Riverside WWTP was $437,000. The baseline net operating cost for the digester system (before running the ultrasound system) for June 1 – August 31, 2004 was $ 78,000. These costs are broken out and discussed further in Section 2.5.

Dewatering Baseline Performance

The dewaterability of digested solids is a key cost component for digester operation and the cost-benefit analysis of using ultrasound. With the use of ultrasound there is the potential to improve dewaterability, through less use of polymer and production of a drier cake. Baseline data showed that the two belt filter presses (BFPs) typically achieved a cake solids concentration of 13 percent. This is lower than what would be expected from BFP dewatering of digested sludge, which a concentration of 14 to 18 percent is more typical. Polymer use during the baseline period averaged 26 lb/ton of solids processed, which is slightly higher than typical BFP operations of 15 to 20 lb/ton. The filtrate quality from dewatering operations is normally returned to the main treatment plant and therefore the quality can impact performance and the cost of running the secondary treatment process. The ammonia and solids concentration in the return drain to the plant (filtrate and washwater combined) averaged 543 mg/L and 631 mg/L respectively, which is an expected range for this type of operation.

Next Phase – Ultrasound Test

The digester performance monitoring will continue through the next phase of the test, when the ultrasound equipment will be in place. Daily operation of the ultrasound equipment will be recorded by the City of Riverside staff on a log sheet that has been developed. This includes parameters such as power draw by each system, number of operational units, flow rate through each system and ultrasound operating frequency. In addition, periodic tests will be conducted on samples into and out of each ultrasound unit to determine soluble chemical oxygen demand (COD) generation and microscope filamentous analyses. The data collected will enable development of a cost-benefit analyses for implementation of ultrasound at sewage treatment plants (STPs) in California for enhanced digestion and renewable energy recovery.

SECTION 1

Introduction

In June 2001, the Commonwealth Energy Team was awarded a programmatic contract under the California Energy Commission's Public Interest Energy Research (PIER) Program to conduct research on strategies for making renewable energy more affordable in California. The Commonwealth Energy approach involves assessing the combined potential of biogas and photovoltaic (PV) resources in a defined study area and identifying how these resources could be developed in a complementary and cost-effective manner. The Commonwealth Energy Team conducted this research in a real world setting so that the findings could be applied elsewhere in California and thereby benefit more California ratepayers. The local area Commonwealth Energy selected for its renewable energy research activities is the Chino Basin, referred to in this report as the study area.

1.1 Background

The Chino Basin is rich in PV and biogas resources. Moreover, it is a rapidly growing area with substantial and increasing electrical loads. The underlying goal of the Commonwealth Energy PIER Renewables Mini-Grid Program is to identify potential Building Integrated PV (BIPV) and biogas energy projects, bring innovative technologies and business practices to these projects, assess the benefit to the local electricity distribution system (the mini-grid), and then use the findings to develop a business model for siting cost-effective, renewable energy projects. A description of the Commonwealth Energy PIER Program, including the results of some of the work undertaken to date, is presented on the project Web site, http://www.pierminigrid.org.

An important element of the Commonwealth PIER Renewables Mini-Grid Program is a project devoted to research on improving energy recovery from biogas derived from anaerobic digestion. This project is identified as Project 2.2, "Enhanced Energy Recovery Through Optimization of Anaerobic Digestion and Microturbines." The work summarized in this report, Task 2.2.5 – "Collect and Analyze Data for Optimized Anaerobic Digestion System", is the fifth activity of Project 2.2. This task requires provision of quarterly data reports on data collection and analysis activities.

1.2 Aim of this Report

The aim of this report is to summarize the baseline data collected from June 1 to August 31, 2004 to document performance of the digesters, which will be used for comparison during the ultrasound test phase.

Baseline performance provides site-specific digester performance with regard to gas production, solids reduction and various other parameters based on the known amount of PS and TWAS fed to the digesters. As with any test that seeks to measure improvements in a process, it is vital that the baseline performance is well established. This is even more important when two different systems will be tested side-by-side.

1.3 Report Content and Organization

This report is organized as follows:

- **Section 1** introduces the Commonwealth Energy program, provides background information on the Chino Basin, presents an overview of the Commonwealth PIER project for Enhanced Energy Recovery through Optimization of Anaerobic Digestion, and describes the objectives and contents of this report.
- **Section 2** describes and summarizes the baseline digester operation and performance, data and the dewatering process data for the first quarter (June 1 to August 31, 2004).
- **Section 3** provides an evaluation and discussion of the data provided in Section 2 and compares performance of the digesters.
- **Section 4** describes quality assurance and data analysis procedures followed for the data collected through the first quarter.
- **Section 5** describes the following test phase, including daily checkout list and additional tests needed to prepare for the ultrasound test phase.

1.4 Overview of Project 2.2

The Project 2.2 is entitled "Enhanced Energy Recovery through Optimization of Anaerobic Digestion and Microturbines". The objectives of Project 2.2 are to:

- Increase and optimize digester gas production through thermal hydrolysis and ultrasound processes.
- Develop and optimize cost-effective gas cleanup systems.
- Evaluate and quantify environmental benefits that result from using microturbines at sewage treatment plants.
- Evaluate performance and cost during operation so sewage treatment plants have greater certainty on cost and reliability of using microturbines.

The gas cleaning and microturbine baseline period is on-going and the first quarterly report will be submitted with the second quarterly report for enhanced digestion. Therefore, this report is focused on the enhanced digestion baseline period. The Process Selection Report for Wastewater Treatment Plants, delivered under Task 2.2.1 (Project 2.2) of this PIER program, recommended focusing on ultrasound testing for enhanced anaerobic digestion.

The Site Selection and Test Plan Report, delivered under Task 2.2.2 (Project 2.2) of this PIER program, carried forward the conclusions from the above-mentioned report and provided specific site recommendations, further definition of the processes and integration into the host facility at the recommended site, and the test plan for the recommended processes.

This second task, 2.2.2, included a report on selection of the best sites at which to deploy the technologies and processes for enhanced anaerobic digestion that were selected in Task 2.2.1. It also provided (1) expanded process flow diagrams that further define the selected processes and show integration into the selected host facility, and (2) the test plan for the new systems.

1.5 Task 2.2.5 Scope and Deliverables

The scope for task 2.2.5 is to submit quarterly data reports on data collection and analysis activities. Gas quantity and quality information is to be collected before and after installation.

The work statement for task 2.2.5 lists data to be collected as follows:

> The data to be collected after installation to analyze the performance of the microturbine and associated gas cleaning systems include power generation, heat recovery, air emissions, construction costs, and operating costs. The equipment's performance will be measured in terms of heat rate, reliability, and emissions. Analyses will be conducted and compared to predicted values for these data.
>
> The data will also be collected to analyze the effectiveness of the systems installed for anaerobic digestion gas production optimization. Information collected prior to installation on flow rates, solids quality and quantity, digester loading rates, process recycles, and gas production will be compared to similar data collected after installation. Installation, operation, and maintenance cost information will be collected. The analysis process will focus on determining the impact on process operation.

The deliverables for Task 2.2.5 are:

- ✓ a) Quarterly Data Report # 1
- ✓ b) Quarterly Data Report # 2
- ✓ c) Quarterly Data Report # 3
- ✓ d) Quarterly Data Report # 4

The microturbine and gas cleaning systems pilot equipment was installed at IEUA's RP-1 facility. The pilot equipment for anaerobic digestion gas production optimization was installed at the City of Riverside Water Quality Control Plant. Due to the different timing of these two separate installations, the testing for anaerobic digestion gas production optimization was started before the microturbine and gas cleaning systems pilot equipment. Therefore, this 1st quarterly report, for the period of June 1 to August 31, 2004, includes only data from the first phase of testing for the anaerobic digestion gas production optimization pilot equipment, which was the ultrasound equipment at Riverside. Baseline data points for the parameters listed above for anaerobic digestion gas production optimization pilot testing are included in this report as follows:

- Flow Rates, (see Tables 2-1, 2-2, 2-3 and 3-1)
- Solids Quality and Quantity, (see Tables 2-4, 2-5, 2-6 and 3-3)
- Digester Loading Rates, (see Tables 2-1, 2-2, 2-3 and 3-1)

- Process Recycles, (not applicable for ultrasound tests)
- Gas Production (see tables 2-1, 2-2, 2-3 and 3-2) and,
- Installation, Operation, and Maintenance Cost Information (see Section 2.5)

Test data for microturbine and gas cleaning systems will be included starting with the 2nd Quarterly Report, for the period of September 1 to November 30, 2004. To complete the data reporting, two extra quarterly reports will be done for a total of six Quarterly Reports.

1.6 Recommended Test Plan from Project 2.2 (Task 2.2.2)

Task 2.2.2 recommended a demonstration trial be conducted to investigate the economic, practical and technical benefits of using ultrasound to increase gas production on existing anaerobic digesters at the City of Riverside Regional Water Quality Control Plant (Plant).

1.6.1 Test Objectives and Technical Approach

The aim of the enhanced anaerobic digestion test is to evaluate the cost-effectiveness of using ultrasound to increase digester gas production at sewage treatment plants. The test is being conducted at the City of Riverside Plant, as it has primary and secondary treatment processes that are typical of those found in California. Two different ultrasound systems from two manufacturers, IWE Tec and Sonico, will be tested side-by-side to compare different approaches to application of this technology for enhanced digestion. The Sonico equipment will be installed on Digester #1 and the IWE Tec equipment on Digester #2. Digester #3 will be used to compare improvements with conventional digestion. However, as this digester is slightly smaller in volume, it will not be used as an exact control.

To achieve the aim of the enhanced anaerobic digestion project, the objectives of this test are to:

- Establish robust baseline performance data for the test digesters
- Evaluate performance of two digesters, each with a different ultrasound system
- Evaluate operability of the two ultrasound systems (downtime, energy draw etc.)

1.6.2 Test Matrix

To achieve the test objectives, the test will be conducted in four phases, briefly described below and summarized in Table 1-1.

1. **Pretest Phase -** During this phase, a number of checks will be carried out at the City of Riverside sewage treatment plant, to ensure that the data collected during the test will be robust and reliable. This includes calibration of all flowmeters (sludge flows and gas flows), evaluation of mixing systems on the test digesters, tracer tests to determine digester operating volume, and collection of plant data for the past year.

2. **Baseline Phase** - During the first three months of the test, detailed baseline data will be collected with the newly calibrated instrumentation and following the test procedures described in Task 2.2.2 of Project 2.2.

3. **Ultrasound Test Phase** - Once the two ultrasound systems are installed, the ultrasound systems and digesters' performance will be monitored, as per the test procedures described in Task 2.2.2 of Project 2.2.

4. **Continuation Phase** – After the ultrasound systems have been shut down at the end of phase three, the digesters will continue to be monitored for another two to three months, to follow the change in digester performance back to the baseline. This confirms that improvements seen during the ultrasound testing phase can truly be attributed to the use of the equipment.

TABLE 1-1
Enhanced Anaerobic Digestion Test Matrix

	Digester #1		Digester #2		*Digester #3
Phase	No Ultrasound	With Sonico Ultrasound	No Ultrasound	With IWE Tec Ultrasound	No Ultrasound
Pretest Phase	1 month	-	1 month	-	1 month
Baseline Phase	3 months	-	3 months	-	3 months
Ultrasound Phase	-	6 months	-	6 months	6 months
Continuation Phase	3 months	-	3 months	-	3 months

* Digester #3 is and will be operated through the whole testing period without ultrasound installation. It will be used later for performance comparison with ultrasound installations to the other two digesters (#1 and #2). This digester has about 70% of the total digester volume for Digester #1 and #2 (Diameter for Digester 1 and 2 = 90 ft, Digester 3 = 75 ft).

1.7 Process for Collecting Information

The test plan developed in the Task 2.2.2 of Project 2.2 and summarized in the Site Selection Report Section 1.4 was reviewed and agreed upon by the City of Riverside sewage treatment plant. The test parameters and procedures laid out in the test plan were strictly followed through this baseline test phase. The parameters include operational parameters such as sludge flow rates, gas flow rates and polymer use, as well as analytical parameters for which samples must be collected and analyzed in a laboratory. These include solids concentrations, ammonia, methane and carbon dioxide. Other values, such as VSR and gas yield are calculated values based on other parameters such as flow and solids concentrations.

1.7.1 Digester Operation and Performance Parameters

To ensure that both test digesters operate under similar conditions, primary and TWAS flow rates and solids loading rates for each digester will be monitored through out the test. In addition, tracer tests were conducted to evaluate digester mixing characteristics and potential dead volume. The main digestion performance parameters are volatile solids destruction and gas production. Additional parameters were monitored, to verify stability of the digestion process and downstream impacts on dewaterability and filtrate quality. Some of these parameters have cost impacts that will need to be considered in the ultrasound cost benefit analysis. Table 1-2 lists the key parameters that are measured in this study along with an explanation of their importance.

TABLE 1-2
Major Test Parameters for Baseline Solids Handling and Digestion Data Collection

Parameter	Importance	Anticipated Trend with Ultrasound Installation in the next test phase
Primary solids (PS) flowrate	for mass balance and hydraulic retention time (HRT) calculation	no change
TWAS flowrate	for mass balance and HRT calculation	no change
Total solids (TS) - (%)	for indicating the solids concentration in the sludge, and for mass balance calculation	decrease in the digester effluent TS
Volatile solids (VS) - (%)	for indicating the volatile solids in the sludge, and for mass balance calculation	decrease in the digester effluent VS
Digester side water depth (SWD)	For digester operating volume and HRT calculations	no change
Ammonia	Potential cost impacts include struvite formation, increased filtrate load on the plant. Very high ammonia can inhibit the digestion process.	increases with greater VS reduction (VSR)
*VSR	Indicates the digester performance in terms of efficiency of destruction of organic material	increase
Dewatered biosolids cake volume	Reflects changes in VSR and dewaterability. Biosolids reuse/disposal is a major cost item.	decrease
Polymer use	Improved dewaterability will reduce polymer use and reduce associated costs.	decrease
Daily biogas volume	Indicates the digester performance in terms of efficiency of gas production	increase
Methane content (%) in the biogas	Indicates digester gas quality in terms of methane content. Total methane production should increase as biogas production increases.	no change
H_2S in the biogas	Indicates digester gas quality in terms of H_2S content. Has cost implications of controlling H2S to meet requirements of the co-gen equipment and air emission standards.	no change
BTU content of digester gas	Indicates digester gas quality in terms of BTU content and can be related to methane content. Total BTU available should increase as biogas production increases.	no change

TABLE 1-2
Major Test Parameters for Baseline Solids Handling and Digestion Data Collection

Parameter	Importance	Anticipated Trend with Ultrasound Installation in the next test phase

* VSR is a calculated number based on the mass of VS in and out of the digester.

SECTION 2

Digester Baseline Data

During the pre-test phase, a number of checks were carried out at the City of Riverside sewage treatment plant, to ensure that the data collected during the test would be robust and reliable. This included calibration of all flowmeters (sludge flows and gas flows). New gas meters were installed on Digesters 1 and 2 on April 13 2004 and on Digester 3 on July 13, 2004. Tracer tests were also conducted to evaluate digester mixing characteristics and potential dead volume.

This section focuses on summarizing the baseline data from the first quarter (June 1 - August 31, 2004) with regard to solids handling data as well as gas and energy production and also summarizes the tracer test results from the pre-test phase. Discussion of the results and evaluation of digester performance is provided in the Section 3 of this report.

2.1 Summary of Baseline Digester Data

Tables 2-1 through 2-3 present the monthly averages of the digester data for the three month baseline period. The data include the feed characteristics, such as flow and solids concentrations to each digester and digester effluent characteristics such as solids concentrations and chemical data including alkalinity, ammonia and volatile acids. The flow and solids data were used to determine the mass balance and solids reduction in each digester. The chemical data are measures of digester stability (alkalinity, pH, VAs, ammonia). Ammonia and TKN also have implications for the cost of filtrate treatment and the fertilizer value of the biosolids product and sulfate concentrations can impact gas quality through H_2S formation. The digester gas data are also presented, including total gas produced and gas yield. Gas flow meter measurements provided the gas production for Digesters 1 and 2 and the total digester gas flow. Although a new gas meter was installed on Digester 3 in July, it was not calibrated and linked to the SCADA system. Therefore Digester 3 gas flows were calculated based on the difference between the total gas meter and the Digester 1 and 2 meters. The value includes the small amount of gas produced in the holding digester. However, the difference in gas yield between Digester 3 and the other two digesters indicates that gas from the holding digester would be less than 10 percent of the Digester 3 gas. Gas quality parameters include methane content and H_2S concentrations. The methane content was calculated based on carbon dioxide content measured in the gas. Detailed gas and BTU analyses conducted in April 2004 (Appendix A) showed that the gas was composed primarily of methane and carbon dioxide, with approximately one percent of the biogas being other gases such as H_2S and nitrogen. These parameters will continue to be monitored through the ultrasound test phase. Any impacts of the ultrasound treatment on these parameters will then be included in the cost benefit analysis.

Digester operational parameters, such a temperature, active volume (based on reported side water depth, not including the digester cone volume) and VS loading rate, as also presented in Tables 2-1 through 2-3. Digester operation impacts digester performance and therefore it is necessary to monitor these parameters in relation to digester performance. For the purpose of comparison of the two ultrasound installations, operation of Digester 1 and 2 should be maintained as similar as possible. Ferric chloride is added to the headworks at Riverside's Plant 1 treatment train. This assists in odor control in the headworks and primary basins, and also reduces the generation of H_2S in the digester gas by binding the sulfur in the form of iron sulfate. The equivalent ferric chloride concentration in the digesters was calculated based on the amount of ferric chloride added at the Plant 1 headworks, and the proportion of primary sludge received by each digester. Changes in H_2S concentration in the digester gas can be cross-checked with the amount of ferric chloride added. A summary of the key baseline digester operation and performance parameters is presented in section 3 of this report, along with discussion and evaluation of the digesters.

TABLE 2-1
Baseline Digester Data Averages for June 2004

Parameter	Units	Digester #1	Digester #2	Digester #3
Digester Feed Characteristics				
PS Flow	gpd	30,304	30,681	18,287
TWAS flow	gpd	30,774	30,760	18,607
Combined Flow	gpd	61,078	61,441	36,893
PS TS	lb/d	11,573	11,583	6,991
PS VS	lb/d	9,068	9,076	5,477
TWAS TS	lb/d	13,870	13,888	8,383
TWAS VS	lb/d	11,023	11,039	6,669
Combined TS	lb/d	25,688	25,702	15,120
Combined VS	lb/d	20,291	20,304	11,949
Combined FS	lb/d	5,397	5,398	3,171
Digester Effluent				
Dig Eff. TS	TS%	2.67%	2.76%	3.27%
Dig Eff. VS	VS%	68%	67%	67%
Dig Eff. TS	lb/d	12,826	13,417	9,327
Dig Eff. VS	lb/d	8,705	9,009	6,231
Dig Eff. FS	lb/d	4,121	4,408	3,095
TSR	lb/d	12,862	12,285	5,793
VSR	lb/d	11,586	11,295	5,718
TSR	%	46%	55%	102%
VSR	%	53%	55%	47%
Eff FS/ Inf FS	ratio	0.82	0.87	1.02
Alkalinity	mg/l	4,595	4,633	4,915
VFA	mg/l	102	103	113
pH	SU	7.7	7.7	7.8
NH3-N	mg/l	38,162	40,586	35,176
TKN	mg/l	86,640	86,596	75,210
Sulfate	mg/l	NA	NA	NA
VA:Alk		0.02	0.02	0.02
Digester Gas				
Gas	cf/d	175,122	145,049	112,060
Gas Production	cf/lb VS in	9	7	NA
Gas Yield	cf/lb VSR	12	15	NA
CH_4	%	66	66	NA
H_2S	ppm	53	53	NA

TABLE 2-1
Baseline Digester Data Averages for June 2004

Parameter	Units	Digester #1	Digester #2	Digester #3
Digester Operations				
Digester Temperature	^0C	38	39	38
Digester SWD	ft	30	30	30
Digester active vol[2]	gal	1,441,947	1,441,947	984,828
HRT by SWD vol	days	24	24	28
VS load rate	lbVS/cf	0.11	0.11	0.09
Iron Salt Addition	mg/l	2,105	2,109	2,139

NA – data not collected

[1] Calculated based on the difference between the total gas flow meter and Digesters 1 & 2 meters. Includes gas from the holding digester, which will be a small amount.

[2] Active vol. based on SWD and diameter of 90-ft for Digesters 1 & 2, 75-ft for Digester 3 and does not include digester cone volume. Total digester vol. including total height of digester and cone vol. is 1.64 MG for Digesters 1 & 2, 1.06 MG for Digester 3.

TABLE 2-2
Baseline Digester Data Averages for July 2004

Parameter	Units	Digester #1	Digester #2	Digester #3
Digester Feed Characteristics				
PS Flow	gpd	35,059	33,782	17,299
TWAS flow	gpd	33,820	34,099	17,821
Combined Flow	gpd	68,879	67,881	35,735
PS TS	lb/d	12,146	11,078	6,912
PS VS	lb/d	9,228	8,784	5,490
TWAS TS	lb/d	17,001	14,723	11,055
TWAS VS	lb/d	13,014	11,576	8,695
Combined TS	lb/d	27,967	25,576	18,035
Combined VS	lb/d	22,076	20,173	14,237
Combined FS	lb/d	5,891	5,403	3,798
Digester Effluent				
Dig Eff. TS	TS%	2.50%	2.67%	2.75%
Dig Eff. VS	VS%	67%	67%	66%
Dig Eff. TS	lb/d	14,467	14,782	9,530
Dig Eff. VS	lb/d	9,358	9,205	6,299
Dig Eff. FS	lb/d	4,598	4,508	3,231
TSR	lb/d	13,500	10,795	8,505
VSR	lb/d	12,718	10,969	7,938
TSR	%	52%	57%	86%
VSR	%	59%	57%	56%
Eff FS/ Inf FS	ratio	0.75	0.79	0.86
Alkalinity	mg/l	4,182	4,057	4,615
VFA	mg/l	263	824	181
pH	SU	7.7	7.6	7.6
NH3-N	mg/l	36,000	36,000	42,333
TKN	mg/l	76,407	67,646	83,484
Sulfate	mg/l	NA	NA	NA
VA:Alk	ratio	0.07	0.23	0.04

TABLE 2-2
Baseline Digester Data Averages for July 2004

Parameter	Units	Digester #1	Digester #2	Digester #3
Digester Gas				
Gas	cf/d	183,520	144,494	114,805
Gas Production	cf/lb VS in	9	8	NA
Gas Yield	cf/lb VSR	14	13	NA
CH_4	%	65	64	NA
H_2S	ppm	64	64	NA
Digester Operations				
Digester Temperature	^0C	38	39	39
Digester SWD	ft	30	30	30
Digester active vol[2]	gal	1,441,947	1,441,947	984,828
HRT by SWD vol	days	22	22	25
VS load rate	lbVS/cf	0.11	0.10	0.03
Iron Salt Addition	mg/l	1,962	1,937	1,911

NA – data not collected

[1] Calculated based on the difference between the total gas flow meter and Digesters 1 & 2 meters. Includes gas from the holding digester, which will be a small amount.

[2] Active vol. based on SWD and diameter of 90-ft for Digesters 1 & 2, 75-ft for Digester 3 and does not include digester cone volume. Total digester vol. including total height of digester and cone vol. is 1.64 MG for Digesters 1 & 2, 1.06 MG for Digester 3.

TABLE 2-3
Baseline Digester Data Averages for August 2004

Parameter	Units	Digester #1	Digester #2	Digester #3
Digester Feed Characteristics				
PS Flow	gpd	30,304	30,681	18,287
TWAS flow	gpd	30,774	30,760	18,607
Combined Flow	gpd	61,078	61,441	36,893
PS TS	lb/d	11,573	11,583	6,991
PS VS	lb/d	9,068	9,076	5,477
TWAS TS	lb/d	13,870	13,888	8,383
TWAS VS	lb/d	11,023	11,039	6,669
Combined TS	lb/d	25,688	25,702	15,120
Combined VS	lb/d	20,291	20,304	11,949
Combined FS	lb/d	5,397	5,398	3,171
Digester Effluent				
Dig Eff. TS	TS%	2.67%	2.76%	3.27%
Dig Eff. VS	VS%	68%	67%	67%
Dig Eff. TS	lb/d	12,826	13,417	9,327
Dig Eff. VS	lb/d	8,705	9,009	6,231
Dig Eff. FS	lb/d	4,121	4,408	3,095
TSR	lb/d	12,862	12,285	5,793
VSR	lb/d	11,586	11,295	5,718
TSR	%	46%	55%	102%

TABLE 2-3
Baseline Digester Data Averages for August 2004

Parameter	Units	Digester #1	Digester #2	Digester #3
VSR	%	53%	55%	47%
Eff FS/ Inf FS	ratio	0.82	0.87	1.02
Alkalinity	mg/l	4,595	4,633	4,915
VFA	mg/l	102	103	113
pH	SU	7.7	7.7	7.8
NH3-N	mg/l	38,162	40,586	35,176
TKN	mg/l	86,640	86,596	75,210
Sulfate	mg/l	NA	NA	NA
VA:Alk		0.02	0.02	0.02
Digester Gas				
Gas	cf/d	175,122	145,049	112,060
Gas Production	cf/lb VS in	9	7	NA
Gas Yield	cf/lb VSR	12	15	NA
CH_4	%	66	66	NA
H_2S	ppm	53	53	NA
Digester Operations				
Digester Temperature	^0C	38	39	38
Digester SWD	ft	30	30	30
Digester active vol[2]	gal	1,441,947	1,441,947	984,828
HRT by SWD vol	days	24	24	28
VS load rate	lbVS/cf	0.11	0.11	0.09
Iron Salt Addition	mg/l	2,105	2,109	2,139

NA – data not collected

[1] Calculated based on the difference between the total gas flow meter and Digesters 1 & 2 meters. Includes gas from the holding digester, which will be a small amount.

[2] Active vol. based on SWD and diameter of 90-ft for Digesters 1 & 2, 75-ft for Digester 3 and does not include digester cone volume. Total digester vol. including total height of digester and cone vol. is 1.64 MG for Digesters 1 & 2, 1.06 MG for Digester 3.

2.2 Summary of Baseline Dewatering Data

The dewatering data are provided in Tables 2-4 through 2-6. This includes parameters related to the dewatered biosolids cake, the filtrate and the belt filter press (BFP) operation. The dewatered cake TS concentration is the primary measure of dewaterability. It impacts the final quantity, or wet tons per day, of cake to be sent for reuse or disposal, which is a significant cost factor for STPs in California. The polymer dose required to achieve the cake dryness also has a cost impact. The volatile solids concentration is an indicator of stability of the biosolids, and also is related to the BTU value of the biosolids, should it be used for production of energy through pyrolysis or combustion technologies. The chemical characteristics of the cake, such as ammonia, nitrate, and TKN, impact the fertilizer value of the biosolids when used in land application or compost production. The filtrate and washwater flows are typically returned to the headworks of the plant and therefore the ammonia concentration increases the load to the plant, with an associated cost factor.

TABLE 2-4
Baseline Dewatering Data for June 2004

Parameter	Unit	Value	Parameter	Unit	Value
Dewatered Cake			**Filtrate**		
Quantity Produced	wtpd	190	Filtrate Flow	gpd	206,660
TS%	%	13.0%	Washwater Flow	gpd	71,028
VS% (as in the BFP feed)	%	66%	Drain[1] Solids (TS)	mg/l	720
Alkalinity	mg/kg	4,587	Drain[1] Ammonia	mg/l	546
Ammonia	mg/kg	43,778			
Cake NO_3	mg/kg	256			
Cake TKN	mg/kg	84,222			
BFP Operation					
Polymer	lb/ton	26			
Capture rate (assumed)	%	94%			
BFP 1 Operation	hr/d	10			
BFP 2 Operation	hr/d	10			

NA – data not collected
[1] Drain includes filtrate and washwater flows.

During the baseline test period, dewatered cake quantities were not monitored, as the solids were sent to on-site drying beds before being hauled off-site for beneficial reuse. In addition, the drain flow meter, which measures filtrate and washwater flows, was found not to be reliable. The dewatering mass balance for cake quantity, filtrate flow and filtrate TS were, therefore, based on the digested sludge flow and solids to the dewatering process and an assumed solids capture rate of 94 percent. There were a few days in June and July when the dewatered cake TS content was not measured and the values for these days were interpolated between the two adjacent values. The washwater flow rates are set at 60 gpm per BFP, and were calculated based on hours of operation of each press.

TABLE 2-5
Baseline Dewatering Data for July 2004

Parameter	Unit	Value	Parameter	Unit	Value
Dewatered Cake			**Filtrate**		
Quantity Produced	wtpd	178	Filtrate Flow	gpd	193,758
TS%	%	13.2%	Washwater Flow	gpd	86,467
VS% (as in the BFP feed)	%	66%	Drain[1] Solids (TS)	mg/l	621
Alkalinity	mg/kg	4,444	Drain[1] Ammonia	mg/l	531
Ammonia	mg/kg	42,000			

TABLE 2-5
Baseline Dewatering Data for July 2004

Parameter	Unit	Value	Parameter	Unit	Value
Cake NO_3	mg/kg	NA			
Cake TKN	mg/kg	81,607			
BFP Operation					
Polymer	lb/ton	NA			
Capture rate (assumed)	%	94%			
BFP 1 Operation	hr/d	12			
BFP 2 Operation	hr/d	12			

NA – data not collected
[1] Drain includes filtrate and washwater flows.

TABLE 2-6
Baseline Dewatering Data for August 2004

Parameter	Unit	Value	Parameter	Unit	Value
Dewatered Cake			**Filtrate**		
Quantity Produced	wtpd	151	Filtrate Flow	gpd	158,937
TS%	%	13.7%	Washwater Flow	gpd	86,957
VS% (as in the BFP feed)	%	66%	Drain[1] Solids (TS)	mg/l	585
Alkalinity	mg/kg	4,803	Drain[1] Ammonia	mg/l	549
Ammonia	mg/kg	44,754			
Cake NO_3	mg/kg	NA			
Cake TKN	mg/kg	92,046			
BFP Operation					
Polymer	lb/ton	NA			
Capture rate (assumed)	%	94%			
BFP 1 Operation	hr/d	13			
BFP 2 Operation	hr/d	11			

NA – data not collected
[1] Drain includes filtrate and washwater flows.

2.3 Validation of Digester 1 and 2 Gas Data

New gas meters were installed on Digesters 1 and 2 on April 13 2004 and on Digester 3 on July 13, 2004. However, the baseline data showed that despite similar solids loadings to Digesters 1 and 2, there was over a 10 percent difference in the gas production, with a five percent difference in VSR. To verify whether some of the difference in gas production may be due to inherent differences between the two gas meters, the gas meters on the two digesters were changed over on August 4, 2004. As shown in Appendix A, the recorded gas production for both digesters show consistent readings before and after the gas meter switch. The gas meters locations are as the two digesters are mirror images of each other. This indicates that the gas readings are accurate and that other differences in the digesters may account for the difference in performance.

2.4 Digester Volume Tracer Tests

Tracer tests were conducted for each digester to evaluate mixing efficiency, to examine the extent of short-circuiting in each system and to determine the potential dead space volume. Digesters 1 and 2 had tracer tests conducted twice, while Digester 3 was tested once. Table 2-7 summarizes the results from the lithium tracer studies. The detailed data and the lithium tracer curves are provided in Appendix B of this report. Each test is conducted over a period of five hours, with effluent samples being collected at regular intervals during the test, and analyzed for lithium. If there is an initial spike in the lithium concentration, it indicates short-circuiting in the digester. The length of time taken to reach a stable concentration is a reflection of mixing efficiency. The stabilized concentration when compared to the concentration expected based on digester theoretical operating volume (digester SWD and diameter) provides the volume of dead or unused space in the digester.

Digesters 1 and 2 have external mixing pumps located on the north and south sides of the digester. Both digesters were operated on a mixing regime where the north and south side mixers were alternated once a week. During the first set of tracer tests, Digester 1 was on north side mixing and Digester 2 was on south side mixing. On the second round both digesters were on north side mixing, although the Digester 1 pump was not pumping for the first two hours of the test. Although Digester 1 was not tested under south side mixing, Digester 2 appears to have less active volume, whether mixing on the south or north side. In mid July 2004, digester mixing was changed to operate both north and south mixers continuously. Tracer tests have not been conducted to compare mixing characteristics under this mode of operation. However, it is proposed to conduct another set of tracer tests part way through the ultrasound test phase.

TABLE 2-7
Summary of LiCl Tracer Test Results

Parameter	Test Date	Findings
Digester #1	April 21, 2004	The digester active volume was 7% lower than the theoretical active volume calculated. There was some short-circuiting in the digester.
	June 29, 2004	The mixing pump was not pumping for the first 2 hours of the test. Lithium concentrations at the end of the test (5 hrs) indicated the digester active volume was 13% lower than the theoretical active volume calculated.
Digester #2	April 22, 2004	The digester active volume was 27% lower than the theoretical active volume calculated. There was slight short-circuiting in the digester.
	June 30, 2004	The digester active volume was 33% lower than the theoretical active volume calculated. Mixing was not as good as during the April test.
Digester #3	March 30, 2004	The digester active volume was 19% lower than the theoretical active volume calculated. The mixing was not as good as in Digesters 1 and 2.

2.5 Baseline Cost Data

2.5.1 Installation Costs

Total direct installation costs for the ultrasound equipment at Riverside WWTP for conducting these tests were $437,000. These costs are broken down as follows:

- **$ 244,000** total equipment costs (from equipment vendors, Sonico and IWE Tech), consisting of:
  - **$130,000** for Sonico equipment
  - **$104,000** for IWE Tech equipment
  - **$10,000** ancillary instrumentation and controls for ultrasound equipment.
- **$ 142,000** host site (Riverside WWTP) installation costs (materials and labor)
- **$ 51,000** host site (Riverside WWTP) labor and administrative costs

These costs are one-time costs to the project, and will be recorded again for reference only in subsequent quarterly data reports for Task 2.2.5.

2.5.2 Operations and Maintenance Costs

For the 1st quarterly period (June 1 – August 31, 2004), baseline operations and maintenance costs for the Riverside digesters are reported in Table 2-8 below, without the ultrasound equipment, which was not running at the time. Baseline operating costs are the same for digesters 1 or 2, so the baseline costs shown are for either one of these digesters – total costs for the two would be double the amount. During ultrasound testing, the baseline costs per digester will be shown next to the operating costs for digester 1 with Sonico equipment and for digester 2 with IWE Tech equipment. These costs were annualized to show what the yearly baseline O&M costs would be for either digester 1 or 2 at Riverside WWTP.

TABLE 2-8
Baseline Operating Costs for Digesters 1, 2 at Riverside WWTP Before Application of Ultrasound

Cost Item	**Quarterly Costs - Existing Riverside STP Individual Digester (1 or 2) – cost for each, $[1]**	**Annualized Costs - Existing Riverside STP Individual Digester (1 or 2) – cost for each, $/yr[1]**
Polymer Cost	$23,871	$95,485
Biosolids Management Cost	$146,264	$585,055
Additional Ultrasound Electricity[2] Cost	N/A	N/A
Ultrasound Maintenance Cost[2]	N/A	N/A
Ultrasound Labor Cost[2]	N/A	N/A
Total O&M Cost	**$170,135**	**$680,539**
Less: Natural Gas Offset Value	($92,096)	($368,382)
Net O & M Cost	**$78,039**	**$312,157**
CH2M HILL cost (quarter only)[3]	$73,390	

NOTES:

1. Costs shown are for each digester, #1 or #2 at Riverside WWTP. Total baseline costs to run the two digesters would be double these amounts.
2. Ultrasound costs are not applicable because this was the baseline period and the ultrasound units were not operational.
3. CH2M HILL costs to manage this period of the pilot study are not annualized – they will not be recurring costs in full-scale projects.

SECTION 3

Digester Performance Evaluation & Discussion

This section provides an evaluation of the digesters at the Riverside Plant, from the baseline data discussed above.

3.1 Digester Operation

The monthly average digester operation data were provided in Tables 2-1 to 2-3. Digester 3 feed was stopped between July 9 and 13 for installation of a new gas meter and therefore the feed to Digesters 1 and 2 was increased. During this time, Digester 2 received excess TWAS on July 9th and 10th, as the feed valve stuck open. Following this, the digester started to go sour, evidenced by a drop in gas production, VS reduction, and alkalinity and an increase in volatile acids (VAs). To rectify this, feed to Digester 2 was reduced on July 19 to 21. Table 3-1 provides a summary of the digester operation data averaged over the baseline period, including PS and TWAS feed rates, solids loading rates, HRT and temperature. All data for all digesters for the period of July 9 through July 25 were omitted as the data for this period does not represent normal operation of the digesters.

TABLE 3-1
Summary of Baseline Digester Operation (Averages of June 1 – August 31, 2004[1])

Operational Parameters	Units	Digester #1	Digester #2	Digester #3
Primary Solids Flowrate[2]	gpd	32,210	32,130	19,440
TWAS Flowrate[2]	gpd	31,760	31,610	19,480
Total Flow rate[2]	gpd	63,960	63,740	38,920
Primary VS load[2]	lb/d	9,240	9,240	5,630
TWAS VS load[2]	lb/d	11,640	11,650	7,240
Total VS load[2]	lb/d	20,980	21,020	12,800
Digester Loading Rate	lbVS/cf	0.11	0.11	0.05
Hydraulic Detention Time	days	26	26	28
Digester Temperature	^0C	39	38	38

1. Does not include data for 07/09/04 to 07/25/04, when Digesters 2 and 3 were unstable.
2. Data were rounded to the nearest 10.

Table 3-1 shows that the measured operating parameters of Digesters 1 and 2 were very similar. Digester 3, being a smaller digester, received lower flows. The HRT in this digester at 28 days was slightly longer than the other digesters. It was preferred to keep the HRT in Digesters 1 and 2 between 20 to 26 days, as this is the typical design range for mesophilic digestion.

3.2 Digester Performance

Tables 2-1 to 2-3 provided the monthly average digester performance data. Averages for key digester performance parameters, including VSR, gas production, gas production yield, methane content and BTU content for the entire baseline testing period are summarized in Table 3-2. As in Table 3-1 data from mid July, when digester feed flow changes impacted performance, have been omitted from these averages. The gas quality across the digesters was similar in terms of methane content and BTU content. Samples collected on April 26 as part of the pre-test phase showed that the methane content of Digesters 1, 2 and 3 were 63 percent, 63.2 percent and 62.1 percent respectively. The corresponding BTU content for each digester was 637 BTU/cf, 639 BTU/cf and 628 BTU/cf respectively. Weekly gas samples taken from Digesters 1 and 2 during the baseline period show that the methane content average 65 percent, which is equivalent to a BTU content of 657 BTU/cf.

TABLE 3-2
Summary of Baseline Digester Performance (Averages of June 1 – August 31, 2004[1])

Performance	Units	Digester #1	Digester #2	Digester #3[3]
Volatile Solids Reduction (VSR)	%	55.5	54.3	53.8
Biogas Production[2]	cfd	181,460	153,910	117,380
Biogas Production Yield	cfd/lb_VSR	16.5	14.4	16.8
CH_4 in Biogas	%	65	65	NA
Unit BTU value	BTU/cf	657	657	NA
H_2S in Biogas[4]	ppm	69	69	69

1. Does not include data for 07/09/04 to 07/25/04, when Digesters 2 and 3 were unstable.
2. Data were rounded to the nearest 10.
3. Biogas flow from Digester #3 was not available. A new gas meter was installed in July 2004, but it was not calibrated and was not connected to the SCADA system. Gas is calculated from the difference between the total gas flow meter and Digesters 1 & 2 and includes a small amount of gas from Digester 4.
4. H2S concentrations were measured in the combined gas stream.

3.2.1 Comparison of Digesters 1 and 2

Overall, Digester 1 appeared to consistently perform better than Digester 2, despite the measured operational parameters being very similar. The average VSR for Digester 2 was approximately two percent lower than that of Digester 1. The average gas production from Digester 2 was 20 percent lower than Digester 1. However, as the Figure 3-1 shows, the gas production in Digester 2 was significantly impacted when the digester was overfed in July. The gas production took a long time to recover and to consistently remain over 150,000 cfd as it was for most of the period prior to becoming unstable. For example, prior to the July disturbance, the gas production in Digester 2 was 13 percent lower than Digester 1 averaging 164,540 cfd and 186,330 cfd respectively.

FIGURE 3-1
Baseline Period Daily Gas Production

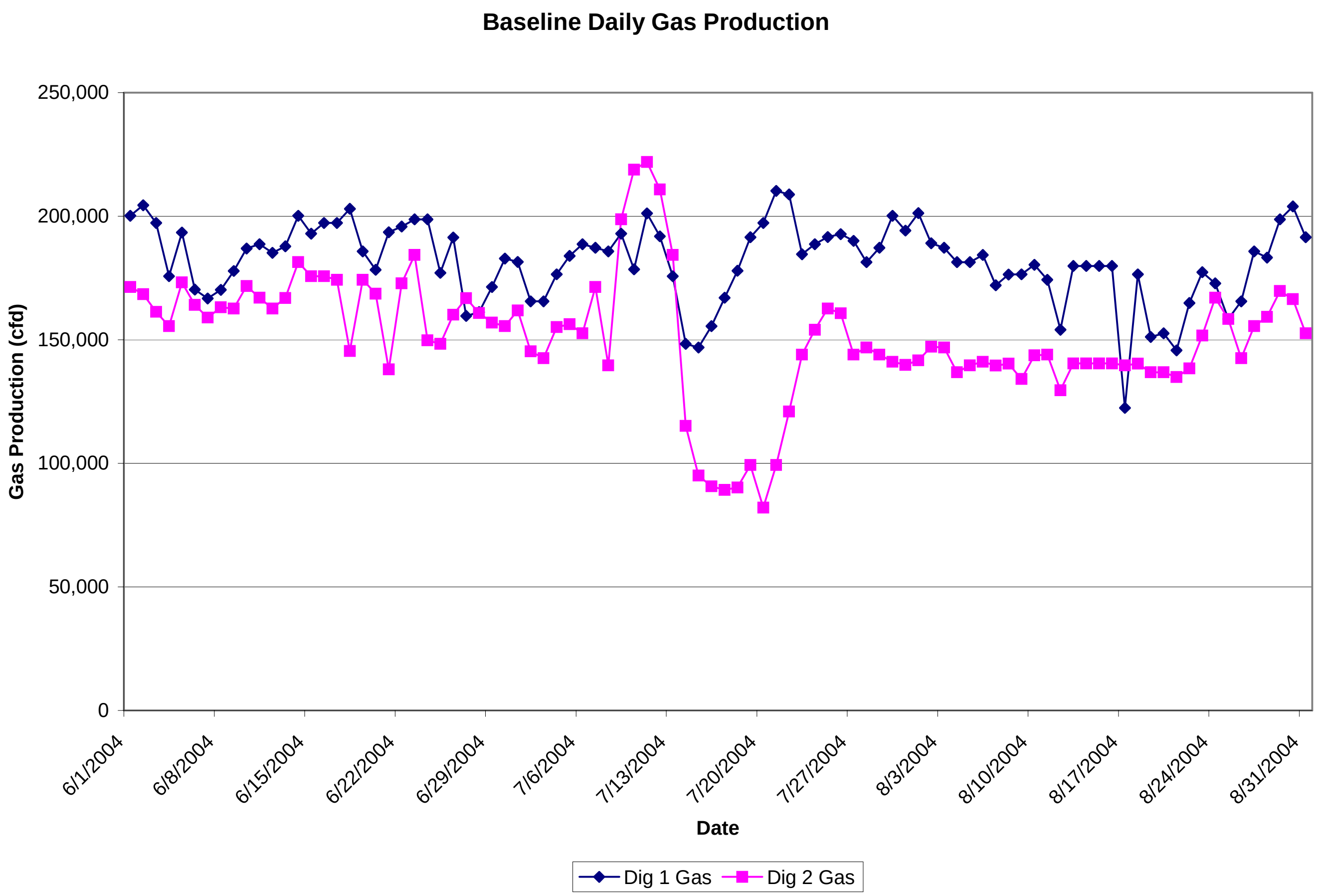


FIGURE 3-2
Baseline Period 9-day Average Gas Yield

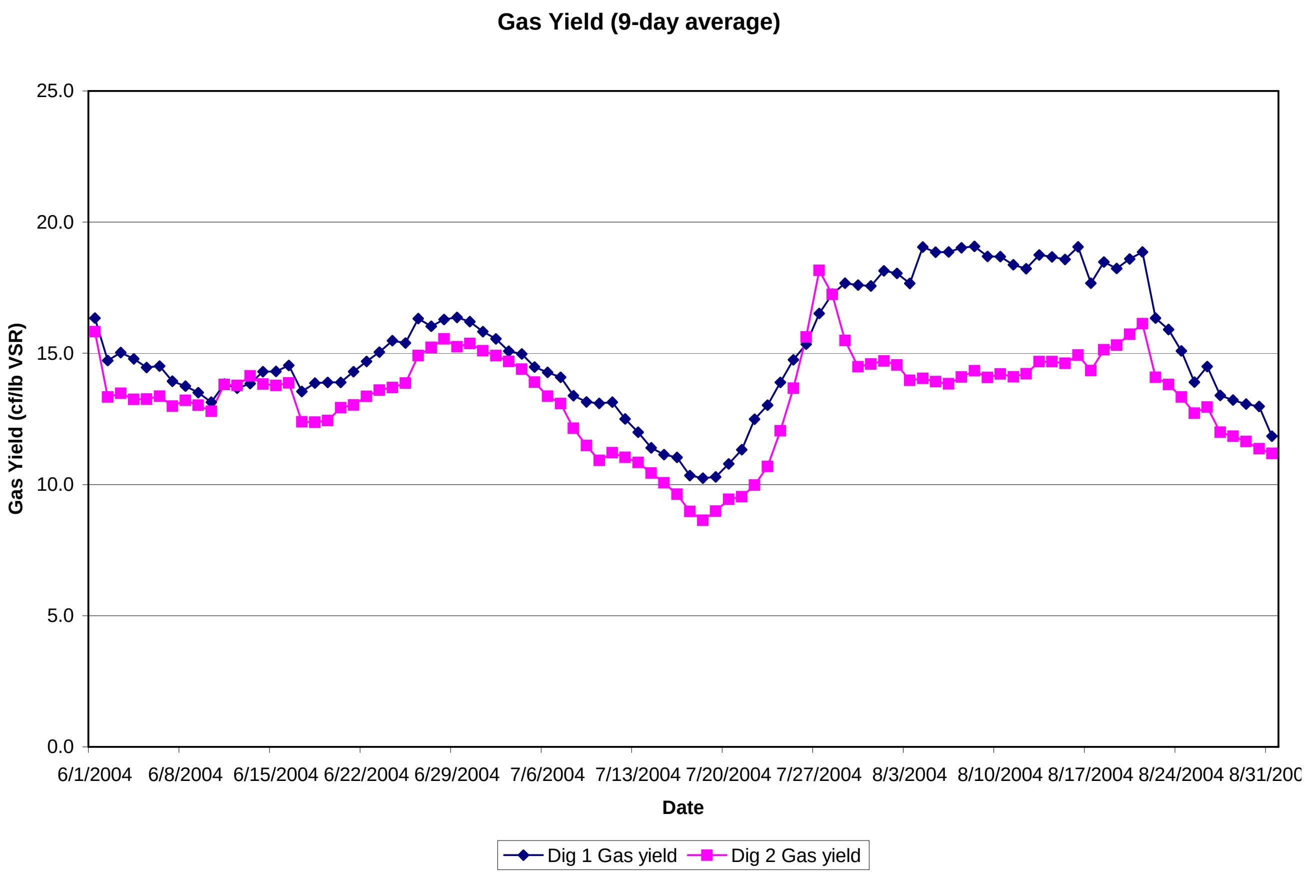


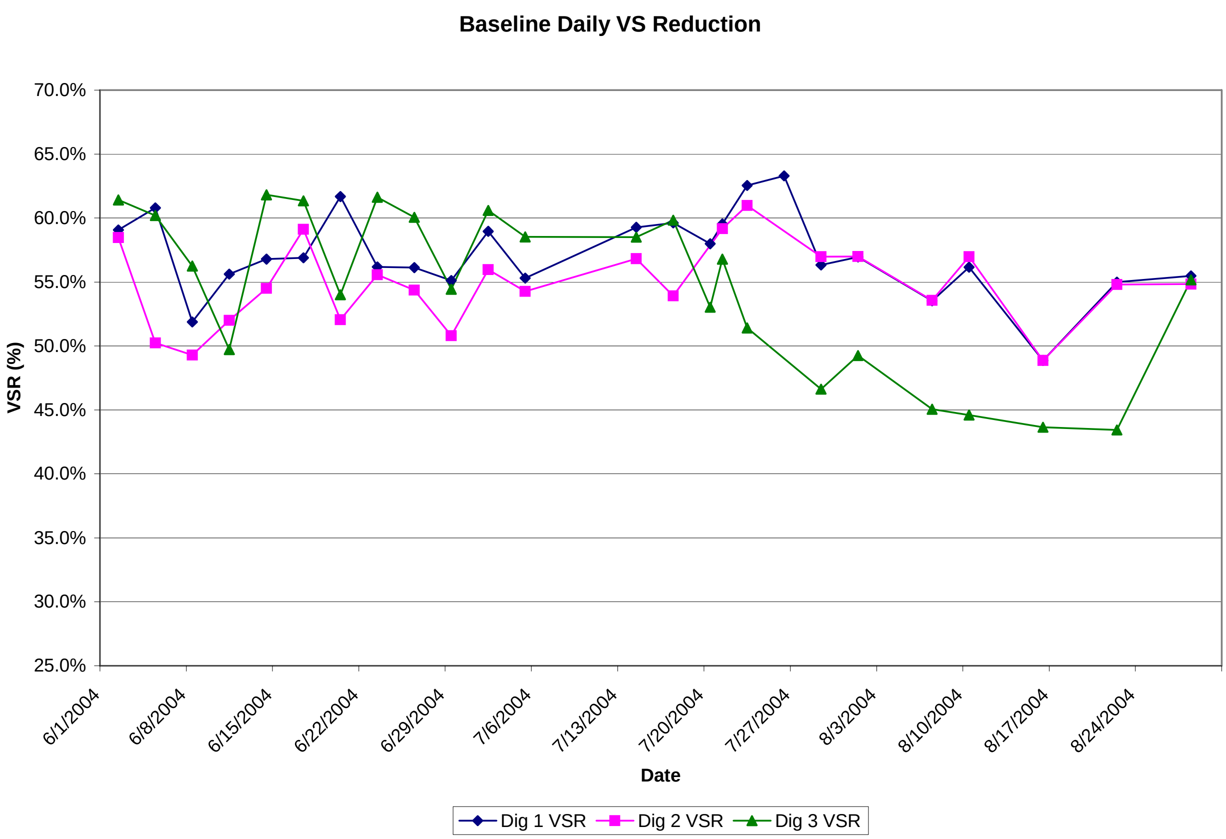
Figure 3-2 shows the gas yield for the baseline period. The gas yield for Digester 2 averaged 14.7 cf/lb VSR and for Digester 1 averaged 14.1 cf/lb VSR during the first month of the baseline period, a difference of four percent. This indicates that the baseline period averages for gas production performance were impacted by the length of time it took Digester 2 to recover from being over-fed in July. The data in Figure 3-2 show that, except for the period when Digester 2 was impacted by overfeeding, the gas yield for Digesters 1 and 2 were similar. However, there is still the difference in total gas and solids destruction between the two digesters, which would not be expected considering that the operational parameters of the digester are similar.

As described earlier, the gas meters on Digesters 1 and 2 were switched on August 4, to check whether inherent differences between the gas meters were impacting the recorded gas production. The change showed no difference. However, the tracer tests indicated that there may be significant differences between the two digesters in terms of dead space. Results showed that on Digester 1 with north side mixing in operation, the dead space was in the range of 7 to 13 percent (on the second test problems with the mixing pump may have increased the apparent dead space). In Digester 2 south and north side mixing showed 27 to 33 percent dead space. The results of the tracer tests suggest that the active volume in

Digester 2 was 23 percent less than that in Digester 1 and this in turn would mean that the actual HRT in Digester 2 was considerably shorter than in Digester 1. This would result in lower VSR and gas production in Digester 2. Tracer tests will need to be conducted again to confirm differences in digester dead volume since simultaneous north and south side mixing was commenced in mid July when Digester 2 became unstable.

3.2.2 Digester 3 Performance

FIGURE 3-3
Baseline Period Daily Average VS Reduction



Digester 3, is a smaller, older digester that was brought on line in April 2004 to reduce the load and increase the HRT in Digesters 1 and 2. Due to this fact and the differences in operational parameters discussed earlier, Digester 3 is not considered a direct control for comparison of the other two digesters. However, the trends in this digester will be used to compare performance trends and variations in the others. Figure 3-3 shows that the trend in VSR in Digester 3 is very similar to the trends in the other digesters. The drop in VSR in late July and the first part of August 2004 were largely due to changes in digester loadings described earlier. Therefore, increases in VSR or gas production that may be seen in Digester 1 and 2 during the ultrasound testing phase may be compared with trends in Digester 3 to determine whether the changes are a general trend, or may be attributed to the ultrasound equipment.

3.2.3 Dewatering Performance

The baseline period monthly average dewatering data were presented in Tables 2-4 through 2-6. Table 3-3 presents the summary for the baseline period.

TABLE 3-3
Summary of Baseline Dewatering Data

Parameter	Unit	Value	Parameter	Unit	Value
Dewatered Cake			**Filtrate**		
Quantity Produced	wtpd	165	Filtrate Flow	gpd	176,441
TS%	%	13.3%	Washwater Flow	gpd	81,376
VS% (as in the BFP feed)	%	65.8%	Drain[1] Solids (TS)	mg/l	631
Alkalinity	mg/kg	4,619	Drain[1] Ammonia	mg/l	543
Ammonia	mg/kg	43,807			
Cake NO_3	mg/kg	111			
Cake TKN	mg/kg	85,524			
BFP Operation					
Polymer	lb/ton	26			
Capture rate (assumed)	%	94%			
BFP 1 Operation	hr/d	12			
BFP 2 Operation	hr/d	11			

NA – data not collected
[1] Drain includes filtrate and washwater flows.

The dewatered cake monthly average was consistently around 13 percent. This is lower than typically expected range of 14 to 18 percent for a BFP dewatering digested sludge. The minimum cake solids concentration during the baseline period was 11.4 percent and the maximum achieved was 14.9 percent, while 90 percent of the samples were in the range of 12.1 to 14.2 percent. The ammonia concentrations in the BFP drain return to the plant also consistently averaged around the mid-500 mg/L. Ninety percent of the samples collected during the baseline period ranged between 247 and 693 mg/L. Polymer use averaged 26 lb/ton. This is slightly higher than typical digested biosolids BFP operations, where polymer use is typically in the range of 15 to 20 lbs/ton.

SECTION 4

Quality Assurance and Data Analysis Procedures

4.1 Quality Assurance Procedures

There are two important aspects with experimental quality assurance and control. The first is the assurance of good sample collection and shipping methods. The appropriate sample collection points and collection times were demonstrated to the plant operators. The samples were collected by the operators in appropriate bottles provided by the laboratory that was conducting the tests. For samples sent to an external laboratory, the sample bottles were stored on ice and shipped in coolers on the same day if possible, or before 10:00 a.m. the next morning for samples taken later in the day. When same day shipping is not possible (usually weekends and evenings), the sample bottles were preserved, stored (usually at 4°C) and shipped the next morning to ensure that the appropriate procedures and holding times are met, as specified by the analytical laboratory.

The second aspect lies with the laboratory's procedures and QA/QC methods. As the laboratory analysis were conducted by the Plant's certified laboratory or by an external certified laboratory, the laboratory staff should be familiar with standard sample storage, analysis and QA/QC procedures. When immediate analysis is not possible (usually weekends and nights), the sample bottles are preserved, stored (usually at 4°C) and delivered to and analyzed in accordance with appropriate procedures and holding times, as specified by the analytical laboratory. Replicate samples and split sample analysis are conducted occasionally to verify reliability of results.

4.2 Data QA/QC and Analysis Procedures

In addition to the QA/QC of the sample preparation and laboratory analysis procedures, QA/QC and data analysis of the collected data are critical to obtain a representation of the digester performance. A detailed procedure was developed to analyze the extracted data during the testing phases. This included development of a daily log sheet for recording operational parameters of the digesters and ultrasound units. Information from the log sheets is in a format that can be easily input into an Excel spreadsheet. On-line data collected by the plant, such as flow rates, and laboratory data are input into Excel spreadsheets. Data analysis consists primarily of monitoring trends in digester performance (volatile solids reduction, biogas production - quality and quantity) using daily data, as well as moving averages to provide long term trends. In addition to the digester performance, the dewaterability of the biosolids is documented and the energy demand of the ultrasound system will be documented. Data are and will be updated and reviewed at least every two weeks, as the laboratory analysis data becomes available. Another excel spreadsheet will be also created with the raw data and the calculations to determine the operational cost for each ultrasound pilot system.

Part of the QA.QC procedure consists of conducting checks within the data to insure that that data are internally consistent. This is particularly important for tracking flows to the digesters, which are recorded as an algorithm based on the primary sludge or TWAS flow meters and the time that a valve is open to each digester. A check sheet has been developed that cross-checks the sum of primary sludge and TWAS flows to the digesters with the flows recorded on the primary sludge and TWAS flow meters. Data that show inconsistencies are noted and checked with the daily operator log book and with information recorded manually by the operators. This was particularly critical on July 9^{th} and 10^{th} 2004 when problems occurred with the TWAS valve feeding digester 2. The valve remained open, although the feeding program was recording flows to all three digesters in their normal feed rotation. The operators noted the duration of the problem in the log book and the data were corrected by obtaining the minute-flow data recorded on the main TWAS meter and calculating the flow for the period that the Digester 2 TWAS valve had remained open. On dates when the flows to the digesters are more than 10 percent different from the primary sludge or TWAS flows, minute flow and valve opening times are obtained from the SCADA system. The digester data are corrected based on the recorded feed valve opening times for each digester and the primary sludge or TWAS flows recorded on the main flow meters.

SECTION 5

Next Phase - Ultrasound Test

In the next phase of test, the ultrasound phase, the testing for the baseline phase will be continued. Daily operational check sheets will be completed by the City of Riverside operations staff to monitor the ultrasound equipment. Equipment parameters recorded on the check sheets will include:

- Electricity used by each ultrasound system;
- Daily recording of line pressure in and out of the ultrasound systems;
- Number of units operational;
- Power draw for each unit; and
- Flow rate through each ultrasound system

A sample log sheet is included in Appendix C. In addition, another set of tracer tests will be conducted part way through the ultrasound test phase. Periodically, samples will be taken before and after the ultrasound units and analyzed for chemical oxygen demand (COD) and soluble COD. Sludge samples will also be examined under a microscope for floc and filament structure.

Appendix A

Trend Data for Key Parameters

Appendix B
Tracer Test Results

Appendix C

Daily Check List for Ultrasound Phase Test