Class A Biosolids

Hyperion Treatment Plant (Phase I)

Wastewater Eng. Services Division (Applied Research)

Hyperion Treatment Plant

Terminal Island Treatment Plant

Environmental Monitoring Division

Regulatory Affairs Division

Environmental Engineering Division

Human Resources Development Division

City of Los Angeles
Bureaus of Sanitation and Engineering

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EXECUTIVE SUMMARY

The City of Los Angeles, Bureau of Sanitation has applied its biosolids to agricultural fields in compliance with United States Environmental Protection Agency (U. S. EPA) regulations since 1988. The biosolids are created by mesophilic digestion of the sewage sludge generated at its wastewater treatment plants. Mesophilically digested sewage sludge meets U. S. EPA Class B standards for pathogens and can be safely recycled. However, adverse public perception of this practice has influenced many local jurisdictions into enacting ordinances to phase out or ban the practice. Kern County passed such an ordinance in late 1999 to phase out Class B after December 31, 2002. It is for this reason that the Bureau decided to investigate the possibility of creating Class A biosolids at its treatment plants.

The highest quality of biosolids is called Exceptional Quality (EQ). In order to qualify for this classification, biosolids must comply with three criteria; low metal concentration limits (Table 3 of 40 Code of Federal Regulation 503.13), a vector attraction reduction requirement (40 CFR 503.33) and the Class A pathogen density reduction requirement (40 CFR 503.32). The City already meets the first two requirements. Thus, the main challenge to produce EQ biosolids is to ensure that the Class A pathogen density reduction requirement is met. In July 2001, Bureau of Sanitation management directed the staff to perform full-scale studies to produce EQ biosolids by forming a Class A certification task force with staff from several Bureau Divisions to conduct and oversee this effort. The objective of this study (Phase I) was to establish a two-stage thermophilic batch process at the Hyperion Treatment Plant (HTP) that would satisfy the requirements for Class A biosolids as indicated by U. S. EPA 40 CFR Part 503, Subsection 32 Alternative 1, time-temperature regimen. The biosolids regulations are briefly discussed in Appendix 7.1

This interim report covers full-scale studies conducted in Phase I during October and November, 2001, and is presented in seven sections; Introduction, Methods, Results, Conclusions, Recommendations, Supporting studies, and Appendices. This report is a contribution to the following goals of the task force:

A. Implementation of protocols to work with strict attention to Quality Control/Quality Assurance (QC/QA) methods (Section 2) during:
    1. Operational procedures to implement a two-stage thermophilic digestion process.
    2. Sampling procedures for digested sludge and wet cake throughout the post-digestion train for microbial studies.
    3. Microbial analysis procedures of samples.
B. Preparation of a report presenting the results, conclusions, and recommendations for the studies on *Salmonella* (pathogen) and fecal coliform (indicator) densities (Sections 3, 4, 5).
C. Additional studies to define the biosolids temperature profile, and to evaluate contamination/regrowth issues throughout the post-digestion train (Section 6).
D. Organizing and presenting the information for U. S. EPA review and comments for future directions.

RESULTS

Process implementation: Digester battery D1 consisting of 6 digesters is currently being operated under thermophilic conditions at HTP. Four digesters (1D1, 2D1, 3D1, 4D1) were operated at 136°F (average) with a residence time of 13 days (stage 1). Sludge from stage 1 was transferred to one or the other of the two remaining batch digesters (5D1 or 6D1) at 130°F (average) for an additional holding time of 13 hrs (stage 2). The post-digestion train was entirely dedicated to the biosolids produced by thermophilic digestion.

Pathogen/indicator densities: Average *Salmonella* densities present in the digester inflow were 9.7 and 2.5 MPN/4 dry gram in primary sludge and thickened waste activated sludge (TWAS) respectively. Average *Salmonella* density in the digester outflow was <1.6 MPN/4 dry gram. In addition, average *Salmonella* densities measured at the other two post-digestion sampling locations, immediately after centrifuge and in the truck loading facility, were <1.2 and < 1.4 MPN/4 dry gram respectively.

Average fecal coliform densities in the digester inflow were 9.7×10^7 and 1.5×10^7 MPN/dry gram in the primary sludge and TWAS respectively. Fecal coliform average density in the digester outflow was around 10^2 MPN/ dry gram. Fecal coliform densities remained around 10^2 MPN/ dry gram or below at all of the post-digestion sampling locations except at the truck loading facility, where fecal coliform densities in the magnitude of 10^5 MPN/ dry gram were observed.

Contamination/regrowth and temperature profile studies: Very low fecal coliform densities ($<10^1$ MPN/dry gram) were observed in wet cake samples obtained at the centrifuge outlet and they remained at the same level at room temperature even after approximately 400 hrs. High counts of the fecal coliform were measured in samples obtained at the truck loading facility ($>10^6$ MPN/dry gram) and they increased up to 10^8 MPN/dry gram at room temperature.

Low fecal coliform density (<20 MPN/dry gram) was measured in the HPE used to help wetcake slip within the pipes after centrifuge.

Very low fecal coliform densities ($<10^1$ MPN/dry gram) were measured in laboratory-centrifuged digested sludge samples and they increased to approximately <250 MPN/dry gram at 25, 37, or 44.5 °C after approximately 72 - 96 hrs. A similar trend was observed in the fecal coliform counts in laboratory-centrifuged digested sludge amended with high-pressure effluent (HPE), polymer-type coagulant, or both. At 55 °C, low fecal coliform counts ($<10^1$ MPN/dry gram) did not increase in laboratory-centrifuged digested sludge with all combinations of HPE and polymer.

The drop in temperature between the digester outlet and the centrifuge was 1.9 °F. A larger drop in temperature was observed between the centrifuge and the silo at the truck loading facility (12.2 °F)

CONCLUSIONS

1. Pathogen/indicator densities measured in the inflow and outflow of the digester demonstrated that the two-stage thermophilic process effectively reduced *Salmonella* (pathogen) and fecal coliform (indicator) densities to levels below the Class A federal standard, 40 CFR Part 503.32.
2. Additional testing along the thermophilic post-digestion train showed that *Salmonella* (pathogen) densities remained below the Class A limit at all the sampling locations.
3. Additional testing along the thermophilic post-digestion train showed that fecal coliform (indicator organisms) densities were well below the Class A limit at all of the sampling locations, except at the truck loading facility. However, the high numbers of these indicator organisms are not an indication of high number of pathogens, because the *Salmonella* (pathogen) densities measured at the truck were below the Class A limit.
4. Fecal coliform regrowth or contamination occurred between the centrifuge outlet and the silo at the truck loading facility. A preliminary profile of the biosolids temperature throughout the post-digestion train showed a major drop between the same locations. This temperature drop probably has facilitated the regrowth/ contamination problem between those locations.
5. Based on preliminary tests, HPE and polymer were not found to be significant sources of contamination. The regrowth/contamination issues are being further investigated in Phase II, as described in section 5.

RECOMMENDATIONS

Short Term: A longer and more comprehensive full-scale thermophilic testing at HTP was recommended (Phase II). It was initiated on February 25, 2002 and will last for a 4-week period. *Salmonella* and fecal coliform densities will be evaluated throughout the complete process, that is, from the digester inflow to the farm where biosolids are applied. This study will allow a better understanding of the bacterial behavior during the thermophilic digestion process, storage in the silo, and application at the farm. Additional efforts are being implemented in order to supply enough steam to maintain the Alternative 1 time-temperature requirement. Also, more stringent procedures for cleaning the pipelines of the post-digestion train and for isolating the thermophilic from the mesophilic train are being implemented. Details on the Phase II study are described in Section 5.

Long Term: Recommended activities related with the design, modification, and construction of existing facilities to accommodate two-stage thermophilic digestion to obtain EQ biosolids are described in Section 5.

1. INTRODUCTION

One of the main goals of the City's Environmental Management System for its biosolid program is to produce biosolids of Exceptional Quality (EQ). To qualify as EQ, biosolids must meet three criteria: low metal concentration limits (Table 3 of 40 Code of Federal Regulation 503.13), a vector attraction reduction requirement (40 CFR 503.33) and a pathogen density reduction requirement (40 CFR 503.32). Historical data indicate that the metal concentrations in the biosolids are also below the required limits in Table 3 of 40 CFR 503.13. The vector attraction requirement is satisfied when volatile solid (VS) reduction is at least 38%. Routine performance of the Hyperion Treatment Plant's (HTP) digester process (mesophilic and thermophilic) has consistently demonstrated a 50% or greater VS reduction. Since the City meets these two requirements, the main challenge to get EQ biosolids is to ensure that the pathogen density reduction requirement is met. Thus, the Bureau of Sanitation's management has directed the HTP staff to perform full-scale studies to produce EQ Biosolids.

The 40 CFR Part 503.32 pathogen reduction alternatives ensure that pathogen levels in biosolids are reduced to levels considered safe for the biosolids to be land applied or surface disposed. Pathogen requirements for Class A biosolids have to be met when the biosolids are prepared to meet the requirements for EQ biosolids. Pathogen requirements for all the alternatives for Class A biosolids in the Part 503.32 rule establish that **either** the density of *Salmonella* bacteria in the biosolids must be less than 3 MPN/4 dry grams **or** the density of fecal coliform in the biosolids must be less than 1000 MPN/ dry gram.

The Part 503.32 regulation lists six alternatives for treating biosolids so they can be classified as Class A. Alternative 1 specifies that biosolids must be subjected to one of four time-temperature regimes. Thermophilic digestion has been selected to disinfect the City's biosolids. Experiments on two-stage thermophilic digestion have been conducted at HTP using a module consisting of 6 digesters (battery D1), that have been operated under thermophilic conditions. Steps were taken to isolate the thermophilic module from the remaining 12 digesters operated under mesophilic conditions. Four of the six thermophilic digesters (1D1 to 4D1) in battery D1 were operated at residence time of 13 days (stage 1). Sludge from these digesters was transferred to one or the other of the remaining two digesters (5D1 or 6D1) for an additional holding time of 13 hrs at a target temperature of 135 ^{o}F to meet the time-temperature requirement of Alternative 1 (stage 2). The post-digestion train, from the outlet of digesters to the silo, was decontaminated of mesophilic sludge. Digested sludge was continuously dewatered in a centrifuge that was dedicated to the thermophilic process.

A task force was formed to oversee the effort. The task force is comprised of personnel from various divisions within the Bureau of Sanitation (HTP staff, Applied Research of Wastewater Engineering Division, Environmental Monitoring Division, Human Resources Development Division, Regulatory Affairs Division), Environmental Engineering Division of Bureau of Engineering and consultants. Task force members have participated in weekly meetings to discuss progress in producing Class A EQ

biosolids. Activities of the task force are being monitored by Bureau of Sanitation Management and discussed at monthly biosolids meetings (REBOC).

This interim report focuses on the results of sampling and testing conducted in October and November, 2001. Samples from various points of the two-stage thermophilic batch process train were taken and analyzed. More specifically, densities of *Salmonella* (pathogen) and fecal coliform (indicator) were analyzed in the digester inflow and compared to the post-digestion counts in order to illustrate the effectiveness of pathogen reduction by thermophilic digestion. Both microbial indicators were analyzed throughout the post-digestion process at five different locations, including the truck loading location, which represents the last point of control at the treatment plant. The study was conducted with attention to Quality Assurance/Quality Control (QA/QC) procedures in all aspects of thermophilic operations, field testing, laboratory procedures, data collection, and analysis.

The specific objectives for this study were:

1. Establish a two-stage thermophilic batch process at HTP that satisfies the requirements for Class A Biosolids as indicated by USEPA 40 CFR Part 503, Subsection 32 Alternative 1, time-temperature regimen.
    1.1. Conduct field inspections at HTP to:
        1.1.1. Identify potential sources of contamination and define procedures that help prevent them.
        1.1.2. Define procedures to secure complete isolation of the thermophilic train from the mesophilic train.
    1.2. Implement a two-stage thermophilic process with four digesters operated under thermophilic digestion conditions (stage 1) at a temperature high enough to maintain the other two digesters (stage 2) at a target temperature of 135°C.
    1.3. Evaluate the pathogen/indicator densities in the biosolids to evaluate the effectiveness of disinfection.
        1.3.1. Sample biosolids at the following locations:
            1.3.1.1. Inflow and outflow of digesters to evaluate the efficiency of the pathogen/indicator removal during the thermophilic digestion process.
            1.3.1.2. Throughout the post-digestion train, that is, after digestion, after dewatering, at storage, and at the truck to define how *Salmonella* (pathogen) densities vary with respect to fecal coliform (indicator) densities.
            1.3.1.3. Follow EPA approved methods (Section 2) in all analysis and sampling operations (collection of samples, sampling schedule, sampling containers, etc.).
        1.3.2. Analyze *Salmonella* (pathogen) densities in biosolids samples to evaluate compliance with EPA standards for pathogen removal.
        1.3.3. Analyze fecal coliform (indicator) densities in biosolids samples to define if there is a correlation between both bacterial criteria.

2. Perform supporting studies as discussed in Section 6, addressing bacterial contamination or regrowth problems in order to investigate potential solutions.
3. Propose additional studies as discussed in Recommendations (Section 5) to address problems that arise from the activities previously described.
4. Compile all data to support EPA requirements for Class A biosolids.

2. MATERIAL AND METHODS

2.1 Operational Procedures

2.1.1 Process description

To produce Class A Biosolids at Hyperion Treatment Plant (HTP), a two-stage, thermophilic digestion process, incorporating a batch pathogen reduction function, was employed by using six egg shaped digesters (1D1 through 6D1) in battery D1. Figure 1 shows schematic diagram of thermophilic operation. Each digester has a capacity of approximately 2.5 x 10^6 gallons with an internal draft-tube mixing system. 400 gallons per minute (GPM) of Primary Sludge (PS) and 100 GPM of Thickened Waste Activated Sludge (TWAS) at about 70 °F were fed to four first stage digesters (1D1 to 4D1) through Flow Indicating Control valve. The mixture of PS and TWAS in the first stage digesters was heated by steam and digested thermophilically at about 135 °F for average detention time of 13 days. Steam flow to each digester is regulated by a Flow Indicating Controller (FIC). The FIC set point is automatically adjusted by Temperature Indicating Controller (TIC) that utilizes the average of two thermocouples installed in the digester to measure the temperature of the digester so that the temperature is maintained at its set point.

The digested sludge from the first stage digesters was then pumped into one of the second stage batch digesters (5D1 or 6D1). Once the batch digester was filled up in 62 hours and the content was held for 13 hours, the pump subsequent to the first stage digesters was switched to fill the other second stage batch digester until it was filled. The two Secondary Digesters are operated on a 62-hour fill, 13-hour hold, and 75-hour withdraw cycle. Figure 2 shows the interrelation of the two batch digesters operating on this cycle.

The batched sludge was then pumped to the Digester Screening Facility (DSF). Hair, fibers, rags, grits, and other impurities that may cause plugging were screened prior to the dewatering facility. Screened sludge then flowed by gravity to a wetwell where it received diluted polymer solution. The sludge and the polymer solution were mixed through an in-line static mixer. The mixture was fed to the dewatering centrifuge. The wetcake from the centrifuge with a total solids of approximately 28 percent, was then pumped into the Wetcake Storage and Truck Loading facility.

2.1.2 Time-temperature batch operations

Temperatures for each digester and their daily averages were automatically recorded and calculated during the two-stage thermophilic digestion testing. Steam injections were provided only to the first stage digesters (1D1 through 4D1) due to the following reasons:

a. All the new egg-shaped digesters were designed to operate under constant tank liquid level.
b. The resistance temperature probes, which measure the digester temperature and provide the steam controller set point, were installed at the upper level of each digester.

c. The digester mixing devices (the draft tubes) were built-in with interlock functions, which were tied-to the digester level.
d. The insulation for the digesters were well designed and constructed to minimize heat loss.
e. The batch digesters 5D1 and 6D1 levels were not constant (except during the 13 hours of holding) during feeding and discharging periods.

Therefore, steam injection heating was not employed for the second stage digesters 5D1 and 6D1. Consequently their temperatures were 4 to 7 degrees lower than the first stage digesters (Table 1). During initial testing (from October 1 to October 4), while first stage digester temperatures were set at 130 to 131°F, the second stage batch digesters showed temperatures of about 126 to 128°F. Subsequently, the temperature set points for first stage digesters were gradually increase to about 141°F resulting in second stage digester temperatures of about 133°F.

2.1.3 Operational Instructions

Detailed instructions were given to the wastewater treatment plant operators. A copy of the instructions is contained in Appendix 7.2.

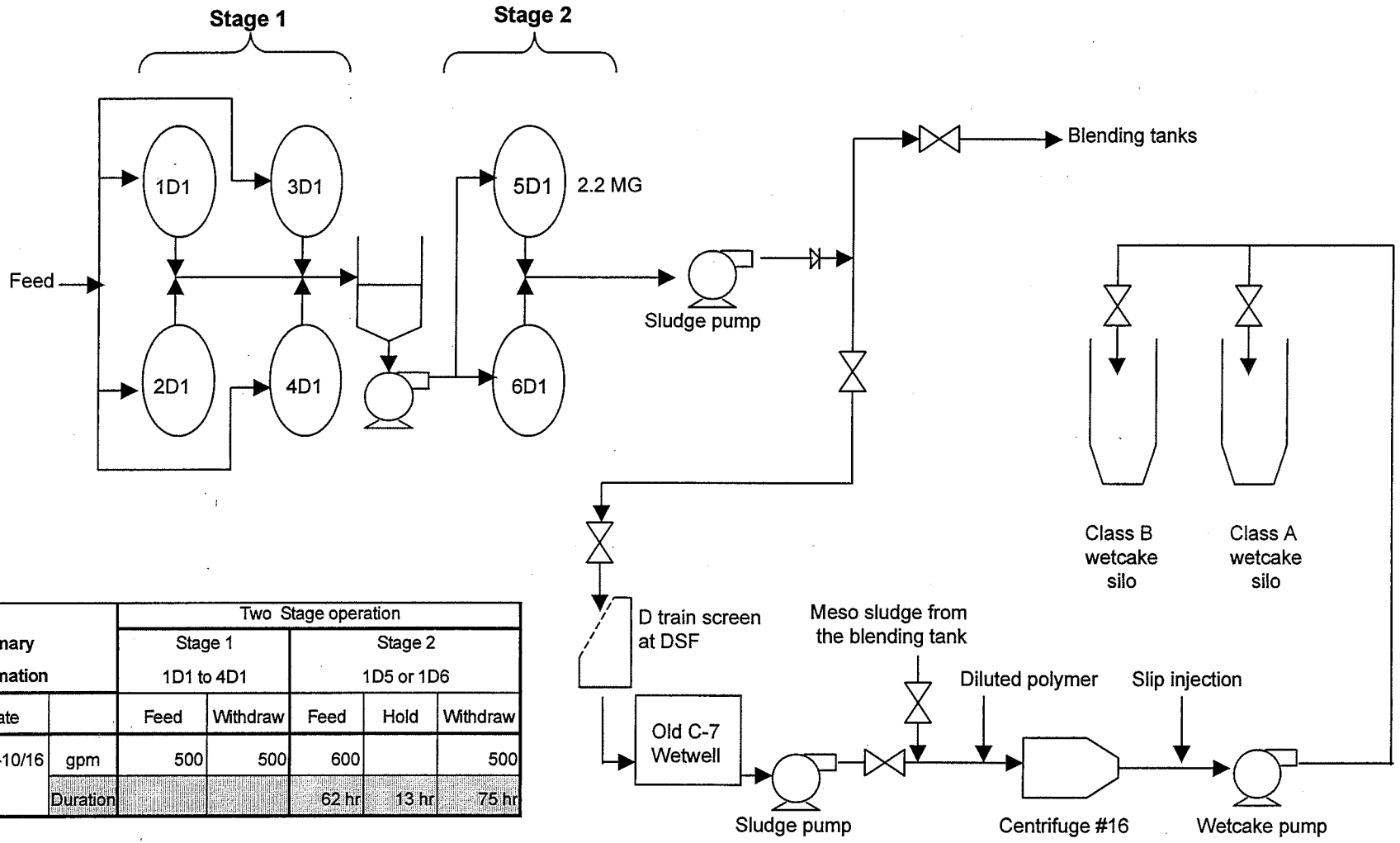
2.1.4 Quality Assurance/Quality Control (QA/QC)

The following items are operational protocols implemented to ensure no cross contamination for the thermophilic train during the October 2001 experiments:

a. The Digester Section Personnel used HPE (High Pressure Effluent) as a flush source from "D Battery Digesters" through the digester cleaning line to DSF (Digester Screening Facility) "Train D". The HPE flowed by gravity to the Dewatering Facility C-7 wetwell. As the water level rose, all surface-floating contaminants eventually overflowed into the HIPS (Hyperion In Plant Sewer). After the surface contaminants were alleviated, the C-7 wetwell HPE was routed through sludge pumps 3,4, and 7. Each pump alternately displaced HPE through the sludge line to Centrifuge 16. All accumulated mesophilic contaminants between the C-7 wetwell and Centrifuge 16 were discharged through the centrate line.
b. In addition to the previous flushing, the C-7 wetwell also received an independent cleansing. During this procedure, the wetwell was first emptied. HPE was applied with a 1" nozzle hose. The interior walls were jetted with HPE thoroughly removing all residual contaminants. A 2" hose discharged HPE into the wetwell. A "fill and draw" took place as sludge pump 4 pumped from the wetwell discharging into the HIPS (Hyperion In Plant Sewer).
c. The Truck Loading Facility Silo 6 received an independent hosing. After the silo was completely relieved of biosolids, the four discharge knife gates were opened. HPE was jetted from the top of the silo through an access hatch. The interior surface area was completely hosed removing all residual contaminants.
d. Due to the fact that Schwing Pump 1 had a pumping efficiency problem, the rams and poppet valves were replaced. In the process, a thorough flush of the interior pump was achieved removing all the wetcake contaminants.

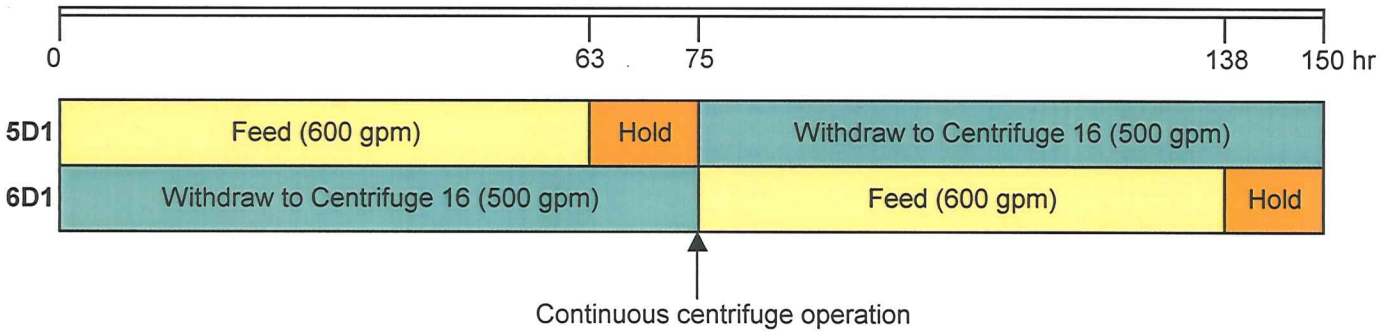
e. A CIP (Clean In Place) of Centrifuge 16 was achieved. A CIP is a flushing procedure that alternates scroll rotation in forward and reverse motion. HPE is applied through the feed line removing all buildup of wetcake within the interior portion of the machine.
f. An "Operation Clearance" was in place on all valves in order to separate the mesophilic operation from the thermophilic operation.
g. During the day of start-up, the first four hours of thermophilic biosolids were purged to silos 5 and 7 prior to filling silo 6. The purpose of this was to remove all mesophilic wetcake to silos 5 and 7. After all mesophilic wetcake was purged, silo #6 was fed.
h. The thermophilic biosolids production was a 24-hour operation.
i. Exam gloves were used for grabbing samples. Before use of sampling tools, alcohol solution was applied to disinfect.

Figure 1. Schematic diagram for D1 battery thermophilic operation



Summary Information		Two Stage operation				
		Stage 1 1D1 to 4D1		Stage 2 1D5 or 1D6		
Date		Feed	Withdraw	Feed	Hold	Withdraw
10/4 -10/16	gpm	500	500	600		500
	Duration			62 hr	13 hr	75 hr

Figure 2. Fill, hold, withdraw cycle for batch operation (Stage 2)



Average temperature for 5D1 between 10/4/01 and 10/16/01 = 129.8 ± 3.3
Average temperature for 6D1 between 10/4/01 and 10/16/01 = 130.1 ± 1.6

Table 1. Digester temperatures during thermophilic operation

Date	Temperature, °F					
	Digestion operation (Stage 1)				Batch operation (Stage 2)	
	1D1	2D1	3D1	4D1	5D1	6D1
10/4/01	131	131	133	130	126	NA
10/4/01	134	135	133	135	126	129
10/5/01	136	136	132	135	126	129
10/6/01	137	136	136	136	NA	129
10/7/01	137	137	136	136	NA	129
10/9/01	137	137	136	135	130	NA
10/10/01	137	137	135	135	132	NA
10/11/01	136	136	136	136	131	131
10/15/01	140	140	139	141	134	131
10/16/01	141	141	141	141	133	133
Average	136.6	136.6	135.7	136.0	129.8	130.1
Standard deviation	2.8	2.7	2.8	3.2	3.3	1.6

Notes

NA: Not Available

2.2 Sampling Procedures

2.2.1 Digester inflow sampling protocols

Table 2 shows schedule of digester inflow sample collection. Samples were collected over a period of four weeks. Similar sampling procedures were followed as in Section 2.2.2

2.2.2 Post-digestion sampling protocols

Table 3 shows schedule for post-digestion sample collection. All sample locations are shown in Figure 3. Samples were collected from five different locations at HTP. The locations are (1) digested sludge immediately after digester, (1a) digested sludge after sludge pump (after wetwell), (2) digested sludge at centrifuge inlet, (3) centrifuge wetcake, (4) wet cake at hopper discharge (hopper wet cake).

All samples collected were grab or composite samples. All sample containers were cleaned and sterilized. Sample containers remain sealed until collection time. New sterile gloves were used for every specimen. QA/QC procedures were complied with during sample collection. Specific activities at each site were as follows:

(1) From sampling location after digester **(digested sludge)**
- Take one sludge sample for salmonella analysis in two 1000-ml sample bottles.
- Take one sludge sample for fecal coliform analysis in one plastic sample bag.
- Take one sludge sample for total solids analysis in two plastic sample bags.

(1a) From sampling location after sludge pump
- Take one sludge sample for fecal coliform analysis in one plastic sample bag.
- Take one sludge sample for total solids analysis in one plastic sample bag.

(2) From sampling location before centrifuge inlet
- Take one sludge sample for fecal coliform analysis in one plastic sample bag.
- Take one sludge sample for total solids analysis in one plastic sample bag.

(3) From sampling location after centrifuge **(centrifuge wetcake)**
- Take one sludge sample for salmonella analysis in one 1000-ml sample bottles.
- Take one sludge sample for fecal coliform analysis in one plastic sample bag.
- Take one sludge sample for total solids analysis in one plastic sample bags.

(4) From sampling location at wetcake hopper discharge **(hopper wet cake)**
- Take one sludge sample for salmonella analysis in one 1000-ml sample bottles.
- Take one sludge sample for fecal coliform analysis in one plastic sample bag.
- Take one sludge sample for total solids analysis in one plastic sample bags.

Total number of sample bottles: four

Total number of sample bags: eleven

Samples were taken between 12:30 and 1:30 PM and delivered to HTP lab no later than 1:30 on same day with clear labels on each sample showing date, time and location.

2.2.3 Quality Assurance/Quality Control (QA/QC)

2.2.3.1 Sample collection: Before use, scoops, shovels and augers were thoroughly washed with soap and water, allowed to air dry, and rinsed with sterile water prior to disinfection by 70% ethanol solution. Sample bottles and whirl-pak bags were autoclaved.

2.2.3.2 Sample preservation: Following measures were implemented to assure sample preservation

a. If sample analysis was to begin within 1 hour following collection, no refrigeration was needed.
b. If sample analysis was to begin within 1 to 6 hours following collection, sample were brought to the laboratory in an ice chest cooled to at least 10 ^{0}C or lower.
c. If sample analysis was to begin within 6 to 24 hours following collection, sample were brought to the laboratory in an ice chest cooled to 10 ^{0}C or lower, and immediately refrigerated in laboratory at 1 to 4 ^{0}C.

Photographs of staff performing the various sampling procedures are presented in Appendix 7.5

Table 2. Sampling schedule for digester inflow

		Week 1			Week 2			Week 3		Week 4			Type of container
Sample	Analysis	11/6 Tue	11/7 Wed	11/8 Thu	11/13 Tue	11/14 Wed	11/15 Thu	11/19 Mon	11/20 Tue	11/26 Mon	11/27 Tue	11/28 Wed	
TWAS	Fecal coliform	S	S	S	NS	NS	NS	NS	NS	NS	NS	NS	One sterile 500ml bottle
	Salmonella	NS	NS	S	S	S	S	S	S	S	S	S	Two sterile 1000 ml bottles
	%TS	S	S	S	S	S	S	S	S	S	S	S	Two plastic sample bag
Primary sludge	Fecal coliform	S	S	S	NS	NS	NS	NS	NS	NS	NS	NS	One sterile 500ml bottle
	Salmonella	NS	NS	S	S	S	S	S	S	S	S	S	Two sterile 1000 ml bottles
	%TS	S	S	S	S	S	S	S	S	S	S	S	Two plastic sample bag
Digested sludge	Salmonella	NS	NS	NS	S	S	S	S	S	S	S	S	Two sterile 1000 ml bottles
	%TS	NS	NS	NS	S	S	S	S	S	S	S	S	One plastic sample bag

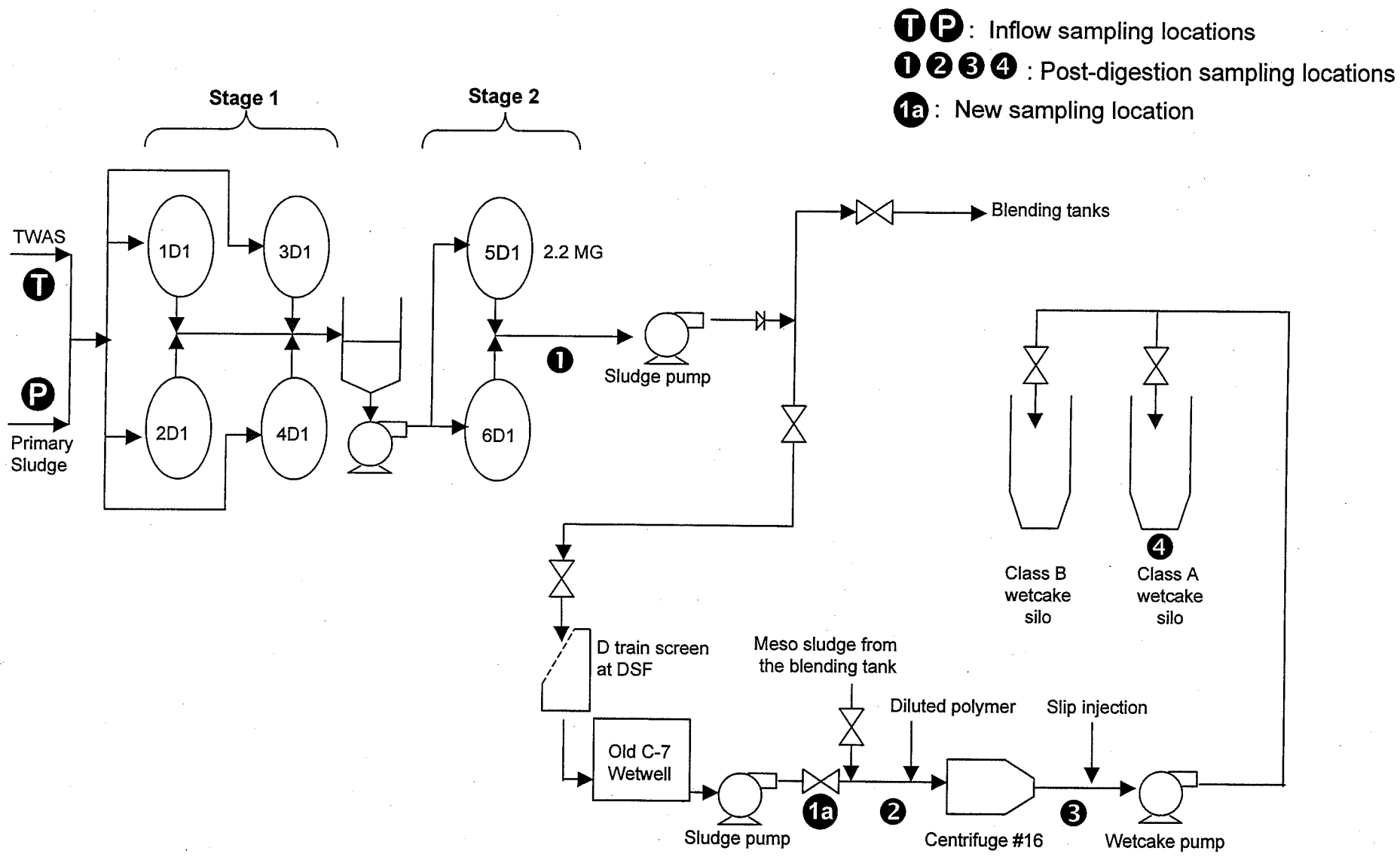
Notes
S: Sample
NS: No Sample
TWAS: Thickened wastewater activated sludge
%TS: Percentage of total solid

Table 3. Sampling schedule for post-digestion train

Location	Analysis	10/5 Fri	10/6 Sat	10/7 Sun	10/8 Mon	10/9 Tue	10/10 Wed	10/11 Thur	10/12 Fri	10/15 Mon	10/16 Tue	Type of container
Location 1	Fecal coliform	S	S	S	S	S	S	S	S	S	S	One plastic sample bag
	Salmonella	NS	NS	NS	NS	S	S	S	NS	S	S	Two sterile 1000 ml bottles
	%TS	S	S	S	S	S	S	S	S	S	S	Two plastic sample bag
Location 1a	Fecal coliform	S	S	S	S	S	S	S	S	S	S	One plastic sample bag
	Salmonella	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	One sterile 1000 ml bottles
	%TS	S	S	S	S	S	S	S	S	S	S	One plastic sample bag
Location 2	Fecal coliform	S	S	S	S	S	S	S	S	S	S	One plastic sample bag
	Salmonella	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	One sterile 1000 ml bottles
	%TS	S	S	S	S	S	S	S	S	S	S	One plastic sample bag
Location 3	Fecal coliform	S	S	S	S	S	S	S	S	S	S	One plastic sample bag
	Salmonella	NS	NS	NS	NS	S	S	S	NS	S	S	One sterile 1000 ml bottles
	%TS	S	S	S	S	S	S	S	S	S	S	One plastic sample bag
Location 4	Fecal coliform	S	S	S	S	S	S	S	S	S	S	One plastic sample bag
	Salmonella	NS	NS	NS	NS	S	S	S	NS	S	S	One sterile 1000 ml bottles
	%TS	S	S	S	S	S	S	S	S	S	S	One plastic sample bag

Notes
S: Sample
NS: No Sample
%TS: Percentage of total solid

Figure 3. Schematic diagram for sampling during thermophilic operation



2.3 Analytical Methods

The methods for *Salmonella* and fecal coliform analysis are listed in "Standards for the Use and Disposal of Sewage Sludge", 40 CFR Part 503.

2.3.1 Salmonella analysis (Part 9260-D, Standard Methods, 18th Ed.)

2.3.1.1 Liquid samples (percent solids: <4 %; TWAS, primary sludge & digested sludge)

a. Shake sample to mix
b. Using a sterile 100 mL graduated cylinder dispense 100 mL of sample into each of 5 flasks containing 100 mL of double-strength Sulfa enriched Selenite Brilliant Green broth (2X SBG) for samples with suspected low concentrations of *Salmonella.*
c. Using a sterile 10 mL pipette dispense 10 mL of sample into each of 5 tubes containing 10 mL of 2X SBG media
d. Using a sterile 1 mL pipette dispense 1 mL of sample into each of 5 tubes containing 1X SBG and 1 mL of sample into a sterile 9 mL buffer dilution tube. (Do a serial dilution to desired concentration)
e. Using a sterile 10 mL pipet, dispense 1 mL of each dilution into each of 5 tubes of media
f. Incubate at 37$\pm$ 0.5 ^{0}C. Read tubes at 20 - 24 hrs.
g. Using a sterile cotton-tipped swab, transfer presumed positive tubes to XLT4 and mLIA plates. Incubate at 37$\pm$ 0.5 ^{0}C for 20 – 24 hrs.
h. For XLT4 and mLIA plates showing typical *Salmonella* colonies, transfer them to BioMerieux' Vitek for confirmation.
i. Calculate *Salmonella* concentration using MPN table.

2.3.1.2 Solid samples (percent solids: >5 %; wet cake from centrifuge, silo, truck and farm)

a. In sterile blender, add 270 mL of sterile Tween 80/buffer to 30 gm of sample
b. Mix/blend for one minute
c. Repeat Steps a –h for liquid samples given above

2.3.2 Fecal coliform analysis (Part 9221-E, Standard Methods, 18th Ed.)

2.3.2.1 Liquid samples (percent solids: <4 %; TWAS, primary sludge & digested sludge)

a. Shake sample to mix
b. Using a sterile 1 mL pipet, dispense 1 mL of sample into each of 5 tubes of A1 media
c. Using a sterile 10 mL pipet, dispense 1 mL of sample into 9 mL buffer dilution tube. (Do a serial dilution to desired concentration)
d. Using a sterile 10 mL pipet, dispense 1 mL of each dilution into each of 5 tubes of A1 media
e. Incubate at 35 ^{0}C for 3 hrs, then transfer to 44.5 ^{0}C water bath for continued incubation
f. Read tubes at 24$\pm$ 2 hrs

2.3.2.2 Solid samples (Percent solids: >5 %; wet cake from centrifuge, silo, truck and farm)

a. In blender, add 270 mL of Tween/buffer to 30 gm of sample
b. Mix for one minute
c. Repeat Steps b –e for liquid samples given above

2.3.3 Quality Assurance/Quality Control (QA/QC) (Part 9020, Standard Methods, 18th Ed. And USEPA Environmental Regulations and Technology)

2.3.3.1 Water
a. Daily test – pH, conductivity, and Chlorine
b. Monthly Test - Heterotrophic Plate Count
c. Annual Test - Water Suitability

2.3.3.2 Media: QA performed for each batch
a. pH
b. Sterility check
c. Positive and negative control cultures

2.3.3.3 Duplicate analysis
5% of the total number of samples analyzed

2.3.3.4 Equipment
a. Incubators/Waterbaths. - Temperatures are monitored and recorded twice a day; once
b. in the morning and once in the afternoon
c. Incubator thermometers are calibrated semi-annually

Complete literature references mentioned in this section are listed in Appendix 7.4

3. RESULTS

3.1 Density of *Salmonella*

3.1.1 Digester inflow

Digester inflow at HTP consists of a mixture of primary sludge (80%) and TWAS (20%). Average densities of *Salmonella* in the primary sludge and TWAS were 9.7 MPN/4 dry gram and 2.5 MPN/4 dry gram respectively (Table 4). Some of the densities in Table 4 are reported as upper (<) or lower bound (>) values.

3.1.2 Post-digestion train

The *Salmonella* counts at sampling locations 1, 3 and 4 in the post-digestion train are reported in Table 5. Samples from locations 1a and 2 were not obtained since they were not considered relevant and to reduce sampling costs. Levels of *Salmonella* measured at the three sampling locations, including the truck loading facility (location 4) were consistently below the EPA limit of 3 MPN/4 dry gram total solids. An independent laboratory, operated by the LA County Sanitation District analyzed identical samples in two occasions. The results obtained by the County are reported in the gray cells of Table 5. The *Salmonella* levels reported by the County were lower than the levels measured at BioVir Laboratory.

3.2 Density of fecal coliform

3.2.1 Digester inflow

Levels of fecal coliform in each of the two components, primary sludge and TWAS are shown in Table 6. A large number of fecal coliform (approximately 10^7 to 10^8 MPN/dry gram) was observed in both components of the digester inflow which is a typical result.

3.2.2 Post-digestion train

Densities of fecal coliform in samples taken at the five locations throughout the post-digestion train at HTP are shown in Table 7. Some of the densities at locations 1, 1a, 2 and 3 are reported as upper bound values (<). Some densities at location 4 are reported as lower bound values (>).

Figure 4 is a graphical representation of values presented in Table 7. In Figure 4 arrows indicate lower bound values at location 4. Upper bound values for locations 1, 1a, 2 and 3 are not indicated on Figure 4 in order to keep the data clearly visible. Figure 4 indicates that fecal coliform concentrations were consistently below the EPA limit of 1000 MPN/ dry gram at locations 1, 1a, 2 and 3. Levels of fecal coliform in the wetcake at location 3 were remarkably low (<72 MPN/dry gram most of the time) especially considering that the total solids in locations 1, 1a and 2 are around 2% and total solids at location 3 are around 30%. A significant increase in the densities of fecal coliform was observed at the truck loading facility (location 4) where the numbers were above 10^5.

Raw data used in all figures and tables is presented in Appendix 7.3.

Table 4. *Salmonella* in digester inflow

Date	*Salmonella*, MPN/ 4 dry gram Location	
	Primary sludge	TWAS
11/8/01	5.1	<2.6
11/13/01	3.3	1.8
11/14/01	11.0	4.4
11/15/01	13.0	<2.4
11/19/01	>18	<2.4
11/20/01	7.7	<2.4
11/26/01	7.0	2.3
11/27/01	11.4	2.1
11/28/01	>10.6	<2.1

Table 5. *Salmonella* in post-digestion train

Date	*Salmonella*, MPN/ 4 dry gram				
	Location 1	Location 1a	Location 2	Location 3	Location 4
	Digester 5D1 or 6D1	C7 wet well	Centrfuge feed	Centrifuge cake	Truck loading
	Digested sludge			Wet cake	
10/1/01	<1.3	NS	NS	<1.4	NS
10/2/01	NS	NS	NS	NS	<1.6
10/3/01	<1.8	NS	NS	<1.5	NS
10/4/01	NS	NS	NS	NS	<1.8
10/9/01	<1.8	NS	NS	<2.1	<2.1
10/10/01	<2.2	NS	NS	<1.7	<1.5
	<0.41	NS	NS	<0.27	NS
10/11/01	<2.5	NS	NS	<1.3	<1.5
10/15/01	<2.0	NS	NS	<1.3	<1.4
10/16/01	<1.8	NS	NS	<1.5	<1.4
	<0.41	NS	NS	<0.252	<0.261

Notes

TWAS: Thickened wastewater activated sludge

NS: No Sample

Analysis were conducted by Biovir Laboratory Inc.

: Samples were analyzed by Microbiology Laboratory, LA County Sanitation District

Part 503.32 *Salmonella* limit: <3 MPN/4 dry gram total solids.

Table 6. Fecal coliform in digester inflow

Date	Fecal coliform, MPN/ dry gram	
	Location	
	Primary Sludge	TWAS
11/6/01	1.7E+08	< 1.8E+07
11/7/01	9.4E+07	1.4E+07
11/8/01	2.7E+07	1.4E+07

Table 7. Fecal coliform in post-digestion train (MPN/ dry gram)

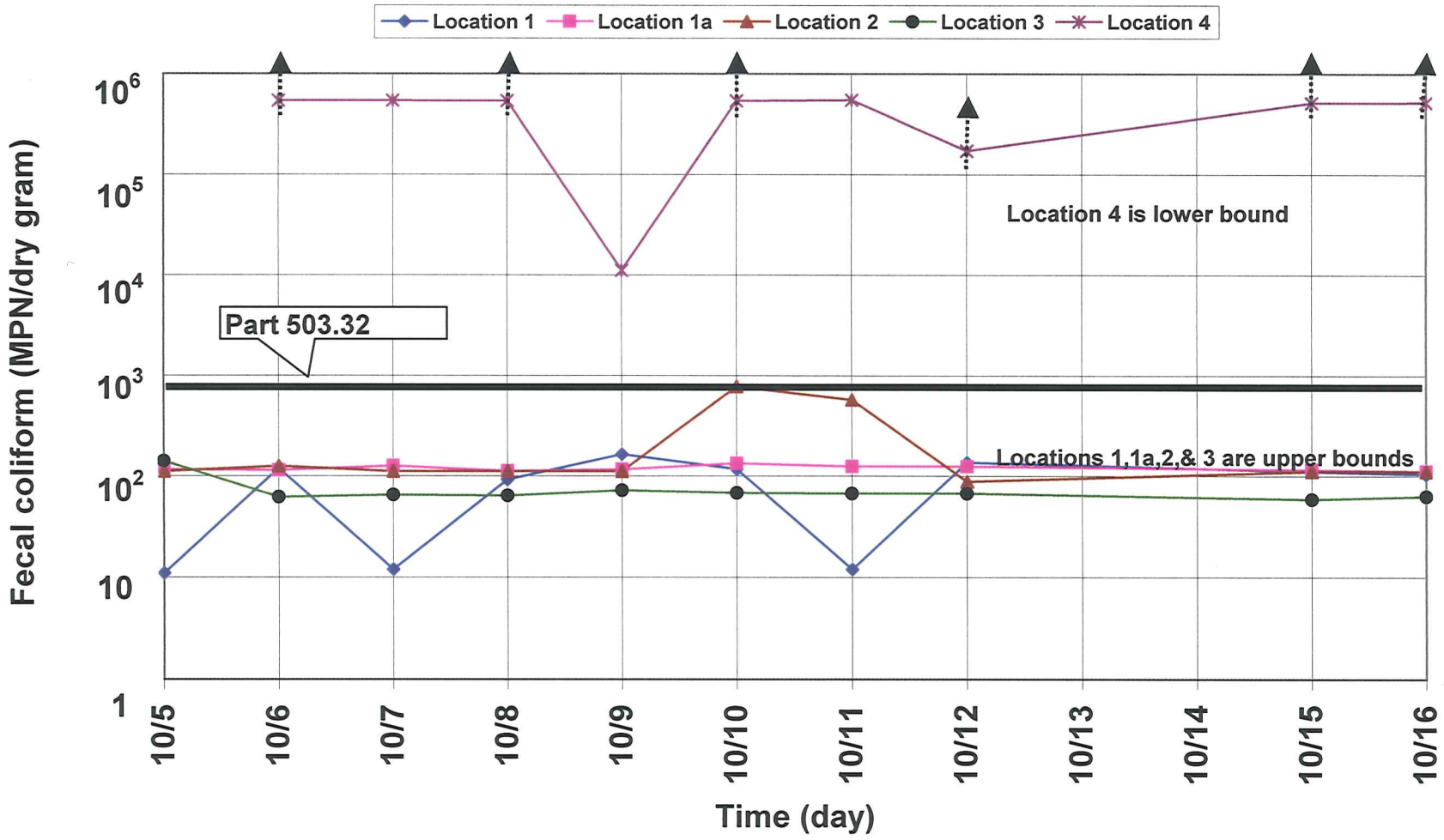
Date	Digester	Temp. (°F)	Digested sludge			Wet cake	
			Location 1	Location 1a	Location 2	Location 3	Location 4
10/5/01	5D1	125.2	< 11	< 116	111	140	NS
10/6/01	5D1	125.7	119	< 114	< 125	< 62	>= 5.4E+05
10/7/01	5D1	129.5	< 12	< 126	111	< 65	5.4E+05
10/8/01	6D1	127.5	92	< 112	111	< 64	>= 5.4E+05
10/9/01	6D1	130.5	164	< 116	111	< 72	1.1E+04
10/10/01	6D1	128.8	117	< 133	778	< 68	>= 5.4E+05
10/11/01	5D1	126.7	< 12	< 124	575	< 67	>= 5.5E+05
10/12/01	5D1	130	136	< 124	< 88	< 67	1.7E+05
10/15/01	6D1	129.6	< 111	< 115	< 111	< 59	>= 5.2E+05
10/16/01	6D1	124.8	< 104	< 112	< 111	< 63	>= 5.2E+05

Notes

TWAS: Thickened wastewater activated sludge

Part 503.32 Fecal coliform limit: <1000 MPN/dry gram total solids.

Figure 4. Fecal coliform in post-digestion train



4. CONCLUSIONS

Pathogen/indicator densities measured during Phase I showed that the levels of *Salmonella* after digestion were reduced to below the Class A limit. Fecal coliform densities after digestion were reduced to approximately 10 times below the Class A limit. These results indicate that the combination of thermophilic digestion and time-temperature batch processing at HTP produced biosolids that meet the Class A limits.

Additionally, densities of both *Salmonella* and fecal coliform throughout the post-digestion train were measured. *Salmonella* densities remained below the Class A limit at all sampling locations. Fecal coliform densities remained below the Class A limit at all locations except the truck loading facility. These data indicate that there is a good correlation between *Salmonella* densities and fecal coliform densities throughout the post-digestion train with the exception of the truck loading facility. In addition the data suggests the existence of a fecal coliform regrowth or contamination problem between the centrifuge outlet and the silo.

Potential sources of bacterial contamination are the ambient air in the silo, the effluent (HPE) used to lubricate the pipelines that transport the wetcake to the silo, and the polymer added during dewatering. Supporting studies to test these hypotheses (Section 6) showed that HPE and polymer were not a significant source of contamination.

Based on the data presented in this report our conclusions are:

1. The two-stage thermophilic process (Phase I) effectively reduces *Salmonella* (pathogen) and fecal coliform (indicator) densities to levels below the Class A federal standard, 40 CFR Part 503.32.
2. Additional testing along the thermophilic post-digestion train showed that *Salmonella* (pathogen) densities remained below the Class A limit at all the sampling locations.
3. Additional testing along the thermophilic post-digestion train showed that fecal coliform densities also remained below the Class A limit at all sampling locations, except at the truck loading facility. However, the high numbers of fecal coliform might not be an indication of high number of pathogens, since the *Salmonella* densities measured at the truck were below the Class A limit.
4. Fecal coliform regrowth or contamination occurred between the centrifuge outlet and the silo at the truck loading facility. A preliminary profile of the biosolids temperature throughout the post-digestion train showed a major drop between the same locations that might have allowed the increase in fecal coliform counts.
5. Based on preliminary tests, HPE and polymer were found not to be a significant source of contamination. The regrowth / contamination issue is being further investigated in Phase II as described in Section 5.

5. RECOMMENDATIONS

It is important to mention that excellent results were obtained at HTP although the temperature of the second stage digesters 5D1 and 6D1 was often below the target disinfection temperature (135°F). Additional efforts are underway to fully meet the Alternative 1 time-temperature requirement. More stringent procedures for cleaning the pipelines of the post-digestion train and for isolating the thermophilic from the mesophilic train will also be implemented. These modifications may help to prevent the fecal coliform regrowth/contamination observed at the truck loading facility.

Recommendations by the Task Force for the Phase II full-scale studies are discussed in the following sections.

5.1 Short Term

1. Repeat the full-scale testing of *Salmonella* and fecal coliform densities under thermophilic operation throughout the complete process, i.e., from the digester inflow to the farm where biosolids are applied.

    a. A 4-week sampling period instead of a 2-week period will be performed. Samples of digester inflow and outflow will be taken within one residence time or earlier. In the October study (Phase I) inflow and outflow samples were phased out by several residence times. Sampling locations are indicated in Fig. 5. Sampling protocol for this full-scale study is shown in Tables 8a and 8b. These modifications will allow a more comprehensive study and synoptic view of the bacterial survival throughout the thermophilic digestion process. That is, bacteria present in the inflow at the beginning of the study will be monitored through the complete digestion process including the biosolids stored at the silo.
    b. Sampling at the farm where biosolids are applied will be included in order to obtain a picture of what happens to the bacterial densities from the silo to the farm. Sampling at the farm will start on March 6, 2002 continuing for three weeks. The bottom of Table 8 contains sampling activities for the farm.
    c. A longer cleaning procedure and a better flushing of pipelines will be performed in order to reduce the chances of recontamination of biosolids with pathogens.
    d. Isolation of the thermophilic train from the mesophilic train operating at the plant will also be secured to avoid cross contamination with mesophilic sludge.
    e. Enough steam has to be provided to maintain the time-temperature requirement. To obtain more reliable source of heat for digesters, debugging and testing of boilers will continue for one week starting February 4, 2002. Stable operation of digesters maintaining the required temperature will be achieved on February 25, 2002, on which sampling activities will begin.
2. A temperature profile study will be repeated in order to obtain more reliable data. Table 9 contains sampling locations and descriptions for this study.
3. Additional slip injection points were identified in recent walkthrough. In order to determine if these locations contribute to the high counts of fecal coliform at the truck

loading facility random testing of slip injection points are included in the upcoming testing.

5.2 Long term

The City of Los Angeles is implementing several projects to convert the HTP into thermophilic operations, and obtain Class A biosolids. The projects are listed below.

1. **2119 - Class A Biosolids Test Facility**: The City of Los Angeles is preparing for the future by pilot testing **advanced biosolids processing scenarios** that may yield Class A biosolids. The City staff is looking into the current operational mode of the digesters at the City of Los Angeles' Hyperion Treatment Plant, and what digestion scenario will best work to produce Class A biosolids, complying with EPA 40 CFR Part 503 regulations.

   The pilot scenarios included Two-Phased Acid/Methane Digestion, a Temperature Phased Thermo/Meso Digestion, a Temperature-Stress Digestion and Food Waste fed into a Single Stage Thermophilic Digester.

   Data from the pilot tests will guide the City in determining optimal sludge digestion operation parameters. The pilot tests will also provide information on the effects of food waste digestion on the quality of the biosolids produced.

2. **Gravity Thickener Pilot**: The current primary sedimentation process at the Hyperion Treatment Plant produces primary sludge with an average total solids of 3%. In order to increase the total solids handling capacity of the egg-shaped digesters or the hydraulic retention time gravity thickeners will be built to raise the solids content from 3% to 7%.

   HTP is planning to use a full scale primary sludge gravity thickener to concentrate the primary sludge. However, it is prudent that the ranges of the operational parameters of the gravity thickener should be determined before the engineering design of the full scale thickener begins. Therefore, a pilot gravity thickener shall be installed to determine these operational parameters.

3. **2124 – Digester Upgrade Project** – HTP converted a battery of egg-shaped digesters to produce Class A Biosolids. This project included:
   - Insulating pipes from transfer pumps to truck loading facility
   - Heat tracing of stagnant pipes from batch tanks to truck loading
   - Isolating control valves on cake transport lines
   - Dome Rehabilitation of 12 digesters
   - Thermal insulation and jacketing

4. **2123 – Odor Survey Project** A major concern of the Bureau of Sanitation is odors at the Hyperion Treatment Plant. The plant conducted an odor survey to determine

the impact of the Class A Biosolids to the immediate environment, in particular the community of City of El Segundo. All indications from literature (McGinley, Charles M., 2001) and experts in the field suggest that thermophilic sludge is more odorous then mesophilic sludge. URS Corporation of Santa Ana, California was retained to conduct an evaluation of the air emissions of mesophilic and thermophilic sludges. They performed a chemical analysis and an odor panel analysis of each air sample for a comprehensive analytical comparison of the two sludge digestion processes. The chemical analysis made of all samples was for methane, carbon dioxide, total non-methane volatile organic compounds (VOC's), and total reduced sulfur (TRS).

Odor evaluations were conducted in accordance with the American Society for Testing and Materials (ASTM), Standard Practice E679-91, for the "Determination of Odor and Taste Thresholds by Forced-Choice Ascending Concentration Series of Limits," and E544-99, "Referencing Supra-threshold Odor Intensity". The odor evaluation panel was managed in accordance with ANSI/ASWC Q2-1991, "Quality Management and Quality System Elements for Laboratories". The odor evaluation panels consisted of individual assessors that were selected and trained following the "Guidelines for Selection and Training of Sensory Panel Members".

5. **2263 – Digester Feed System Modification to include LAX Feed Addition Project (future)** – HTP is planning to process the food waste generated from the Los Angeles World Airport as direct feed to the digesters in order to meet trash diversion targets in State law. Other benefits of this project include increase in gas production and enhancement of the biosolids produced. The data gleamed from one of the experiments conducted at the **Class A Biosolids Test Facility** (see above) provided the design parameters to optimize the processing of the food waste and to be fed to thermophilic digesters.

6. **2264 – Centralized Odor Control Project (future)** – HTP will be centralizing all odor control process into one area to maximize treatment efficiency, to facilitate alternative treatment options, and to centralize chemical feed storage tank farms.

Figure 5. Schematic diagram for sampling during thermophilic operation, March 2002

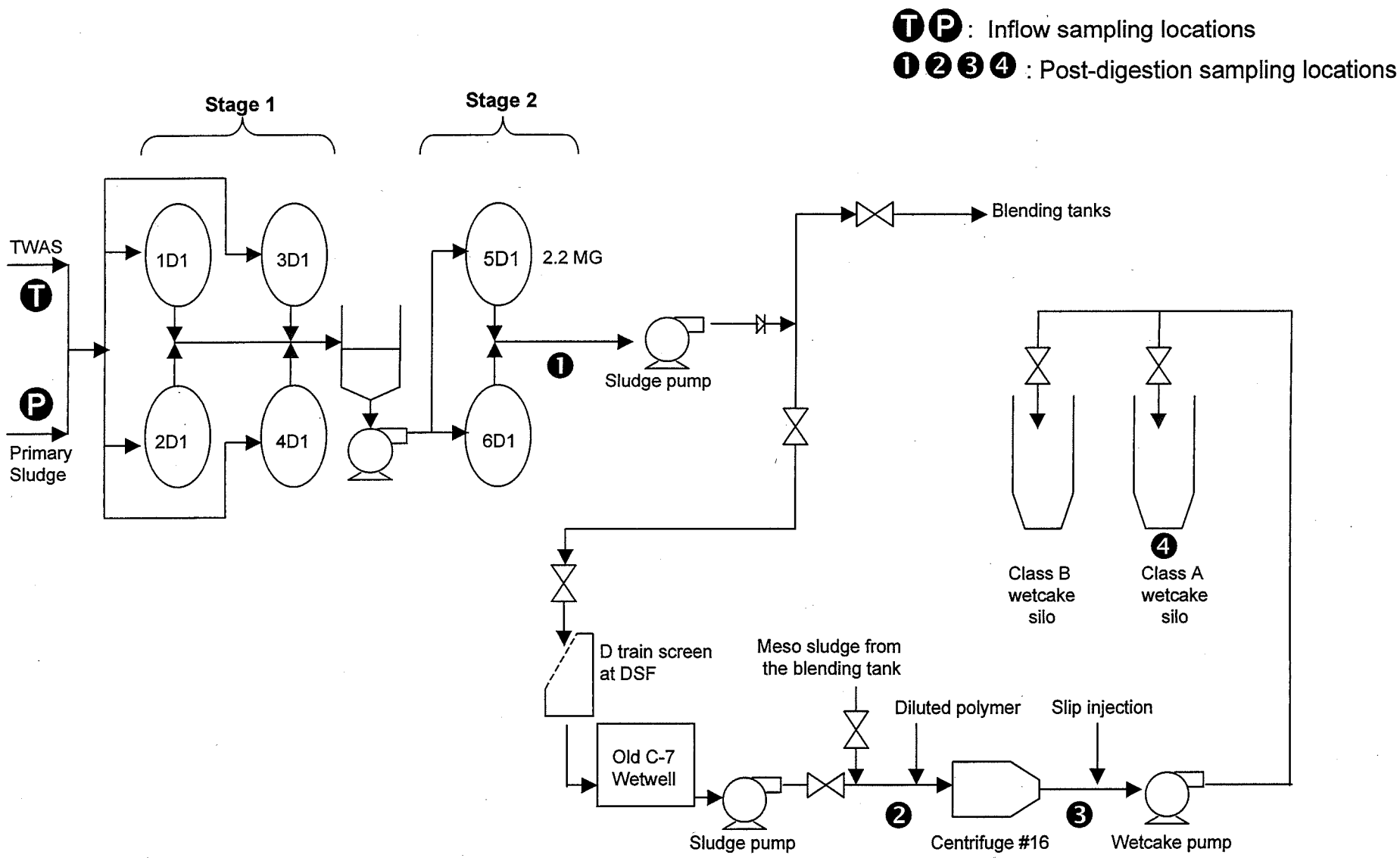


Table 8a. Sampling schedule for fecal coliform and *Salmonella* at HTP and farm

Sample Type	Sample	Detention Time	Analysis	Lab	Sampling Time	Week 1				Week 2				Week 3				Week 4				Sample Containers
						Mon	Tue	Wed	Thu	Mon	Tue	Wed	Thu	Mon	Tue	Wed	Thu	Mon	Tue	Wed	Thu	
Raw Sludge	TWAS	NA	Fecal Coliform	EMD	7:00 AM	S	S	S	S	S	S	S	S	S	S	S	S	NS	NS	NS	NS	One Sterile 500 ml bottle
			Salmonella	BioVir	1:00 PM	S	S	S	S	S	S	S	S	S	S	S	S	NS	NS	NS	NS	Two Sterile 1000 ml bottles
	Primary Sludge	NA	Fecal Coliform	EMD	7:00 AM	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	One Sterile 500 ml bottle
			Salmonella	BioVir	1:00 PM	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	Two Sterile 1000 ml bottles
Digested Sludge	First stage digestion	13 days	Fecal Coliform	EMD	7:00 AM	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	One Sterile 500 ml bottle
			Salmonella	BioVir	1:00 PM	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	Two Sterile 1000 ml bottles
	Batch Digestion	2 to 3 days	Fecal Coliform	EMD	7:00 AM	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	One Sterile 500 ml bottle
			Salmonella	BioVir	1:00 PM	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	Two Sterile 1000 ml bottles
Wet Cake	Centrifuge	NA	Fecal Coliform	EMD	7:00 AM	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	One Sterile 500 ml bottle
			Salmonella	BioVir	1:00 PM	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	One Sterile 1000 ml bottles
	Silo	1 to 5 days	Fecal Coliform	EMD	7:00 AM	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	One Sterile 500 ml bottle
			Salmonella	BioVir	1:00 PM	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	One Sterile 1000 ml bottles
	Truck	4 to 6 hours	Fecal Coliform	EMD	7:00 AM	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	One Sterile 500 ml bottle
			Salmonella	BioVir	1:00 PM	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	One Sterile 1000 ml bottles
	Farm	NA	Fecal Coliform	EMD	??	NS	NS	NS	NS	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	One Sterile 500 ml bottle
			Salmonella	BioVir	??	NS	NS	NS	NS	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	One Sterile 1000 ml bottles

NA = Not Applicable; S = Sample to be collected; NS = No sample to be collected
Total Solids samples will be collected at the time of Fecal Coliform samples being collected

Table 8b. Sampling personnel for fecal coliform and *Salmonella* at HTP and farm

						Person in charge for sampling															
						Week 1				Week2				Week3				Week4			
Sample Type	Sample or Location	Analysis	Lab	Sampling Time	Sampling Party	2/25 Mon	2/26 Tue	2/27 Wed	2/28 Thu	3/4 Mon	3/5 Tue	3/6 Wed	3/7 Thu	3/11 Mon	3/12 Tue	3/13 Wed	3/14 Thu	3/18 Mon	3/19 Tue	3/20 Wed	3/21 Thu
HPE	Slip Injection	Fecal Coliform	EMD	7:00 AM	HTP / Dewatering	NS	JAW	NS	NS	NS	JAW	NS	NS	NS	JAW	NS	NS	NS	NS	NS	NS
Raw Sludge	TWAS	Fecal Coliform	EMD	7:00 AM	HTP / Dewatering	**JAW. Dewatering section (HTP)**												NS	NS	NS	NS
		Total Solids	EMD	7:00 AM														NS	NS	NS	NS
		Salmonella	BioVir	**1PM / 7AM *****														NS	NS	NS	NS
	Primary Sludge	Fecal Coliform	EMD	7:00 AM	HTP / Digester	**PEK. Digester section (HTP)**												NS	NS	NS	NS
		Total Solids	EMD	7:00 AM														NS	NS	NS	NS
		Salmonella	BioVir	**1PM / 7AM *****														NS	NS	NS	NS
Digesgted sludge	Batch Digester 5D1 or 6D1	Fecal Coliform	EMD	7:00 AM	WESD/HTP Digester	NS	NS	NS	NS	Seung /Dariush /Tom	Seung /Daurish /Tony	Seung /Dariush /Tom	Seung /Dariush /Tony	Haul /Samar /David	Haul /Samar /Huub	Haul /Samar /David	Haul /Samar /Huub	Dariush /Samar /Tom	Dariush /Samar /Tony	Dariush /Samar /Tom	Dariush /Samar /Tony
		Total Solids	EMD	7:00 AM		NS	NS	NS	NS												
		Salmonella	BioVir	7:00 AM		NS	NS	NS	NS												
Wet Cake	Centrifuge	Fecal Coliform	EMD	7:00 AM	WESD/HTP Dewatering	NS	NS	NS	NS												
		Total Solids	EMD	7:00 AM		NS	NS	NS	NS												
		Salmonella	BioVir	7:00 AM		NS	NS	NS	NS												
	[1]Silo (Truck at plant)**	Fecal Coliform	EMD	7:00 AM	WESD/HTP Dewatering	NS	NS	NS	NS	NS		NS		NS		NS		NS		NS	
		Total Solids	EMD	7:00 AM		NS	NS	NS	NS	NS		NS		NS		NS		NS		NS	
		Salmonella	BioVir	**5:00 AM**		NS	NS	NS	NS	NS		NS		NS		NS		NS		NS	
	[1]Farm	Fecal Coliform	EMD	7:00 AM	WESD/HTP Dewatering	NS	NS	NS	NS	NS	Haul / David	NS	Haul / David	NS	Dariush / David	NS	Dariush / David	NS	Seung / David	NS	Seung / David
		Salmonella	BioVir	7:00 AM		NS	NS	NS	NS	NS		NS		NS		NS		NS		NS	

NS = No Sample to be collected

[1] Samples will be collected from the designated steam cleaned truck.

** Sample will be collected while the bilsolids are being loaded into the truck.

*** Only **1st week** samples will be collected at 1:00 PM, but samples will be collected at 7:00 AM for other weeks.

Note: Temperature of samples will be measured and recorded while each time of sampling is done.

Table 9. Temperature profile testing locations

Sample Type	Location No.	Location
Digested Sludge/ Centrate	1	After digestion
	2	Before screening facility
	3	After screening facility
	4	After Dice II wetwell
	5	Mixture of digested sludge/polymer
	6	Centrate
Wetcake	7	Centrifuge outlet
	8	Before falling into silo
	9	Truck

Testing will be done by personnel from HTP Operation/WESD Applied Research Group
Tentative Sampling Date: 3/5/02 (subject to change)

6. SUPPORTING STUDIES

High densities of fecal coliform observed at the loading truck facility can be attributed to regrowth of organisms that survived digestion or growth of organisms subsequently introduced by contamination between the centrifuge outlet and the silo at the truck loading facility. Additional studies to test these hypotheses are discussed in this section.

Post-digestion processing at HTP consists of several steps; in-plant transfer (pipelines), water removal (diluted polymer addition and centrifugation), and storage. These steps are potential sources of contamination. The long pipeline to the centrifuge, the centrifuge itself, the post-centrifuge transport, and the storage facilities were all examined as possible sources of contamination and for conditions that would promote bacterial growth. In particular, use of small amounts of secondary effluent (HPE) to lubricate passage of the wetcake through the pipe after it emerges from the centrifuge and added polymer were suspected to be potential sources of contamination. Therefore, fecal coliform densities were measured in HPE samples and, as a result, low levels of fecal coliform were found (raw data is presented in Appendix 7.3)

Temperature drop in the post-digestion train is also another factor that promote bacterial growth. Pipes transporting the sludge between the centrifuge outlet and the silo are located outside of the building without insulation. As a result, the biosolids temperature decreases and this drop in temperature may establish conditions for bacterial growth.

Following experiments were performed in order to evaluate the extent of regrowth in wetcake obtained from the thermophilic digestion process and to define the effect of temperature and contamination sources on the growth of *Salmonella* and fecal coliform:

1. Temperature profile study
2. *Salmonella*/fecal coliform regrowth at ambient temperature
3. *Salmonella*/fecal coliform regrowth at different temperatures
4. Fecal coliform regrowth under centrifuge simulated conditions

6.1 Temperature profile study

Salmonella and fecal coliform require a drop in the sludge temperature along the post-digestion train in order to attain a permissible temperature for bacterial growth. Thus, the sludge temperatures along the post-digestion thermophilic train were measured in order to define the most probable sections of the train where bacterial growth may occur due to a drop in temperature.

Sludge temperatures were measured on December 15, 2001 at the same locations where samples were collected for *Salmonella* and fecal coliform analysis and also at some additional locations. Temperature was measured using three types of thermometers; conventional mercury, dial, and digital. Figure 6 shows the measurement locations.

Photographs of activities during the temperature profile study are presented in Appendix 7.5.

Table 10 shows the temperature profile obtained on December 5, 2001 along the post-digestion thermophilic train. Reported values represent only the measurements obtained with the digital thermometer, which provided the most reliable absolute measurements. Additionally, the calculated difference in temperatures between a given pair of points was similar regardless of the type of thermometer used. The difference in temperature between a given sampling location and the previous one is indicated in Table 10 as ΔT. A negative value indicates a drop in temperature and a positive value indicates an increase. Changes in temperature at locations 2, 3, 4 are small, around 1°F, and they compensate each other. Therefore, overall drop in temperature from location 1 to location 4 is minimal (ΔT = -1.1°F). A larger drop in temperature occurs between locations 4 and 5 (ΔT = -4.1°F). However, this drop is partially compensated by an increase in temperature between locations 5 and 6 (ΔT = 3.3°F). The biggest drop in temperature, ΔT = -12.2°F, was observed between the outlet of the centrifuge (Location 6) and the top of the silo (Location 7). The total drop in temperature between the digester outlet and the silo at the truck loading facility was 14.1 °F.

Table 11 shows the temperature profile at the truck loading location obtained on December 6, 7 and 10, 2001. This profile was obtained in order to evaluate the temperature gradient existing inside the silo. Temperatures of the wetcake obtained at the front of the truck correspond to wetcake located at the lower level of the silo whereas temperatures measured at the rear of the truck correspond to wetcake located at a higher level in the silo. The data indicates that there is a decrease in temperature along the depth of the silo that ranges from 2.2 °F to 8.9 °F.

6.2 *Salmonella*/fecal coliform regrowth at ambient temperature

An initial evaluation of fecal coliform regrowth was performed in wetcake samples obtained at two locations on October 11 (at the truck) and October 16 (after the centrifuge). Several individual samples were left at room temperature for over 400 hrs. One sample per location was analyzed for fecal coliform density at predefined time intervals. Results are shown in Figure 7. Fecal coliform counts in the centrifuge wetcake samples were low ($<10^1$) with a minor deviation to about 10^2. The other deviation to 10^5 was due to a dilution error in the laboratory. No regrowth was observed in the centrifuge wetcake samples at ambient temperature even after approximately 400 hrs. Counts were high (10^6) and regrowth was observed (up to 10^8) in wetcake samples from the truck. After approximately 400 hrs, counts decreased to the initial levels. These results confirm that either regrowth or contamination with an external microbial source occurred between the centrifuge and the silo. *Salmonella* regrowth was also evaluated in wetcake samples obtained on October 11 from the truck. Results in Table 12 shows no regrowth of *Salmonella*.

Figure 6. Temperature profile sampling locations, field test

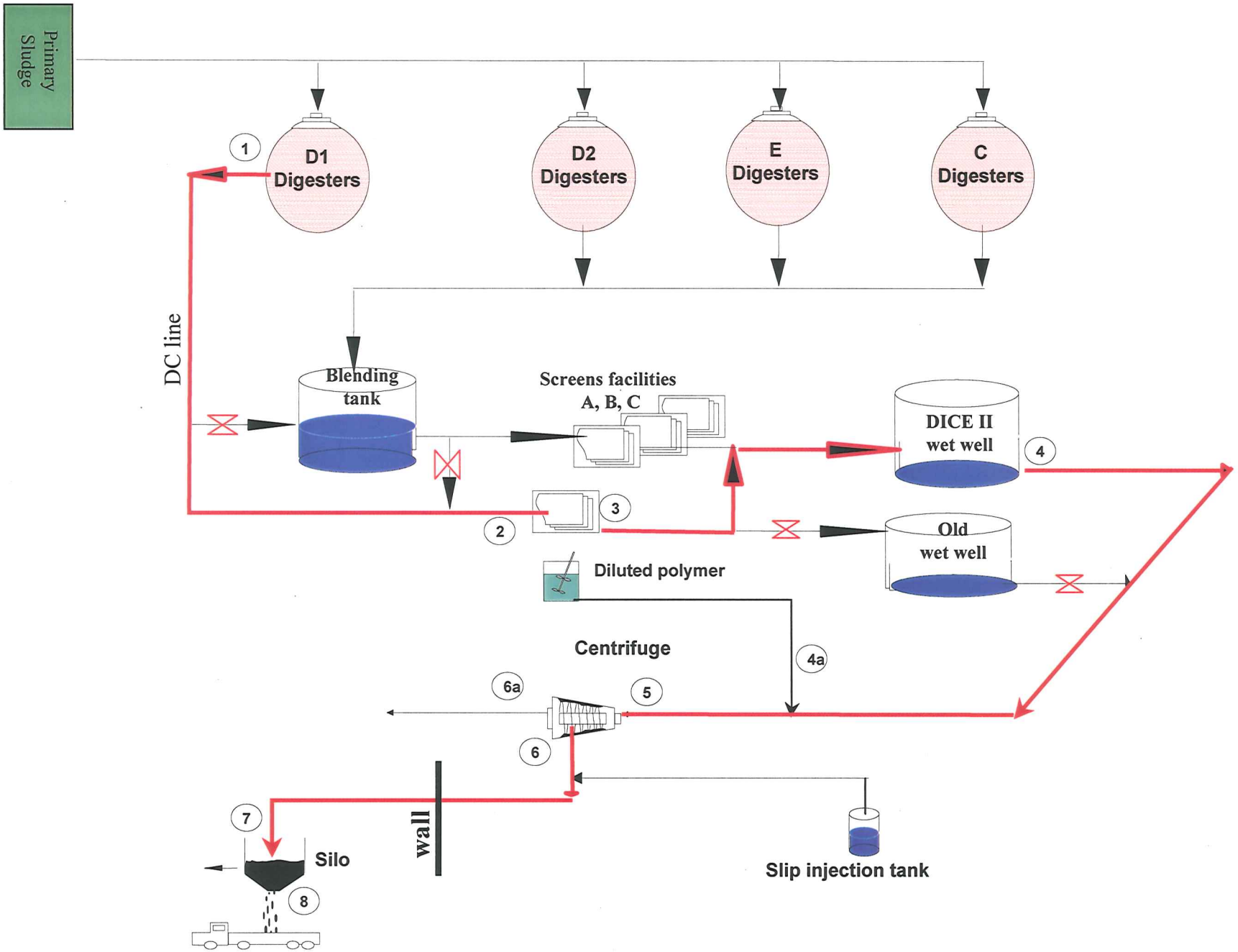


Table 10. Temperature profile data (Locations 1 to 7)

Digester Temperature: 5D1 = 124 °F

	Location	Temperature (°F)		Ambient Temp. (°F)
		Digital	ΔT (°F) **	
1	Digester 5D1	124.6	-	78.5
2	Before screen	123.4	-1.2	
3	After screening facility	122	-1.4	59.7
4	After Dice II wetwell	123.5	1.5	69.2
4a	(Diluted polymer)	76	-	
5	Mixture of digested sludge/polymer	119.4	-4.1	
6	Centrifuge outlet	122.7	3.3	
6a	(Centrate)	121.6	-	
7	Before falling into silo	109 (1pm)*		67.3
		112 (2pm)*	-12.2	

Digested sludge flow rate at Centrifuge # 6 and # 7 = 700 gpm
Test started on 12/05/2001 at 8:20 a.m.
* This temperature may not be representative of actual temperature due to difficulties in the sample collection process
** Change in temperature (ΔT) is calculated with reference to the previous location, i.e. ΔT at location 2 is the change in temperature between location 2 and location 1.

Table 11. Temperature profile data (Location 8)

Date	Time	Time elapsed (hrs)	Truck Location	Thermometers (°F)		Silo level (ft)		Ambient Temp. (°F)
				Digital	ΔT*	before	after	
12/6/01 Thursday	7:20 AM	15	front	97.1 110.5 ***Avg. 103.8***		18.4	13.1	53.6
			rear	110.8 114.5 ***Avg. 112.7***	8.9			
12/7/01 Friday	9:25 AM	41	front	101.8 117.5 116.3 ***Avg. 111.9***		13.1	9.6	65.4
			rear	109.1 116.9 116.2 ***Avg. 114.1***	2.2			
12/10/01 Monday	10:00 AM	114	front	92.4 105.0 98.0 ***Avg. 98.5***		9.6	5.2	58.7
			rear	103 102 105.1 ***Avg. 103.4***	4.9			

* Differnece in temperature (ΔT) between the rear and front samples.

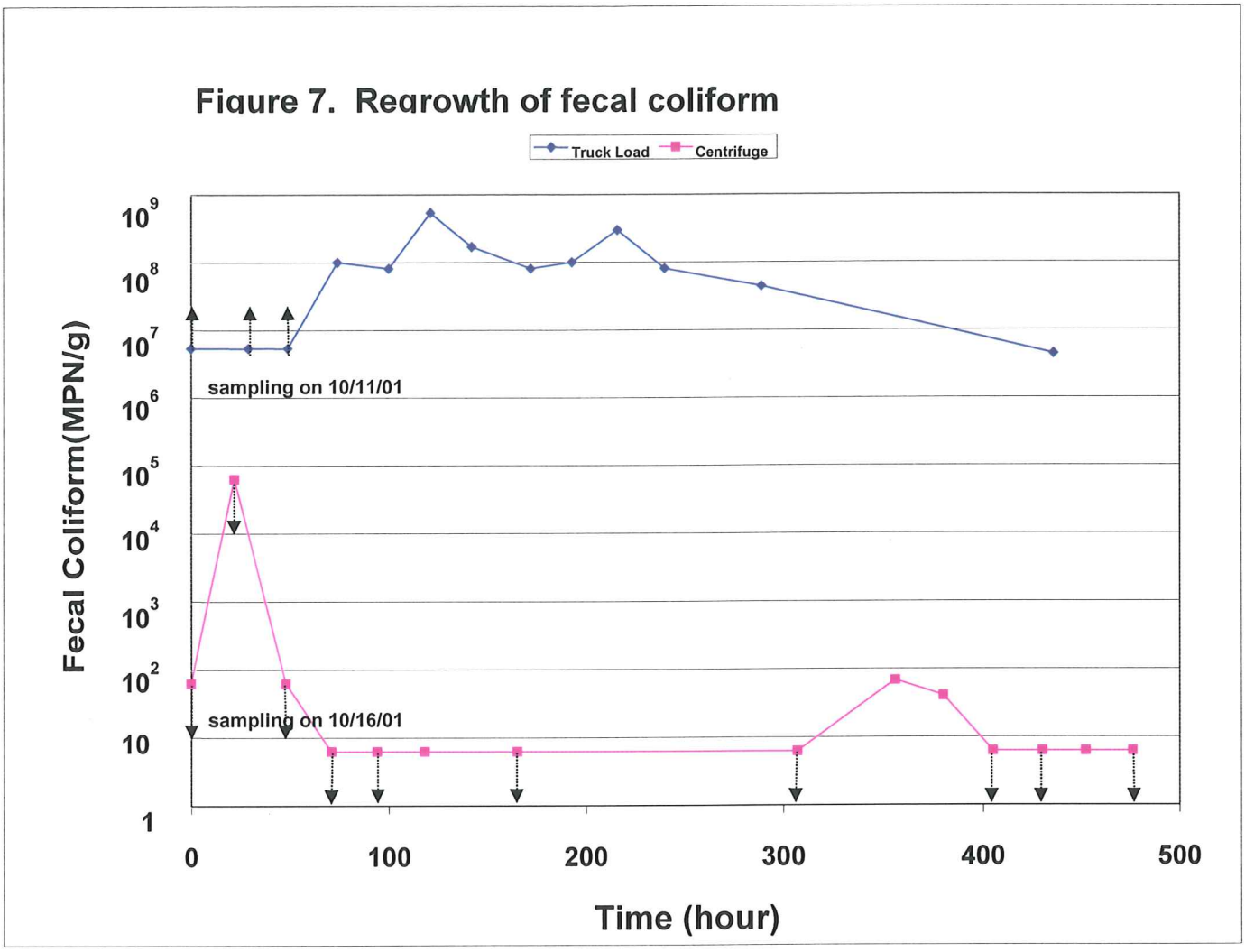


Table 12. Regrowth of *Salmonella*

Sample Date	Location	Analysis Date	Elapsed Time (hr)	MPN/g
10/11/01 8:00	4	10/12/01 11:35 hr	27	3.5
	4	10/15/01 9:35 hr	97	< 1.5
	4	10/19/01 15:18 hr	151	< 1.4

6.3 *Salmonella*/fecal coliform regrowth at various temperatures

Regrowth was evaluated at different temperatures in order to define the minimum temperature that may prevent pathogen/indicator growth in the samples. Wetcake (after centrifuge) and digested sludge (immediately after digester) were obtained on October 15, 2001. Several individual samples were incubated at 25, 35, and 45 °C (77, 95, and 133 °F) for a 96-hrs period. *Salmonella* and fecal coliform densities were measured in individual samples at predefined time intervals.

Some of the samples were spiked with *Salmonella* or fecal coliform in order to test the effect of reinoculation on pathogen/indicator densities.

The results of this study demonstrated that:

a. *Salmonella* spiked to wetcake or digested sludge died-off at all the temperatures tested (Figures 8 and 9). Regrowth data for *Salmonella* in wetcake or digested sludge was not available
b. Fecal coliform regrowth did not occur in wetcake samples at 45°C. However regrowth was observed at 25 and 35°C (Figure 10).
c. Fecal coliform regrowth was not observed in digested sludge at any temperature tested (data not shown).
d. Spiked fecal coliforms died off in wetcake and digested sludge samples (Figures 11 and 12) at all temperatures tested with exception of the wetcake sample incubated at 25°C in which a significant increase in the fecal coliform counts was observed.

In order to confirm the fecal coliform regrowth trends observed in the October test, a second test was conducted on December 10, 2001. Several deviations from the October test occurred during December. As a consequence, fecal coliform densities in the wetcake samples in December were well above the legal limits and no meaningful results were obtained from the wetcake regrowth experiments. Fecal coliform regrowth in digested sludge was not observed (Figure 13) and die-off was observed in the spiked samples (Figure 14) at the three temperatures tested (35, 40, and 45°C) in the same fashion as in the October test.

Based on the data previously presented it is possible to define the following general trends:

a. Thermophilic digested sludge obtained immediately after the digester is resilient to *Salmonella* or fecal coliform regrowth even at low temperatures that allow bacterial growth. Furthermore, *Salmonella* or fecal coliform re-inoculated into digested sludge died off to undetectable levels at any temperature tested.
b. Wetcake (after the centrifuge) is resilient to *Salmonella* regrowth and *Salmonella* re-inoculated into wetcake died off at all the temperatures tested.
c. Wetcake (after the centrifuge) is resilient to fecal coliform regrowth at 45°C. Fecal coliform regrowth was observed at 35 and 25°C. Therefore, maintaining the wetcake temperature at 45°C or higher may help prevent fecal coliform regrowth

in the wetcake. However, the observed fecal coliform regrowth at 35 and 25 °C was in total disagreement with the results from the study at ambient temperature presented above in section 6.1, where fecal coliform regrowth was not observed in centrifuge wetcake for a period of above 400 hrs.

It should be mentioned that *Salmonella* and fecal coliform densities in spiked wetcake samples were unexpectedly low even immediately after spiking in some of the October test samples. In fact, no fecal coliform was detected in spiked wetcake samples even in the initial specimen immediately after spiking (Fig. 11, 35°C). This may be an indication of an analytical error during the preparation or analysis of the spiked wetcake samples. However, this issue does not invalidate the general regrowth trends observed in unspiked wetcake samples but it may be relevant for the trends observed in spiked wetcake samples.

6.4 Fecal coliform regrowth under centrifuge simulated conditions

Fecal coliform inoculant may originate from bacterial contamination introduced during the centrifugation process. Thus, the objective of this study was to evaluate fecal coliform regrowth in digested sludge centrifuged in the laboratory under conditions that simulate the field dewatering system. Possible sources of bacterial contamination tested included the polymer and the high pressure effluent (HPE).

Digested sludge samples were collected from Terminal Island Treatment Plant (TITP) on November 15, 2001 since thermophilic samples from HTP were unavailable at that time. However, HPE, concentrated polymer, and field diluted polymer samples were collected from HTP on the same day. Sludge and various combinations of HPE and polymer were mixed to prepare four batches.

Batch 1 (Blank):	digested sludge
Batch 2 (Blank + HPE):	digested sludge + HPE
Batch 3 (Blank + polymer):	digested sludge + lab diluted polymer (with fresh sterile water)
Batch 4 (Blank + HPE + polymer):	digested sludge + field diluted polymer (with HPE)

The batches were centrifuged to a density of approximately 10% total solids in laboratory centrifuges. After centrifugation, the relatively concentrated solids were transferred to sample bottles that were incubated for selected time intervals at four temperatures, 25, 37, 44.5, and 55°C (78, 99, 115, 131°F). All sample preparation operations were performed following strict QA/QC procedures to avoid bacterial contamination. Photographs of activities performed during this experiment are presented in Appendix 7.5.

Negligible regrowth, well below the legal limit, was observed after 96 hrs at 25, 37°C in all four digested sludge batches (Figures 15, and 16). Small regrowth was also observed in some samples at 44.5°C after 72 hrs (Figure 17). However, the fecal coliform counts

decreased to the initial levels at 96hrs. At the highest temperature tested 55°C (131°F), all counts were at or below the threshold and no regrowth was observed (Figure 18).

This study showed that negligible regrowth was observed in digested dewatered sludge. The increase in fecal coliform densities was well below the legal limit, indicating that the amount of bacteria that may have survived digestion was not sufficient to produce a considerable regrowth as the number observed in the wetcake samples at the truck. It also indicates that the HPE and the polymer are not significant sources of fecal coliform contamination.

It should be mentioned that total solid content of the dewatered sludge obtained by centrifugation in the laboratory was only about 10%, which is one third of the content present in dewatered biosolids in the plant centrifuge. Therefore, regrowth results from this study should be interpreted with some caution.

General Recommendations

It is clear from all the studies presented in this section that *Salmonella* regrowth is not an issue in wetcake samples at any point of the post-digestion train.

Conflicting results of fecal coliform regrowth were obtained from the several studies presented in this section, making it unclear wether regrowth, contamination or both are responsible for the high fecal coliform counts observed at the truck. Therefore, it is important to discuss and define an experimental protocol to re-evaluate the role of contamination and regrowth. The following are issues to be considered in the future protocol:

1) Triplicate samples should be included in order to evaluate experimental variability, especially when working with wetcake samples that are highly heterogeneous in nature.
2) More strict sample controls should be implemented to ensure recovery of spiked organisms in wetcake samples.
3) Simulation of dewatering experiments needs to be performed using wetcake samples with similar total solid concentrations to the field samples in order to obtain conclusions that can be fully extrapolated to the field conditions.
4) A thorough evaluation of the fecal coliform contribution from the HPE and the polymer needs to be conducted. The fecal coliform density in the diluted polymer needs to be evaluated since diluted polymer is prepared by diluting concentrated polymer with HPE and small fecal coliform amounts carried with the HPE may increase during the temporal storage of the diluted polymer in the field. In addition to the fecal coliform densities in HPE and polymer, frequency and quantity of application of both have to be considered.

Figure 8. *Salmonella* in spiked wetcake (October 15, 2001)

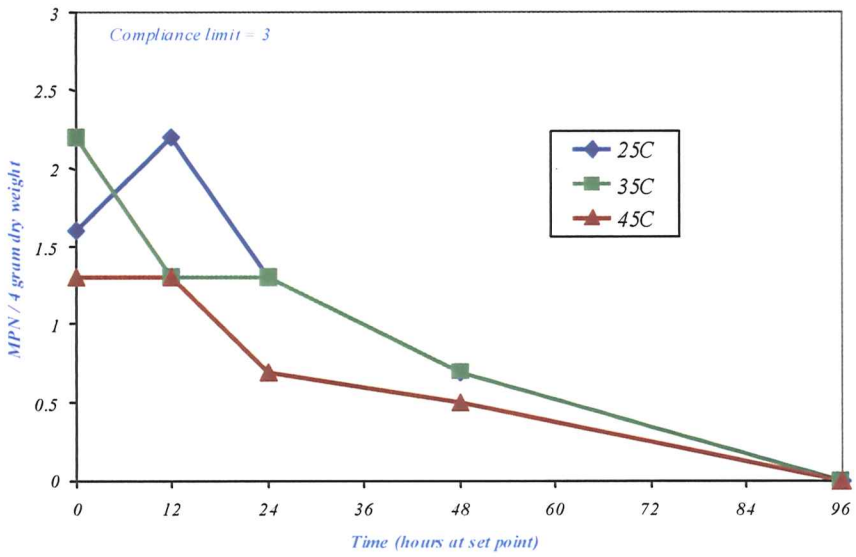


Figure 9. *Salmonella* in spiked thermophilic sludge (October , 2001)

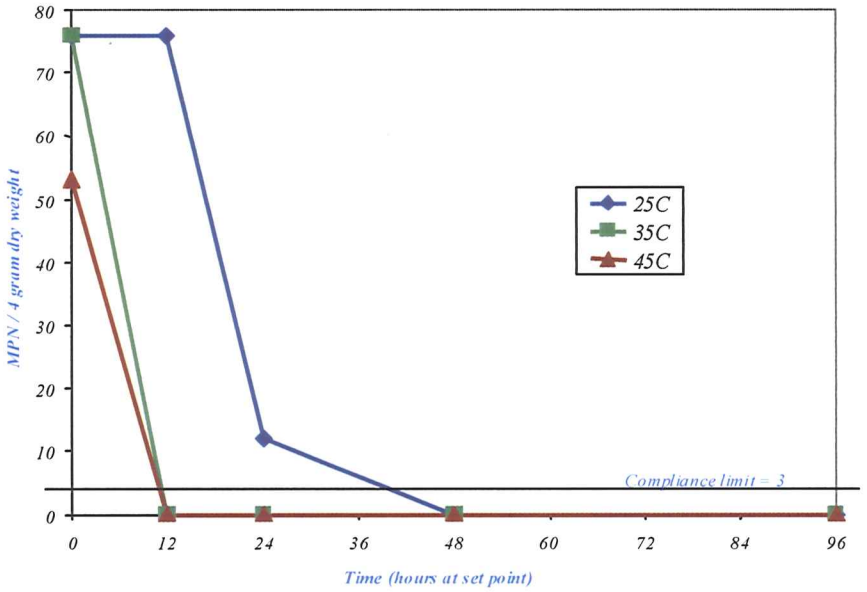


Figure 10. Fecal coliform in unspiked wetcake (October 15, 2001)

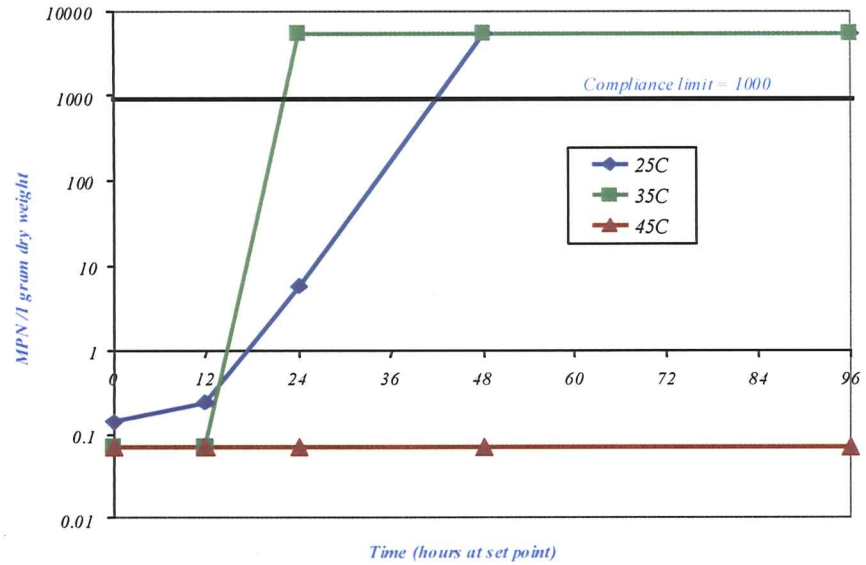


Figure 11. Fecal coliform in spiked wetcake (October 15, 2001)

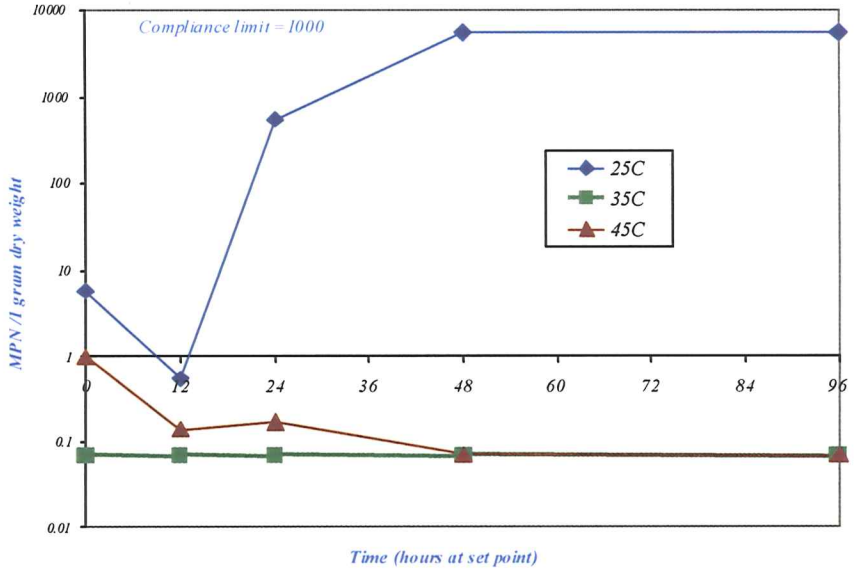


Figure 12. Fecal coliform in spiked thermophilic sludge (October 15, 2001)

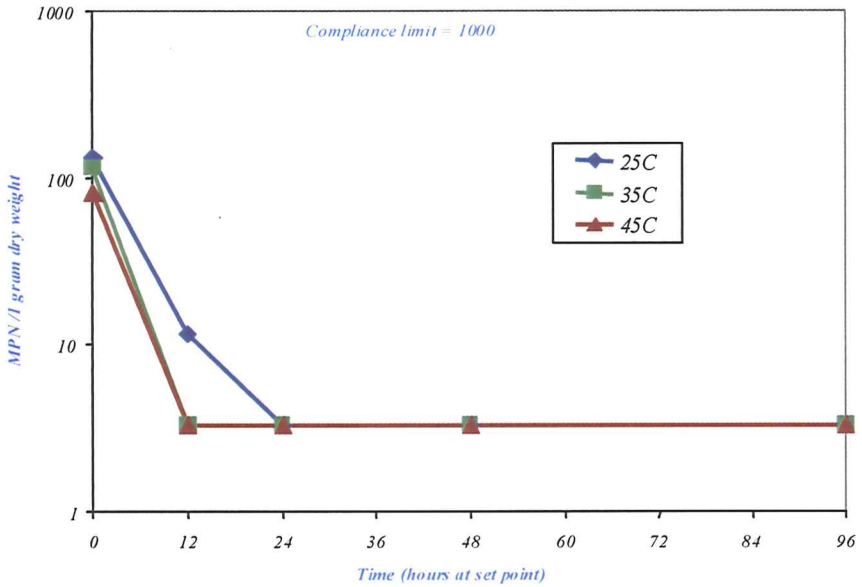


Figure 13. Fecal coliform in unspiked thermophilic sludge (December 5, 2001)

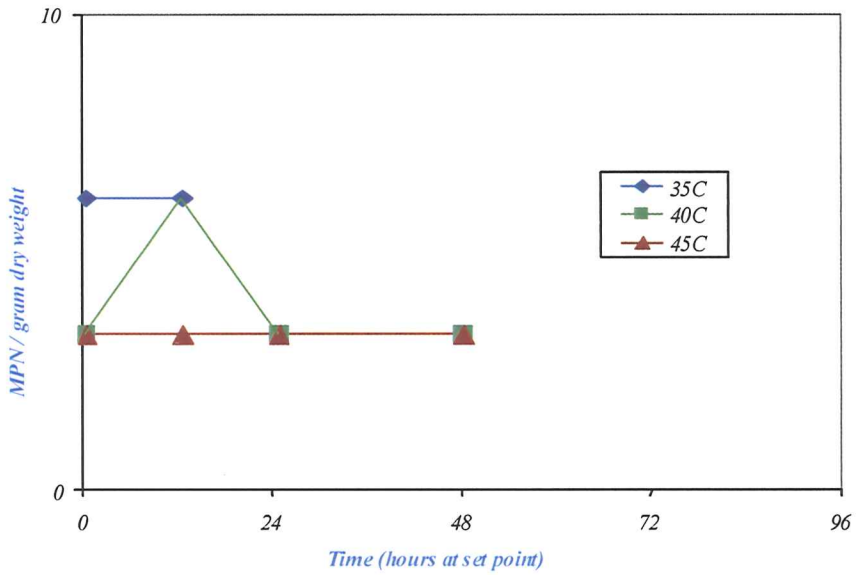


Figure 14. Fecal coliform in spiked thermophilic sludge (December 5, 2001)

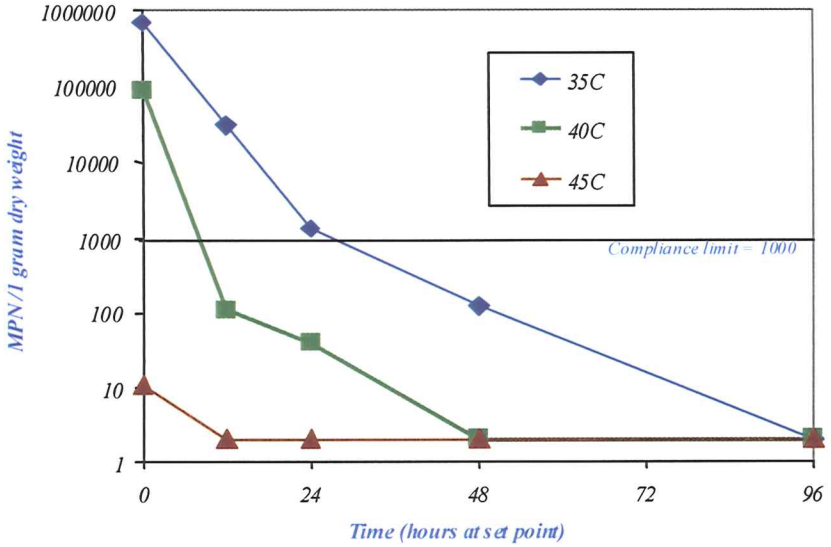


Figure 15. Regrowth results at 78 °F (25 °C)

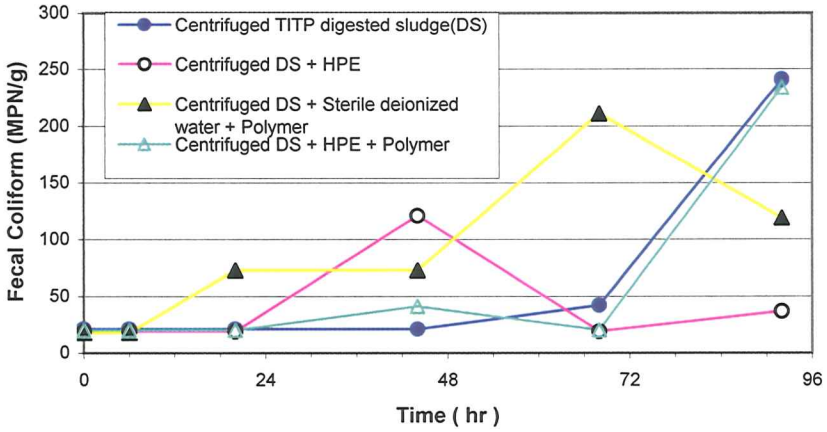


Figure 16. Regrowth results at 99 °F (37 °C)

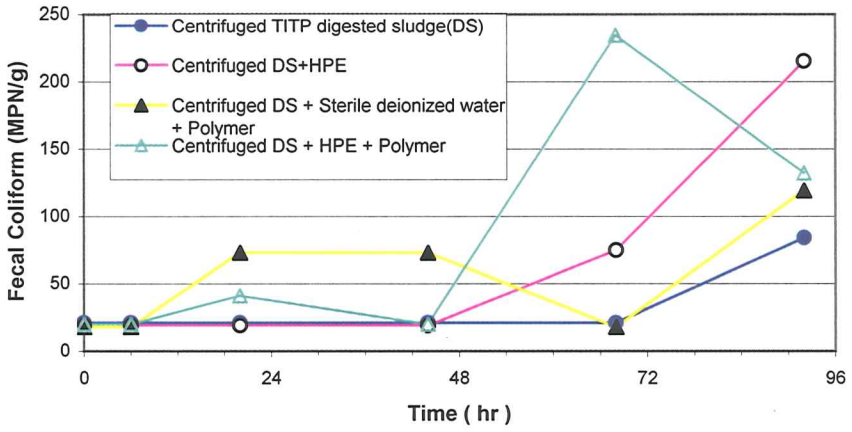


Figure 17. Regrowth results at 115 °F (44.5 °C)

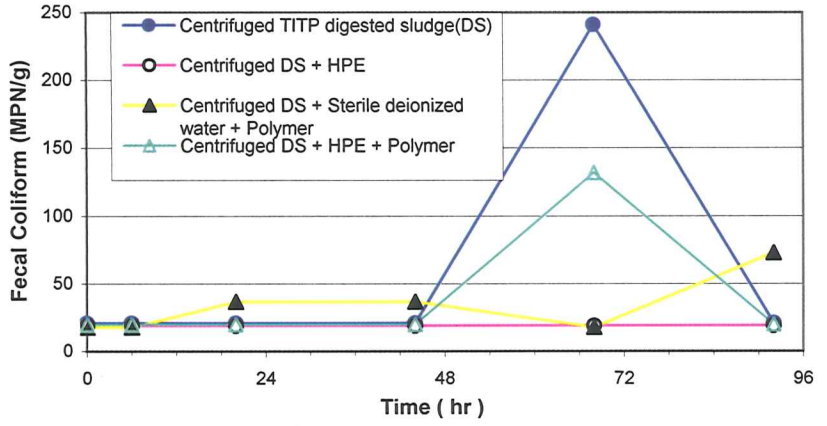
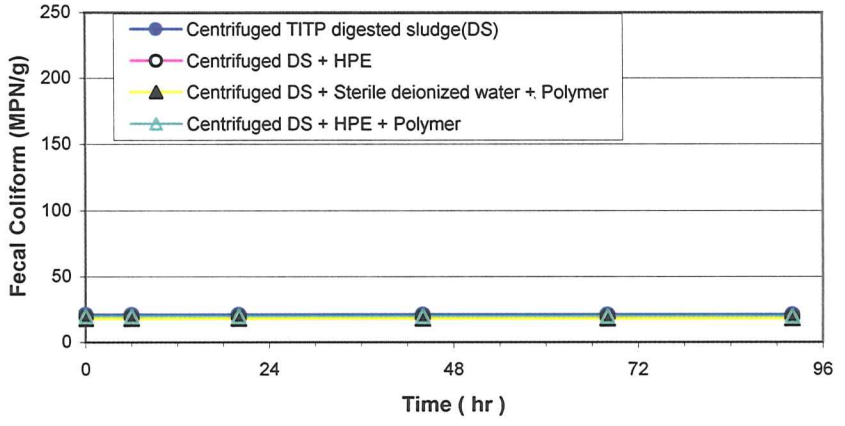


Figure 18. Regrowth results at 131 °F (55 °C)



7. APPENDICES

7.1 Legal Aspects of the 40 CFR Part 503 Rule

The Part 503 Biosolids Rule for POTWs

This appendix provides a short summary of the regulations of the 40 CFR Part 503 Rule (commonly referred to as the Part 503 (Biosolids) Rule, published in 1993), in particular to the production and land application of Class A biosolids. The Part 503 Rule applies to POTWs (§503.10):

- with a design flow greater than 1 mgd;
- that serve a population of 10,000 people or more;
- that are Class I biosolids management facilities.

Exceptional Quality Biosolids

Although not as such specified and defined in the Part 503 Rule, interpretation of the regulations indicates that four types of biosolids with a different quality can be distinguished. The term Exceptional Quality (EQ) biosolids was first introduced in a 1995 Federal publication (The Plain English Guide to the Part 503 Rule) and defined and is reserved for the highest quality of biosolids meeting the most stringent limits and regulations of the Part 503 Rule.

In order to be classified as EQ, biosolids produced from sludge must meet the strictest requirements in all of the three following categories:

1 pollutant (heavy metals) concentration limits, as specified in §503.13;
2 reduction of pathogen densities, as specified in §503.32;
3 reduction of the vector attraction, as specified in §503.33.

The specific requirements for EQ biosolids will be discussed in more detail in later sections of this Appendix.

Safety Concerns of Biosolids Land Application

Land application of the various classes of biosolids is equally safe as is specifically emphasized by the EPA. For EQ biosolids, it is assumed that this product is as safe as any other fertilizer and, hence, EQ biosolids can be applied to land without any site restrictions, general requirements and management practices. Other classes of biosolids face regulations that become more stringent with decreasing product quality. It is because of these regulations that poorer quality biosolids can be applied equally safe as EQ biosolids, provided that regulations specific to the class of biosolids are being met. It should however be noted that the Part 503 Rule allows state and local authorities to impose additional requirements to biosolids land application (§503.5), and they may therefore require the use of EQ biosolids only.

Class A Biosolids

The purpose of thermophilic digestion is to produce Class A biosolids, as described in this report. It should be noted that "Class A Biosolids" is not a specific category of biosolids under the Part 503 Rule. Class A biosolids meet the strictest pathogen reduction requirements, however, the Class A designation does not relate to the extend of meeting

the requirements for vector attraction reduction and pollutant limit concentrations. Class A and EQ biosolids are therefore not necessarily the same, although it can be said that EQ biosolids are Class A with respect to pathogens.

Pollutant Limit and Ceiling Concentrations

Regulations with respect to pollutant concentrations in biosolids have only been formulated for ten toxic heavy metals, as summarized in Table 13. Land application of any class of biosolids is not allowed if one or more of the pollutant ceiling concentrations are exceeded. If all heavy metal concentrations are less than the limit concentrations in Table 13, the biosolids are considered to be safe with respect to pollutants. This is the case for EQ biosolids, which can be applied to land unrestricted provided the application rate is not greater than the agronomic rate.

Table 13. Pollutant ceiling and limit concentrations.

Metal	Ceiling concentration[a] (mg/kg dry total solids)	Limit concentration[b] (mg/kg dry total solids)
Arsenic	75	41
Cadmium	85	39
Chromium	3000	1200
Copper	4300	1500
Lead	840	300
Mercury	57	17
Molybdenum[c]	75	
Nickel	420	420
Selenium	100	36
Zinc	7500	2800

[a] Table 1 in §503.13. [b] Table 3 in §503.13. [c] Limits for molybdenum are pending.

Pathogen Reductions

In order to qualify as Class A, biosolids must meet a general requirement for pathogen reduction and in addition undergo one of six specified treatment alternatives. Limits for bacterial densities have been formulated for *Salmonella* sp. and fecal coliform. For Class A biosolids (and thus for EQ biosolids), only one of both bacterial densities need to be reduced to less than the limit, as specified in Table 14. These limits correspond to the method detection limits: thus, Class A biosolids can be considered safe with respect to pathogens.

Table 14. General bacterial density limits for Class A biosolids (§503.32).

Organism	Class A
Fecal coliform	< 1000 MPN/g dry total solids
Salmonella sp. bacteria	< 3 MPN/4 g dry total solids

Section §503.32 of the Part 503 Rule specifies 6 alternatives to achieve the Class A requirements. Thermophilic anaerobic digestion falls under alternative 1 (§503.32(a)(3)(ii)), containing four treatments with time-temperature specifications. Selection of the time-temperature relationship depends on the solids content of the biosolids (more or less than 7%), the particle size, and the selected ranges of temperature

and/or time for treatment. For HTP sludge, which has a solids content significantly less than 7%, the following time-temperature equation would apply (§503.32(a)(3)(ii)D):

$D = 50{,}070{,}000 / 10^{0.14T}$,

where T is the temperature (^{0}C) and D the required time of treatment (days). It is important to emphasize that the above equation should be applied to a batch process (where all material meets the time-temperature relationship) rather than to a continuous process (characterized by the mean residence time). Further requirements to this treatment include a temperature of 50^{0}C (122 degrees F) or higher and a treatment time of at least 30 minutes.

Vector Attraction Reduction

The Part 503 Rule lists 12 options to meet the vector attraction reduction, of which 8 options would apply for production of EQ biosolids (§503.33). Thermophilic anaerobic digestion at HTP reduces the mass of volatile solids by over 50%, which is greater than the imposed minimum reduction of 38% required in option 1 (§503.33(b)(1)). Thus, vector attraction reduction requirements are in general easily met by thermophilic anaerobic digestion at HTP.

Literature references pertinent to this appendix are included in Appendix 7.4.

7.2 Operational instructions

The following section contains detailed operational instruction during thermophilic operation.

Approx. time	Operating instruction
10/4/01 13:00	When tank 5D1 fills up, 1. Reduce the PS flow to 500 gpm and TWAS flow to 100 gpm. 2. Start the holding cycle for tank 5D1 3. Start feeding tank 6D1
10/5/01 9:00	When the holding cycle completes, 1. Start the discharge cycle at the rate of 1400 gpm. Send 500 gpm to dewatering section and the rest, 900 gpm, to the blending tanks.
10/5/01 20:00	11 hours after discharging the sludge at the rate of 1400 gpm, 1. Reduce the discharge rate to 500 gpm 2. Secure the flow to the blending tanks.
10/7/01 3:00	When Tank 6D1 fills up, 1. Secure the PS and TWAS flow to D1 battery. (PS flow = 0 gpm, TWAS flow = 0 gpm) 2. Start the holding cycle for 6D1
10/7/01 16:00	At the completion of tank 5D1 discharge cycle,
10/7/01 1700	At the completion of tank 5D1 discharge cycle, 1. start following STEP 6-5 of "Battery D1 Manual Batch Mode Operation Sequencing Steps, Continuous Discharge Mode"
10/9/01 2300	When tank 5D1 fills up, 1. Secure WW #1 pump(s) 2. Close 5D1 DS feed valve 3. Increase D2 battery PS flow by 133 gpm 4. Increase E battery PS flow by 133 gpm 5. Secure D1 PS flow 6. Decrease D1 TWAS setpoint to 0 gpm 7. Adjust D2 and E battery TWAS flow to split the TWAS flow between D2 and E batteries 8. Start 5D1 mixer 9. Close 1D1, 2D1, 3D1, and 4D1 discharge valves manually 10. Put 1D1, 2D1, 3D1, and 4D1 out of service

11. Verify that PS feed, TWAS feed, and DS discharge valves for tank 1D1, 2D1, 3D1, and 4D1 are closed and in manual mode
12. Verify that 6D1 DS feed valve is closed and in manual mode
13. Verify that 6D1 DS discharge valve is open and in manual mode
14. Verify that 5D1 feed valve is closed and in manual mode
15. Verify that 5D1 DS discharge valve is closed and in manual mode

10/10/01 1900 At the completion of tank 5D1 discharge cycle,

1. Stop the 5D1 mixer
2. Open 5D1 discharge valve (MOV)
3. Open 5D1 discharge flow control valve by setting the controller output to 100%
4. Keep the WW #2 pump running
5. Close 6D1 discharge valve (MOV)
6. Close 6D1 discharge flow control valve by setting the controller output to 0%
7. Adjust 5D1 discharge flow to 500 gpm
8. Open 6D1 DS feed valve
9. Start a WW #1 pump
10. Put 1D1 tank in service
11. Put 1D1 PS feed, TWAS feed, and DS discharge valves in auto mode.
12. Repeat Step #10 and #11 for tank 2D1, 3D1, and 4D1
13. Increase D1 TWAS flowrate to 100 gpm
14. Adjust D2 and E battery TWAS flowrate
15. Increase the D1 PS flowrate to 400 gpm
16. Decrease the PS flow to D2 battery by 133 gpm
17. Decrease the PS flow to E battery by 133 gpm

10/10/01 0000 When tank 5D1 fills up,

1. Secure the WW #1 steam injector (for 23 operator only)
2. Secure WW #1 pump(s)
3. Close 5D1 DS feed valve
4. Increase D2 battery PS flow by 133 gpm
5. Increase E battery PS flow by 133 gpm
6. Secure D1 PS flow
7. Decrease D1 TWAS setpoint to 0 gpm
8. Adjust D2 and E battery TWAS flow to split the TWAS flow between D2 and E batteries
9. Start 5D1 mixer
10. From DCS, close 1D1, 2D1, 3D1, and 4D1 discharge valves.
11. Change the service mode for 1D1, 2D1, 3D1, and 4D1 to "OUT"

12. Verify that PS feed, TWAS feed, and DS discharge valves for tank 1D1, 2D1, 3D1, and 4D1 are closed and in manual mode
13. Verify that 6D1 DS feed valve is closed and in manual mode
14. Verify that 6D1 DS discharge valve is open and in manual mode
15. Verify that 5D1 feed valve is closed and in manual mode
16. Verify that 5D1 DS discharge valve is closed and in manual mode

10/10/01 1200 After 12 hours of holding, (ignore the bottom discharge totalizer reading)

1. Stop the 5D1 mixer
2. Open 5D1 discharge valve (MOV)
3. Open 5D1 discharge flow control valve by setting the controller output to 100%
4. Keep the WW #2 pump running
5. Close 6D1 discharge valve (MOV)
6. Close 6D1 discharge flow control valve by setting the controller output to 0%
7. Adjust 5D1 discharge flow to 500 gpm
8. Open 6D1 DS feed valve
9. Start a WW #1 pump
10. Put 1D1 tank in service
11. Put 1D1 PS feed, TWAS feed, and DS discharge valves in auto mode.
12. Repeat Step #10 and #11 for tank 2D1, 3D1, and 4D1
13. Increase D1 TWAS flowrate to 100 gpm
14. Adjust D2 and E battery TWAS flowrate
15. Increase the D1 PS flowrate to 500 gpm
16. Decrease the PS flow to D2 battery by 133 gpm
17. Decrease the PS flow to E battery by 133 gpm

10/13/01 0030 When tank 6D1 fills up,

16. Secure the WW #1 steam injector (for 23 operator only)
17. Secure WW #1 pump(s)
18. Close 6D1 DS feed valve
19. Increase D2 battery PS flow by 133 gpm
20. Increase E battery PS flow by 133 gpm
21. Secure D1 PS flow
22. Decrease D1 TWAS setpoint to 0 gpm
23. Adjust D2 and E battery TWAS flow to split the TWAS flow between D2 and E batteries
24. Start 6D1 mixer
25. From DCS, close 1D1, 2D1, 3D1, and 4D1 discharge valves.

26. Change the service mode for 1D1, 2D1, 3D1, and 4D1 to "OUT"
27. Verify that PS feed, TWAS feed, and DS discharge valves for tank 1D1, 2D1, 3D1, and 4D1 are closed and in manual mode
28. Verify that 5D1 DS feed valve is closed and in manual mode
29. Verify that 5D1 DS discharge valve is open and in manual mode
30. Verify that 6D1 feed valve is closed and in manual mode
31. Verify that 6D1 DS discharge valve is closed and in manual mode

10/13/01 No sampling on Saturday

10/13/01 1300 After 12 hours of holding, (ignore the bottom discharge totalizer reading)

1. Stop the 6D1 mixer
2. Open 6D1 discharge valve (MOV)
3. Open 6D1 discharge flow control valve by setting the controller output to 100%
4. Keep the WW #2 pump running
5. Close 5D1 discharge valve (MOV)
6. Close 5D1 discharge flow control valve by setting the controller output to 0%
7. Adjust 6D1 discharge flow to 400 gpm
8. Open 5D1 DS feed valve
9. Start a WW #1 pump
10. Put 1D1 tank in service
11. Put 1D1 PS feed, TWAS feed, and DS discharge valves in auto mode.
12. Repeat Step #10 and #11 for tank 2D1, 3D1, and 4D1
13. Increase D1 TWAS flowrate to 100 gpm
14. Adjust D2 and E battery TWAS flowrate
15. Increase the D1 PS flowrate to 500 gpm
16. Decrease the PS flow to D2 battery by 133 gpm
17. Decrease the PS flow to E battery by 133 gpm

10/14/01 – 10/16/01 No sampling

7.3 Raw data

The following section contains raw data obtained from laboratory analyses.

Salmonella Test Results from BioVir

Sample Date	Location	MPN/4 dry gram
11/8/01	TWAS	<2.6
11/8/01	Primary Sludge	5.1
11/13/01	Digested Sludge	<2.2
11/13/01	TWAS	<1.8
11/13/01	Primary Sludge	3.3
11/14/01	Digested Sludge	<2.4
11/14/01	TWAS	4.4
11/14/01	Primary Sludge	11
11/15/01	Digested Sludge	<2.4
11/15/01	TWAS	<2.4
11/15/01	Primary Sludge	13
11/19/01	Digested Sludge	<2.3
11/19/01	TWAS	<2.4
11/19/01	Primary Sludge	>18.0
11/20/01	Digested Sludge	<2.4
11/20/01	TWAS	<2.4
11/20/01	Primary Sludge	7.7
11/26/01	Digested Sludge	3.8
11/26/01	TWAS	2.3
11/26/01	Primary Sludge	7
11/27/01	Digested Sludge	<2.0
11/27/01	TWAS	2.1
11/27/01	Primary Sludge	11.4
11/28/01	Digested Sludge	<7.3
11/28/01	TWAS	<2.1
11/28/01	Primary Sludge	>10.6

Fecal Coliform Test Results from EMD

Sample Date	Location	MPN/ dry gram
11/6/01	Pri Sludge	1.7E+08
11/6/01	TWAS	1.8E+07
11/7/01	Pri Sludge	9.4E+07
11/7/01	TWAS	1.4E+07
11/8/01	Pri Sludge	2.7E+07
11/8/01	TWAS	1.4E+07

MPN/dry gram = (MPN/100ml) / %TS

Salmonella Test Results from BioVir

Sample Date	Location	MPN/4 dry gram
10/1/01	5D1	<1.3
10/1/01	Location #3	<1.4
10/2/01	Location #4	<1.6
10/3/01	5D1	<1.8
10/3/01	Location #3	<1.5
10/4/01	Location #4	<1.8
10/9/01	Location #3	<2.1
10/9/01	Location #4	<2.2
10/9/01	6D1	<1.8
10/10/01	5D1	<2.2
10/10/01	Location #3	<1.7
10/10/01	Location #4	<1.5
10/10/2001 *	6D1	<0.41
10/10/2001 *	Location #3	<0.27
10/11/01	Location #3	<1.3
10/11/01	Location #4	<1.5
10/11/01	5D1	<2.5
10/15/01	6D1	<2.0
10/15/01	Location #3	<1.3
10/15/01	Location #4	<1.4
10/16/2001 *	5D1	<0.41
10/16/2001 *	Location #3	<0.252
10/16/2001 *	Location #4	<0.261
10/16/01	5D1	<1.8
10/16/01	Location #3	<1.5
10/16/01	Location #4	<1.4

* Samples were anlayzed by LA County Sanitation Distict

Fecal Coliform Test Results from EMD

Sample Date	Location	MPN/ dry gram
10/5/01	5D1	< 1.1E+01
10/5/01	#2	< 1.1E+02
10/5/01	#3	1.4E+02
10/5/01	#5	< 1.2E+02
10/6/01	5D1	1.2E+02
10/6/01	#2	< 1.3E+02
10/6/01	#3	< 6.2E+01
10/6/01	#4	>= 5.4E+05
10/6/01	#5	< 1.1E+02
10/7/01	5D1	< 1.2E+01
10/7/01	#2	< 1.1E+02
10/7/01	#3	< 6.5E+01
10/7/01	#4	5.4E+05
10/7/01	#5	< 1.3E+02
10/8/01	6D1	9.2E+01
10/8/01	#2	< 1.1E+02
10/8/01	#3	< 6.4E+01
10/8/01	#4	>= 5.4E+05
10/8/01	#5	< 1.1E+02
10/9/01	6D1	1.6E+02
10/9/01	#2	< 1.1E+02
10/9/01	#3	< 7.2E+01
10/9/01	#4	1.1E+04
10/9/01	#5	< 1.2E+02
10/10/01	6D1	1.2E+02
10/10/01	#2 **	7.8E+02
10/10/01	#3	< 6.8E+01
10/10/01	#4	>= 5.4E+05
10/10/01	#5	< 1.3E+02

Sample Date	Location	MPN/ dry gram
10/11/01	5D1	< 1.2E+01
10/11/01	#2	5.8E+02
10/11/01	#3	< 6.7E+01
10/11/01	#4	>= 5.5E+05
10/11/01	#5	< 1.2E+02
10/12/01	5D1	1.4E+02
10/12/01	#2	< 8.8E+01
10/12/01	#3	< 6.7E+01
10/12/01	#4	1.7E+05
10/12/01	#5	< 1.2E+02
10/15/01	6D1	< 1.1E+02
10/15/01	#2	< 1.1E+02
10/15/01	#3	< 5.9E+01
10/15/01	#4	>= 5.2E+05
10/15/01	#5	< 1.1E+02
10/16/01	5D1	< 1.0E+02
10/16/01	#2	< 1.1E+02
10/16/01	#3	< 6.3E+01
10/16/01	#4	>= 5.2E+05
10/16/01	#5	< 1.1E+02

Hyperion Treatment Plant - Class A Biosolids Project
Fecal Coliform Test Results

Draft: 11/06/01

Month: October, 2001

Sample Date	Location	MPN/ dry gram
10/11/01	Locn #4 Regrowth (0hr)	>= 5.4E+06
10/11/01	Locn #4 Regrowth (29hr)	>= 5.4E+06
10/11/01	Locn #4 Regrowth (49hr)	>= 5.4E+06
10/11/01	Locn #4 Regrowth (74hr)	1.0E+08
10/11/01	Locn #4 Regrowth (100hr)	8.1E+07
10/11/01	Locn #4 Regrowth (121hr)	5.4E+08
10/11/01	Locn #4 Regrowth (142hr)	1.7E+08
10/11/01	Locn #4 Regrowth (172hr)	8.1E+07
10/11/01	Locn #4 Regrowth (193hr)	1.0E+08
10/11/01	Locn #4 Regrowth (216hr)	3.0E+08
10/11/01	Locn #4 Regrowth (240hr)	8.1E+07
10/11/01	Locn #4 Regrowth (289hr)	4.4E+07
10/11/01	Locn #4 Regrowth (336hr)	AE
10/11/01	Locn #4 Regrowth (436hr)	4.4E+06
10/16/01	Locn #3 Regrowth (0hr)	< 6.3E+01
10/16/01	Locn #3 Regrowth (22hr)	< 6.3E+04
10/16/01	Locn #3 Regrowth (48hr)	< 6.3E+01
10/16/01	Locn #3 Regrowth (71hr)	< 6.3E+00
10/16/01	Locn #3 Regrowth (94hr)	< 6.3E+00
10/16/01	Locn #3 Regrowth (118hr)	6.3E+00
10/16/01	Locn #3 Regrowth (165hr)	< 6.3E+00
10/16/01	Locn #3 Regrowth (214hr)	AE
10/16/01	Locn #3 Regrowth (307hr)	< 6.3E+00
10/16/01	Locn #3 Regrowth (356hr)	6.9E+01
10/16/01	Locn #3 Regrowth (380hr)	4.1E+01
10/16/01	Locn #3 Regrowth (405hr)	< 6.3E+00
10/16/01	Locn #3 Regrowth (430hr)	< 6.3E+00

Note: 5D1 or 6D1 = Location #1(Digester), Location #2 = Centrifuge Feed, Location #3 = Centrifuge Cake, Location #4 = Silo#4 (Truck Loading), Location #5 = C7 Wet Well

Hyperion Treatment Plant: November 2001 - Class A Biosolids Project (Time and Temperature Study)
Fecal Coliform Results from EMD

Sample Date	Location	Time Tested	Temperature (°F)	Temperature (°C)	MPN/ dry gram
11/15/01	BATCH 1	0 hour	78	25	< 21
11/15/01	BATCH 1	0 hour (Dup.)	78	25	< 21
11/15/01	BATCH 1	6 hours	78	25	< 21
11/15/01	BATCH 1	20 hours	78	25	< 21
11/15/01	BATCH 1	44 hours	78	25	21
11/15/01	BATCH 1	68 hours	78	25	42
11/15/01	BATCH 1	92 hours	78	25	241
11/15/01	BATCH 1	116 hours	78	25	AE
11/15/01	BATCH 1	0 hour	99	37	< 21
11/15/01	BATCH 1	6 hours	99	37	< 21
11/15/01	BATCH 1	20 hours	99	37	< 21
11/15/01	BATCH 1	44 hours	99	37	21
11/15/01	BATCH 1	68 hours	99	37	21
11/15/01	BATCH 1	92 hours	99	37	84
11/15/01	BATCH 1	116 hours	99	37	AE
11/15/01	BATCH 1	0 hour	115	44.5	< 21
11/15/01	BATCH 1	6 hours	115	44.5	< 21
11/15/01	BATCH 1	20 hours	115	44.5	< 21
11/15/01	BATCH 1	44 hours	115	44.5	< 21
11/15/01	BATCH 1	44 hours (Dup.)	115	44.5	< 21
11/15/01	BATCH 1	68 hours	115	44.5	241
11/15/01	BATCH 1	92 hours	115	44.5	21
11/15/01	BATCH 1	116 hours	115	44.5	AE
11/15/01	BATCH 1	0 hour	131	55	< 21
11/15/01	BATCH 1	6 hours	131	55	< 21
11/15/01	BATCH 1	20 hours	131	55	21
11/15/01	BATCH 1	44 hours	131	55	< 21
11/15/01	BATCH 1	68 hours	131	55	< 21
11/15/01	BATCH 1	92 hours	131	55	< 21
11/15/01	BATCH 1	116 hours	131	55	AE
11/15/01	BATCH 2	0 hour	78	25	< 19
11/15/01	BATCH 2	6 hours	78	25	< 19
11/15/01	BATCH 2	20 hours	78	25	< 19
11/15/01	BATCH 2	44 hours	78	25	121
11/15/01	BATCH 2	68 hours	78	25	19
11/15/01	BATCH 2	92 hours	78	25	37
11/15/01	BATCH 2	116 hours	78	25	AE
11/15/01	BATCH 2	0 hour	99	37	< 19
11/15/01	BATCH 2	6 hours	99	37	< 19
11/15/01	BATCH 2	6 hours (Dup.)	99	37	< 19
11/15/01	BATCH 2	20 hours	99	37	< 19
11/15/01	BATCH 2	44 hours	99	37	19
11/15/01	BATCH 2	68 hours	99	37	75
11/15/01	BATCH 2	92 hours	99	37	215
11/15/01	BATCH 2	116 hours	99	37	AE
11/15/01	BATCH 2	0 hour	115	44.5	< 19
11/15/01	BATCH 2	6 hours	115	44.5	< 19
11/15/01	BATCH 2	20 hours	115	44.5	< 19
11/15/01	BATCH 2	44 hours	115	44.5	< 19
11/15/01	BATCH 2	68 hours	115	44.5	19
11/15/01	BATCH 2	92 hours	115	44.5	< 19
11/15/01	BATCH 2	116 hours	115	44.5	AE
11/15/01	BATCH 2	0 hour	131	55	< 19
11/15/01	BATCH 2	6 hours	131	55	< 19
11/15/01	BATCH 2	20 hours	131	55	< 19
11/15/01	BATCH 2	44 hours	131	55	< 19
11/15/01	BATCH 2	68 hours	131	55	< 19
11/15/01	BATCH 2	68 hours (Dup.)	131	55	< 19
11/15/01	BATCH 2	92 hours	131	55	< 19
11/15/01	BATCH 2	116 hours	131	55	NS
11/15/01	BATCH 3	0 hour	78	25	< 18
11/15/01	BATCH 3	6 hours	78	25	< 18
11/15/01	BATCH 3	20 hours	78	25	73
11/15/01	BATCH 3	44 hours	78	25	73
11/15/01	BATCH 3	68 hours	78	25	211
11/15/01	BATCH 3	92 hours	78	25	119
11/15/01	BATCH 3	116 hours	78	25	AE

Hyperion Treatment Plant: November 2001 - Class A Biosolids Project (Time and Temperature Study)
Fecal Coliform Results from EMD

Sample Date	Location	Time Tested	Temperature (°F)	Temperature (°C)	MPN/ dry gram
11/15/01	BATCH 3	0 hour	99	37	< 18
11/15/01	BATCH 3	6 hours	99	37	< 18
11/15/01	BATCH 3	20 hours	99	37	73
11/15/01	BATCH 3	44 hours	99	37	73
11/15/01	BATCH 3	68 hours	99	37	< 18
11/15/01	BATCH 3	68 hours (Dup.)	99	37	< 18
11/15/01	BATCH 3	92 hours	99	37	211
11/15/01	BATCH 3	92 hours (dup.)	99	37	119
11/15/01	BATCH 3	116 hours	99	37	AE
11/15/01	BATCH 3	0 hour	115	44.5	< 18
11/15/01	BATCH 3	6 hours	115	44.5	< 18
11/15/01	BATCH 3	6 hours (Dup.)	115	44.5	< 18
11/15/01	BATCH 3	20 hours	115	44.5	37
11/15/01	BATCH 3	44 hours	115	44.5	37
11/15/01	BATCH 3	68 hours	115	44.5	< 18
11/15/01	BATCH 3	92 hours	115	44.5	73
11/15/01	BATCH 3	92 hours (Dup.)	115	44.5	73
11/15/01	BATCH 3	116 hours	115	44.5	AE
11/15/01	BATCH 3	0 hour	131	55	< 18
11/15/01	BATCH 3	6 hours	131	55	< 18
11/15/01	BATCH 3	20 hours	131	55	< 18
11/15/01	BATCH 3	20 hours (Dup.)	131	55	< 18
11/15/01	BATCH 3	44 hours	131	55	< 18
11/15/01	BATCH 3	68 hours	131	55	< 18
11/15/01	BATCH 3	92 hours	131	55	< 18
11/15/01	BATCH 3	116 hours	131	55	AE
11/15/01	BATCH 4	0 hour	78	25	< 20
11/15/01	BATCH 4	6 hours	78	25	< 20
11/15/01	BATCH 4	20 hours	78	25	< 20
11/15/01	BATCH 4	44 hours	78	25	41
11/15/01	BATCH 4	68 hours	78	25	20
11/15/01	BATCH 4	92 hours	78	25	234
11/15/01	BATCH 4	116 hours	78	25	AE
11/15/01	BATCH 4	0 hour	99	37	< 20
11/15/01	BATCH 4	6 hours	99	37	< 20
11/15/01	BATCH 4	20 hours	99	37	41
11/15/01	BATCH 4	44 hours	99	37	< 20
11/15/01	BATCH 4	68 hours	99	37	234
11/15/01	BATCH 4	92 hours	99	37	132
11/15/01	BATCH 4	116 hours	99	37	AE
11/15/01	BATCH 4	0 hour	115	44.5	< 20
11/15/01	BATCH 4	6 hours	115	44.5	< 20
11/15/01	BATCH 4	20 hours	115	44.5	< 20
11/15/01	BATCH 4	20 hours (Dup.)	115	44.5	< 20
11/15/01	BATCH 4	44 hours	115	44.5	20
11/15/01	BATCH 4	68 hours	115	44.5	132
11/15/01	BATCH 4	92 hours	115	44.5	< 20
11/15/01	BATCH 4	116 hours	115	44.5	AE
11/15/01	BATCH 4	0 hour	131	55	< 20
11/15/01	BATCH 4	0 hour	131	55	< 20
11/15/01	BATCH 4	6 hours	131	55	< 20
11/15/01	BATCH 4	20 hours	131	55	< 20
11/15/01	BATCH 4	44 hours	131	55	< 20
11/15/01	BATCH 4	44 hours (Dup.)	131	55	< 20
11/15/01	BATCH 4	68 hours	131	55	< 20
11/15/01	BATCH 4	92 hours	131	55	< 20
11/15/01	BATCH 4	116 hours	131	55	NS

BATCH 1: Digested Sludge (DS)
BATCH 2: DS + HPE
BATCH 3: DS + Sterile deionized water + Polymer
BATCH 4: DS + HPE + Polymer
AE: A-1 Tubes were not transferred from 35 0C incubator to 44.5 0C waterbath
NS: No sample - all sample consumed in previous test days
MPN/dry gram = (MPN/100ml) / %TS

Hyperion Treatment Plant: November 2001 - Class A Biosolids Project

Fecal Coliform Test Results from EMD

Sample Date	Location	MPN/ 100 ml
11/1/01	HPE Slip-in	< 20
11/1/01	HPE Slip-out	< 20
11/1/01	HPE Slip-inject.	< 20
11/2/01	HPE Slip-in	< 20
11/2/01	HPE Slip-out	< 20
11/2/01	HPE Slip-inject.	< 20
11/7/01	HPE Slip-in	< 2
11/7/01	HPE Slip-out	< 2
11/7/01	HPE Slip-inject.	< 2
	Chromogenic Substrate Method	
11/7/01	HPE Slip-in	< 1
11/7/01	HPE Slip-out	< 1
11/7/01	HPE Slip-inject.	< 1
11/8/01	HPE Slip-in	< 2
11/8/01	HPE Slip-out	2
11/8/01	HPE Slip-inject.	2
	Chromogenic Substrate Method	
11/8/01	HPE Slip-in	< 1
11/8/01	HPE Slip-out	< 1
11/8/01	HPE Slip-inject.	< 1

MPN/dry gram = (MPN/100ml) / %TS

7.4 References

Legal aspects of 40CFR 503:

1. USEPA (1993). Technical Regulations for Municipal Sludge Use or Disposal, *Federal Register*, Regulation 40 CFR 503, Document WWBKRG35, National Small Flows Clearinghouse, West Virginia U., Morgantown, WV.

2. USEPA (1994). Plain English Guide to the EPA Part 503 Biosolids Rule. EPA/832/R-93/003

3. USEPA (2000). Guide to Field Storage of Biosolids. EPA/832-B-00-007. July, 2000.

Analytical Methods:

4. Laboratory Section Procedure for the Characterization of Water and Waste (1989), 4th Edition, Sanitation District of Los Angeles County, Los Angeles, CA.

5. Standard Methods for the Examination of Water and Wastewater (1992), 18th Ed. American Public Health Association, Washington, DC, Part 9020, Part 9221 E, and Part 9260 D.

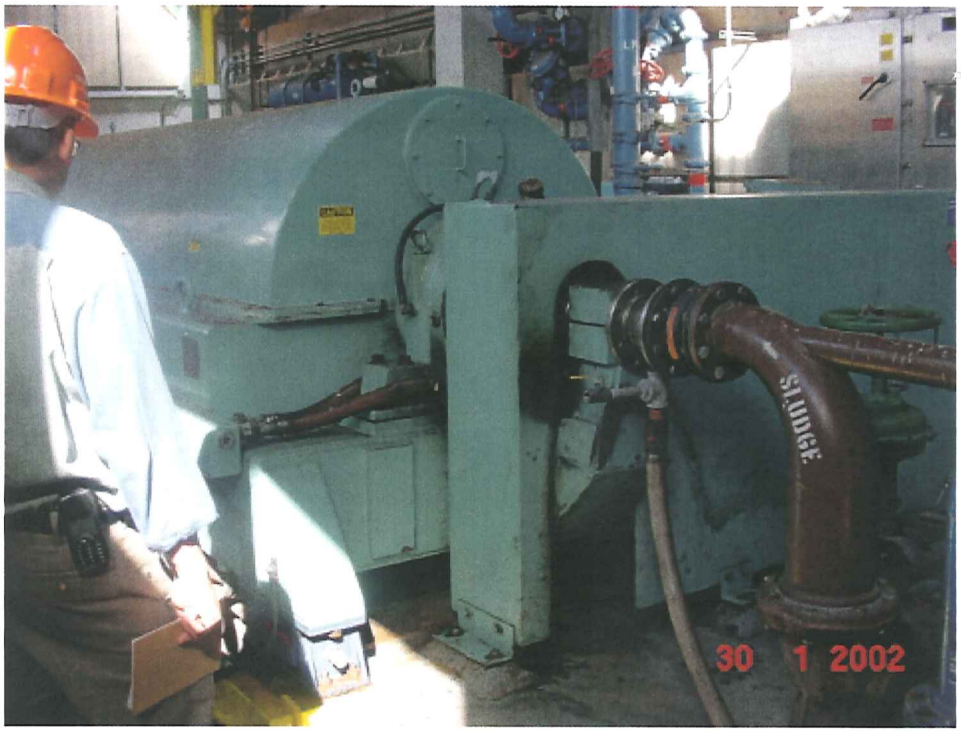
6. USEPA (1999). Environmental Regulations and Technology, Control of Pathogens and Vector Attraction in Sewage Sludge. EPA/625/R92/014.

7.5 Photos

The following section contains photos of activities taken place at various stages of this project.

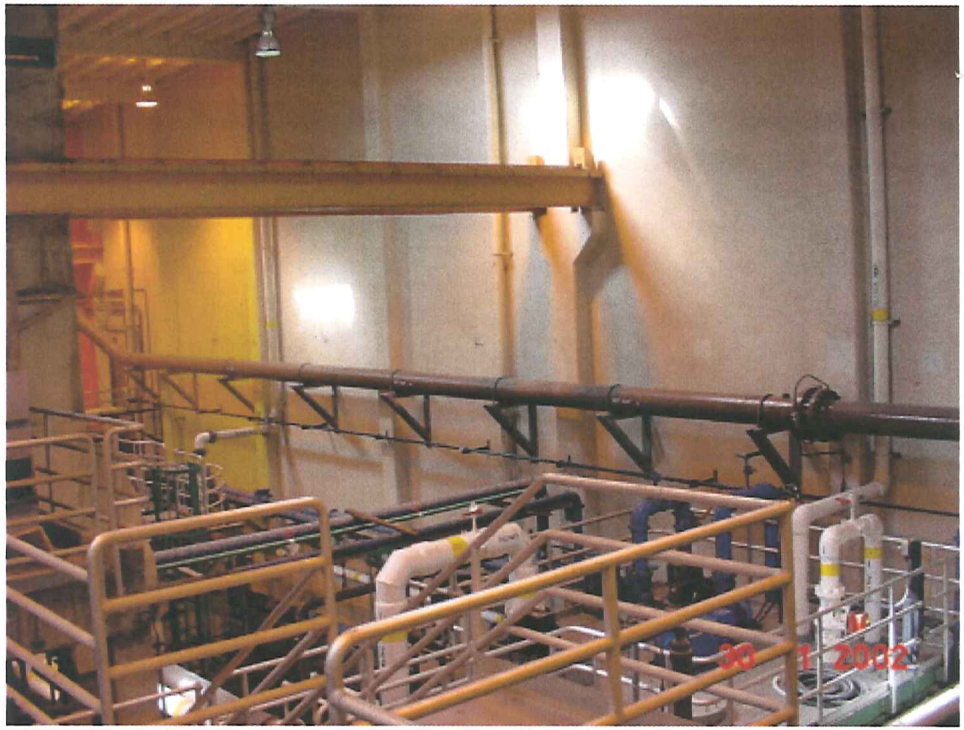
1. Walk-through for QA/QC centrifuge facility.
2. Walk-through for QA/QC interior wetcake pipes.
3. Walk-through for QA/QC exterior wetcake pipes.
4. Digester inflow sampling.
5. Digested sludge sampling.
6. Wetcake sampling.
7. Sample delivery to laboratory (chain of custody).
8. HPE slip injection sampling.
9. Temperature profile measurements.
10. Centrifuge simulation testing.

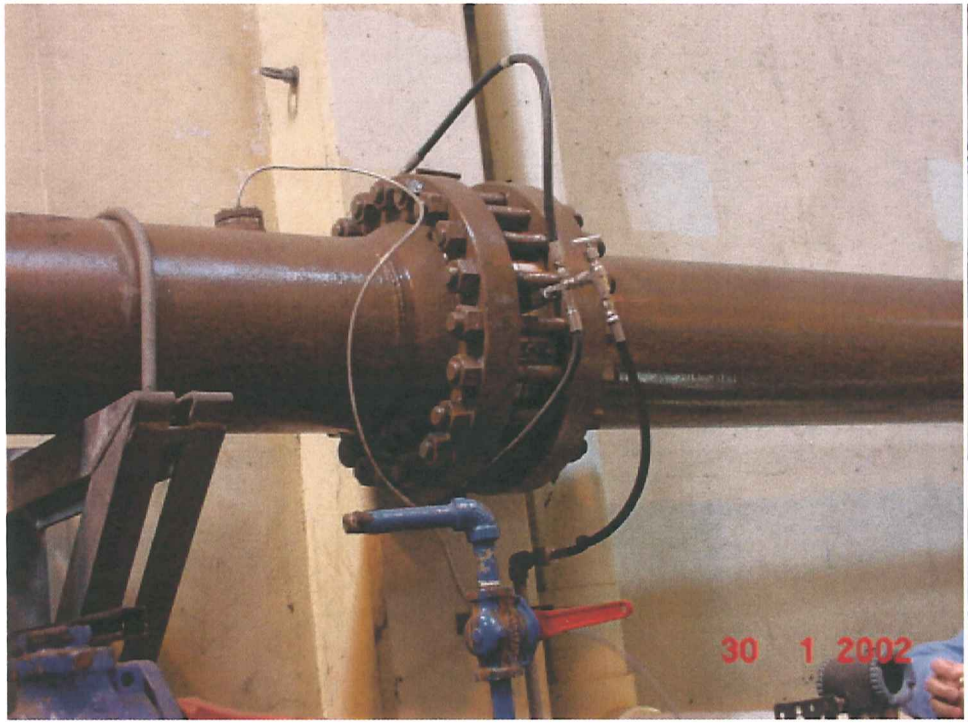
WALK-THROUGH FOR QA/QC
CENTRIFUGE FACILITY



WALK-THROUGH FOR QA/QC
CENTRIFUGE FACILITY

WALK-THROUGH FOR QA/QC
INTERIOR WETCAKE PIPES

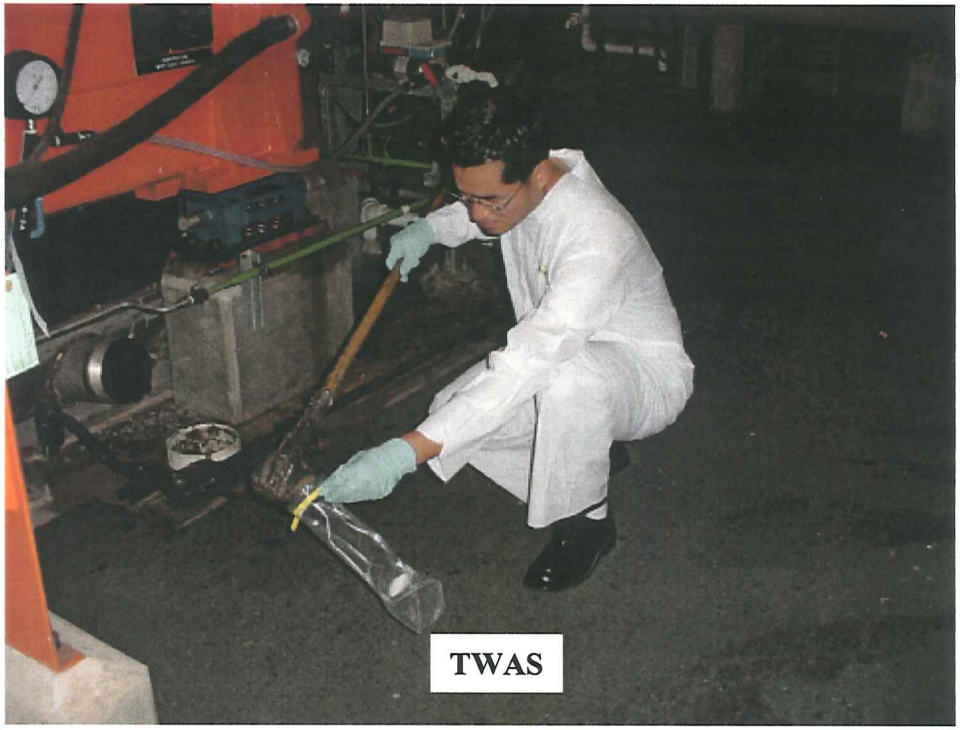




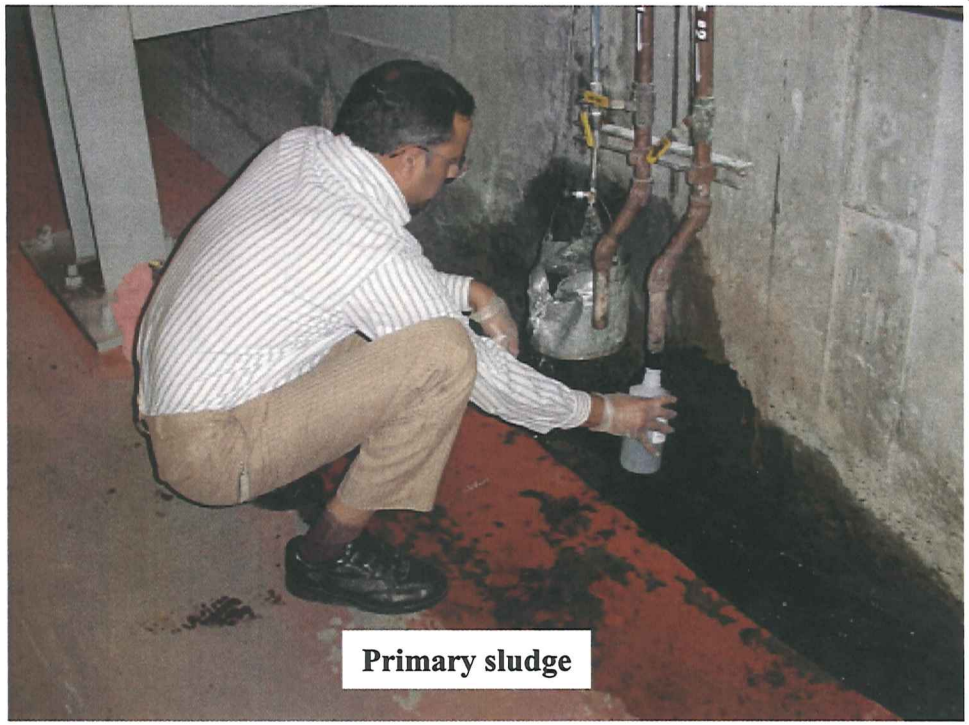
WALK-THROUGH FOR QA/QC
EXTERIOR WETCAKE PIPES

WALK-THROUGH FOR QA/QC
EXTERIOR WETCAKE PIPES

DIGESTER INFLOW SAMPLING

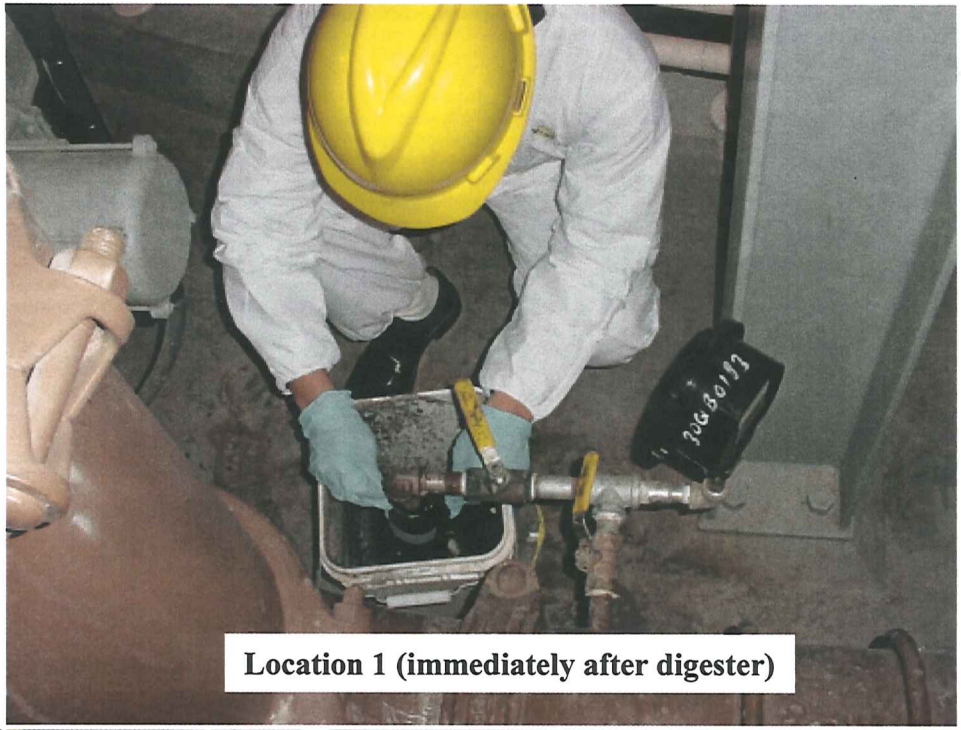


TWAS

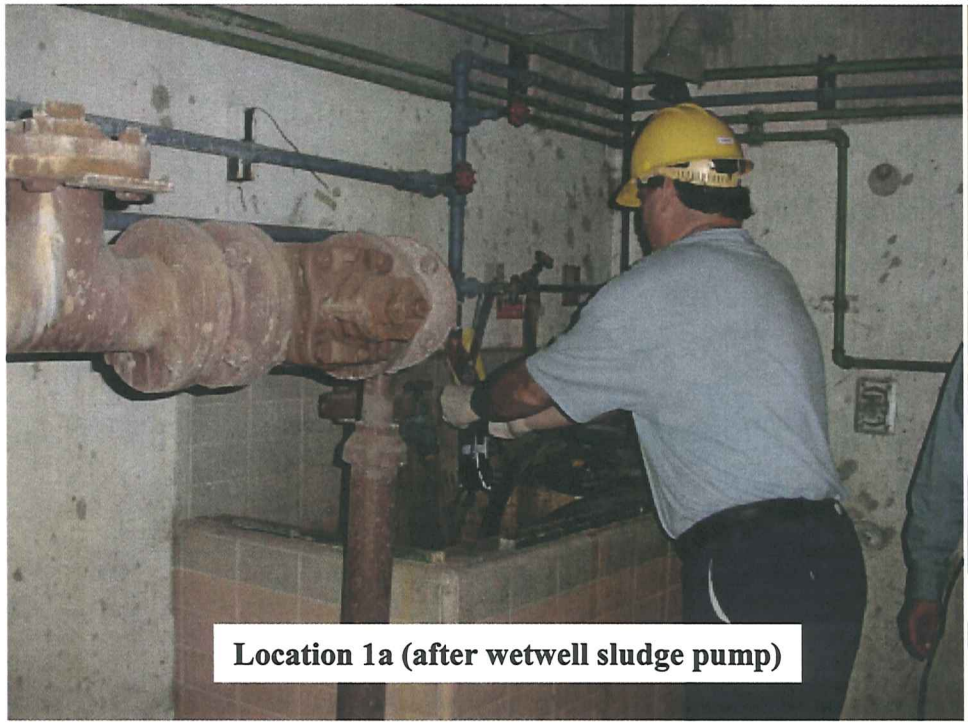


Primary sludge

DIGESTED SLUDGE SAMPLING



Location 1 (immediately after digester)



Location 1a (after wetwell sludge pump)

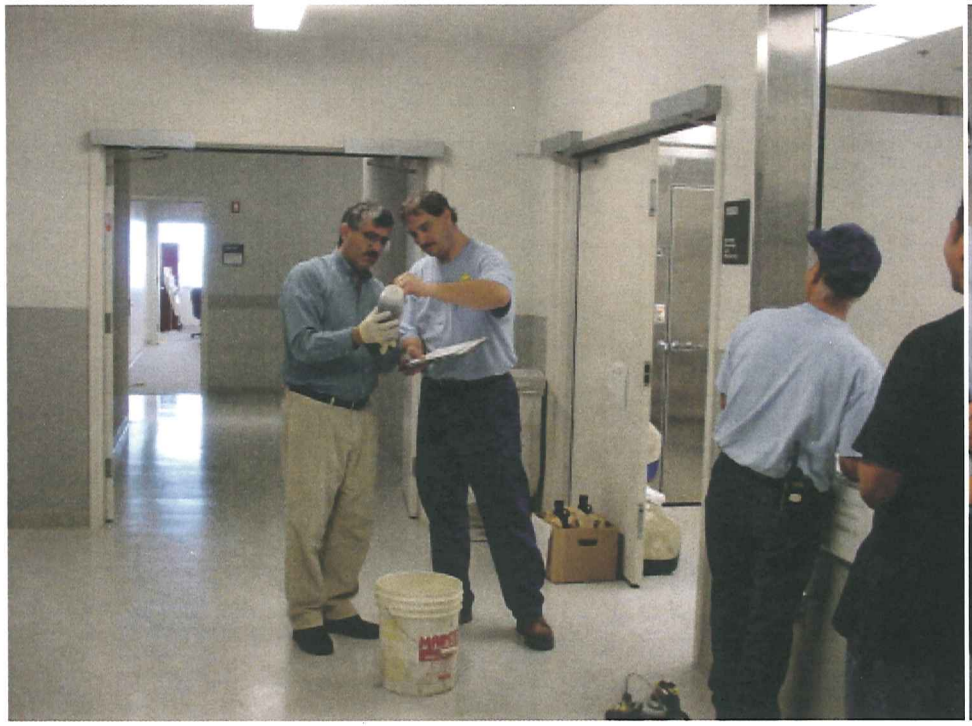
Location 2 (before centrifuge)

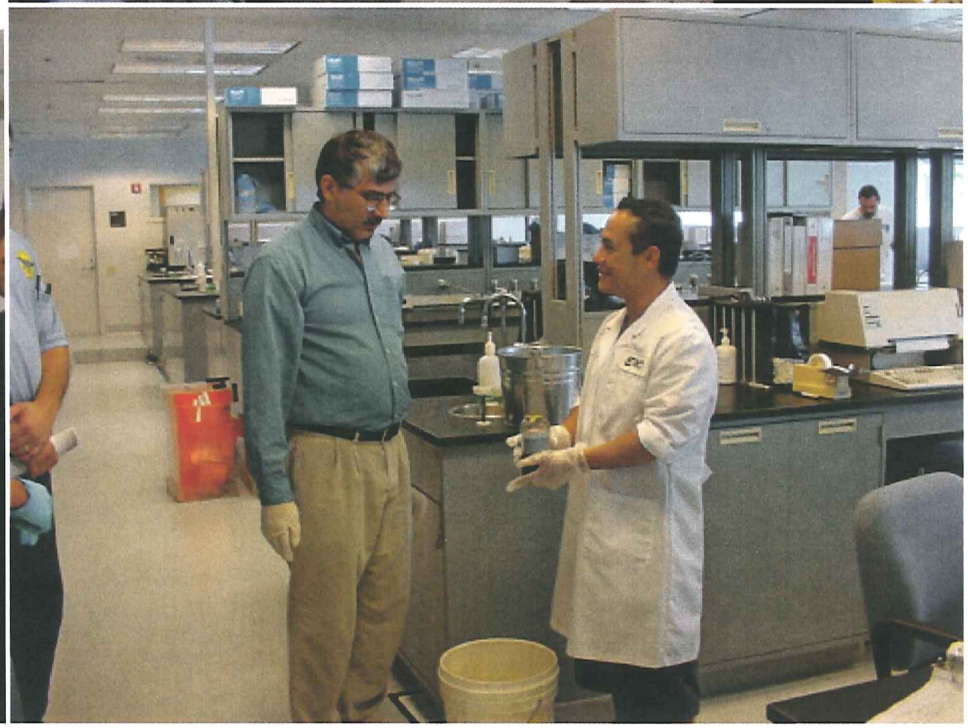
WETCAKE SAMPLING

Location 3 (after centrifuge)

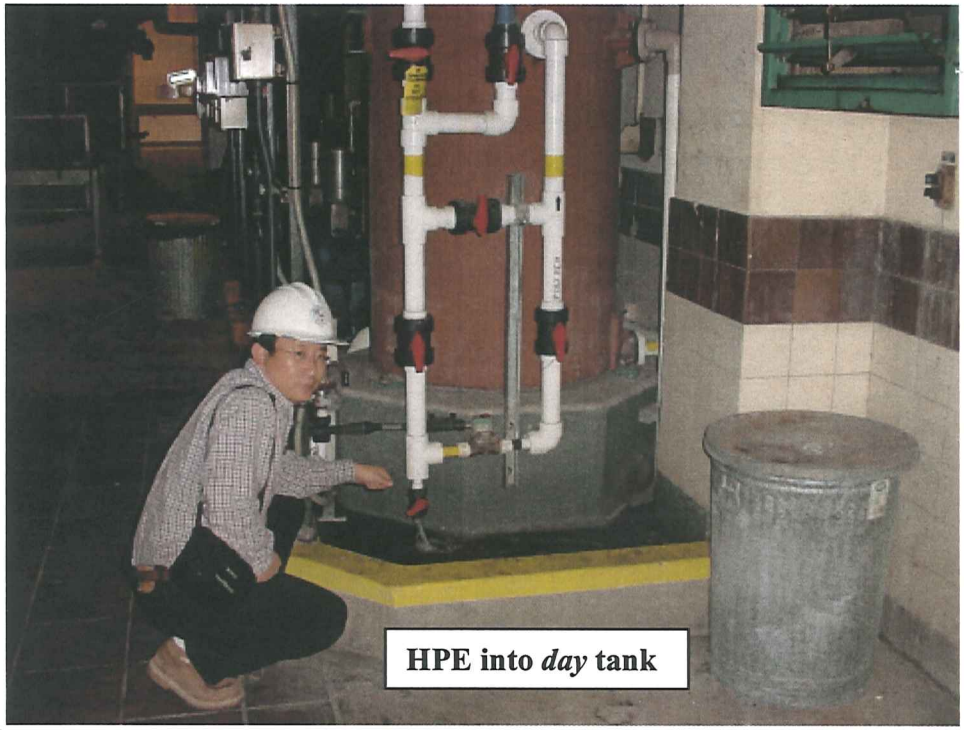
Location 4 (truck loading facility)

SAMPLE DELIVERY TO LABORATORY
(CHAIN OF CUSTODY)





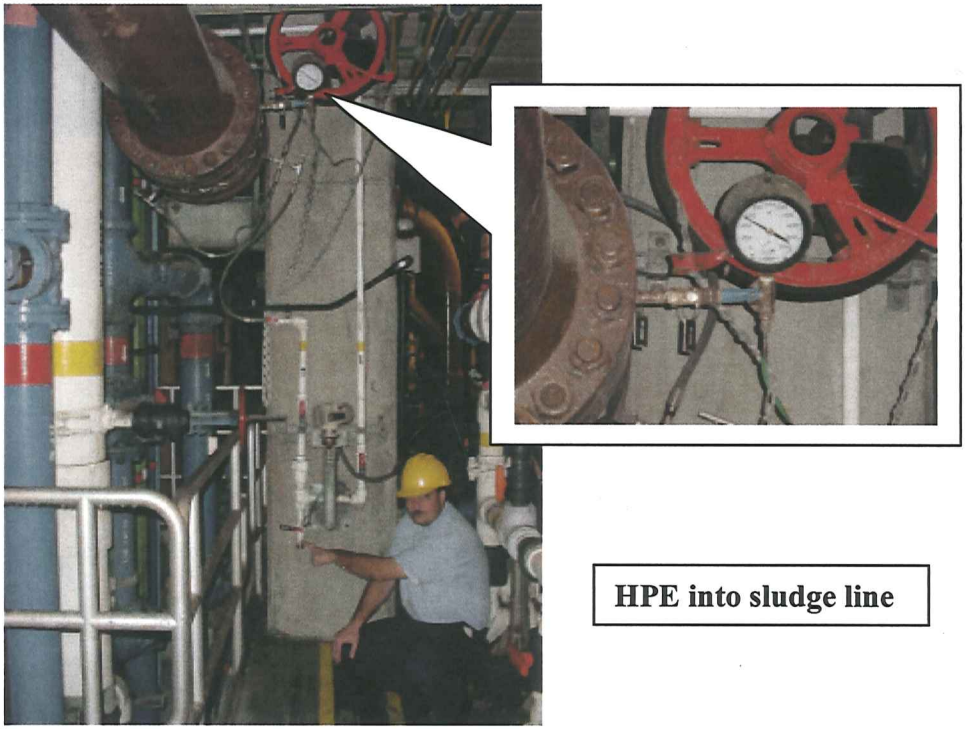
HPE SLIP INJECTION SAMPLING



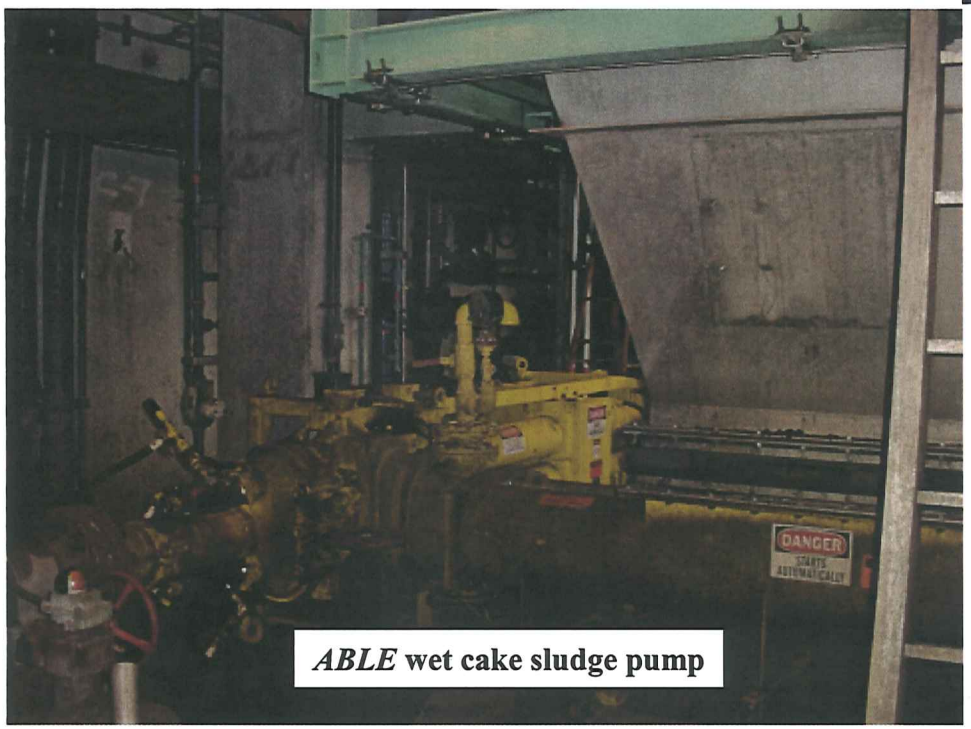
HPE into *day* tank

HPE from *day* tank

HPE SLIP INJECTION



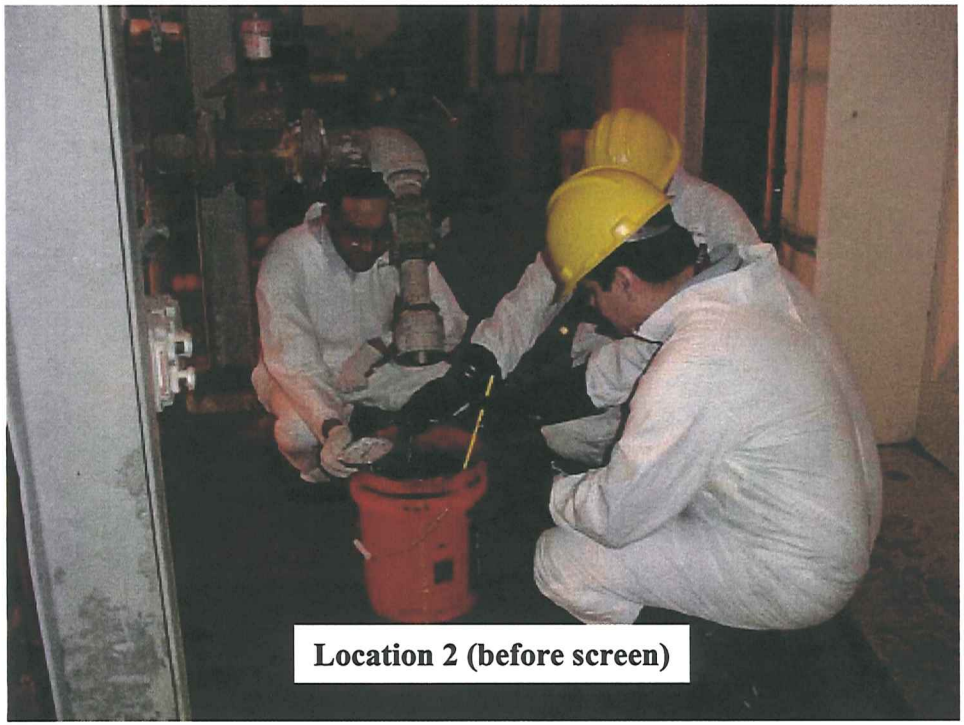
HPE into sludge line



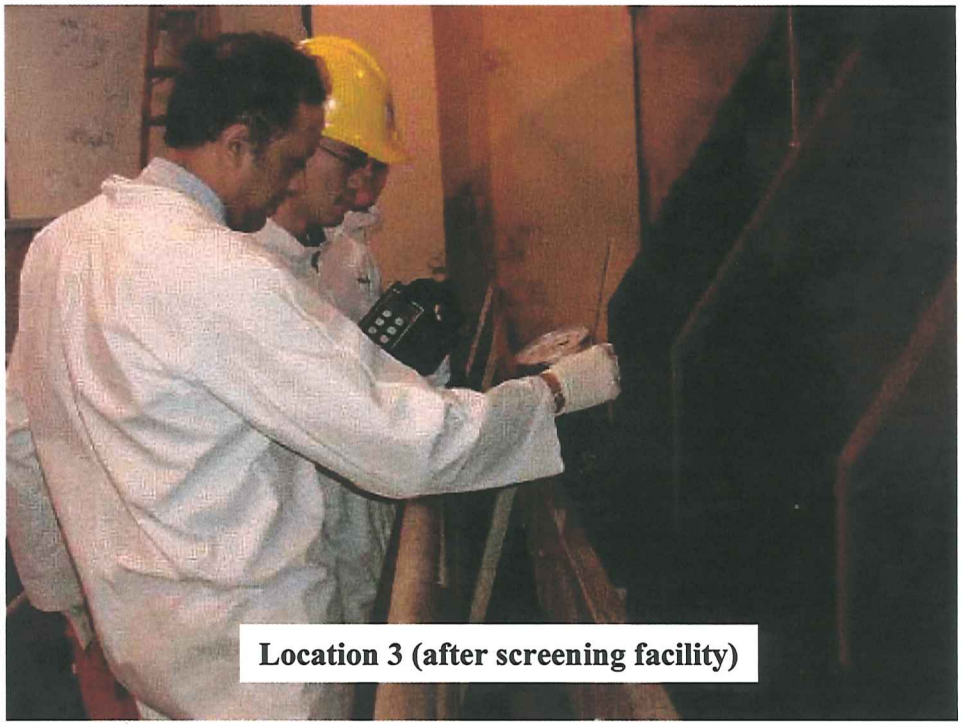
ABLE **wet cake sludge pump**

TEMPERATURE PROFILES

Location 1 (after digester 5D1)

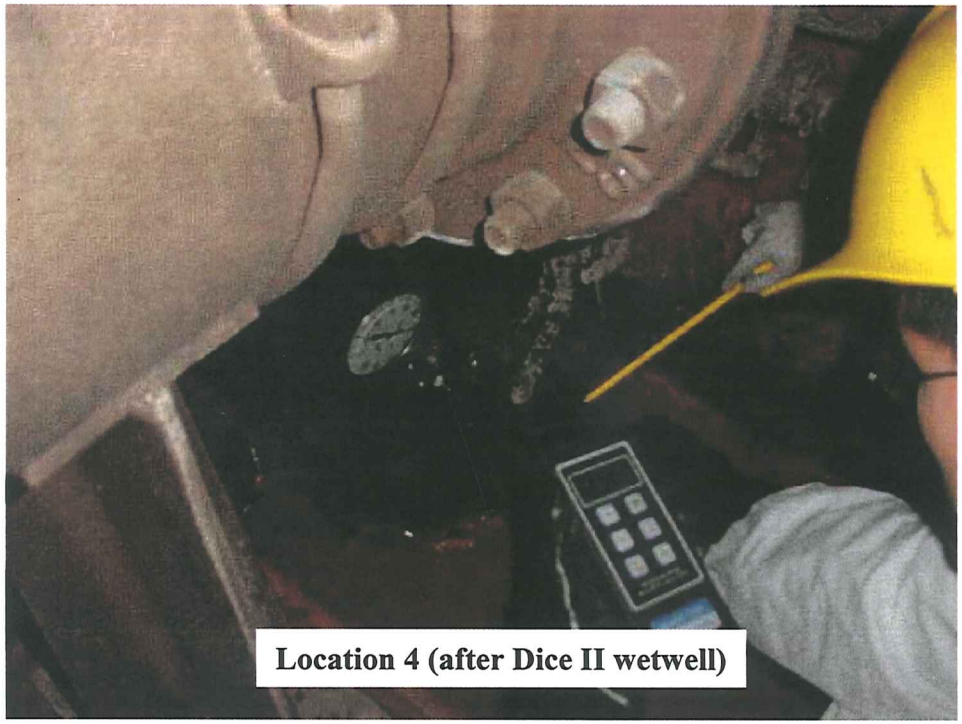


Location 2 (before screen)



Location 3 (after screening facility)

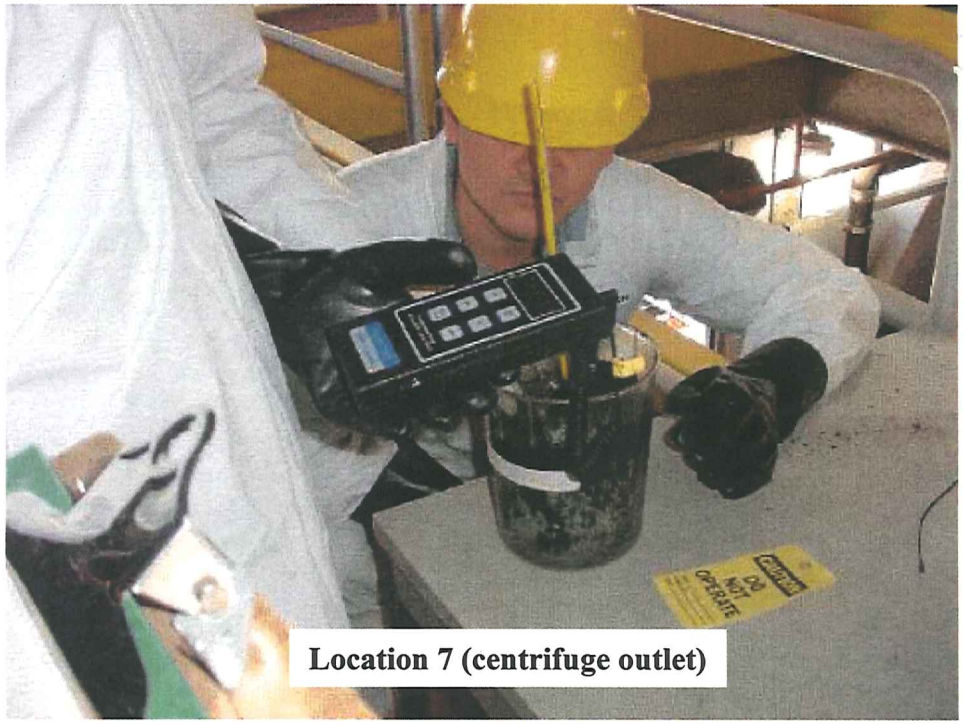
TEMPERATURE PROFILES



Location 4 (after Dice II wetwell)

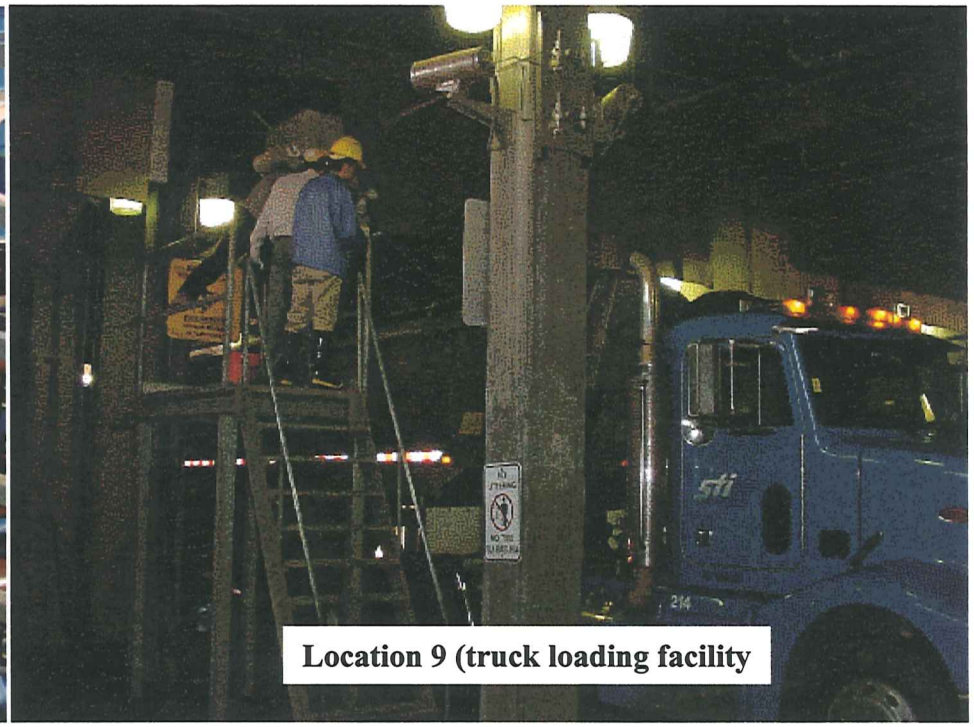
Location 6 (centrate)

TEMPERATURE PROFILES



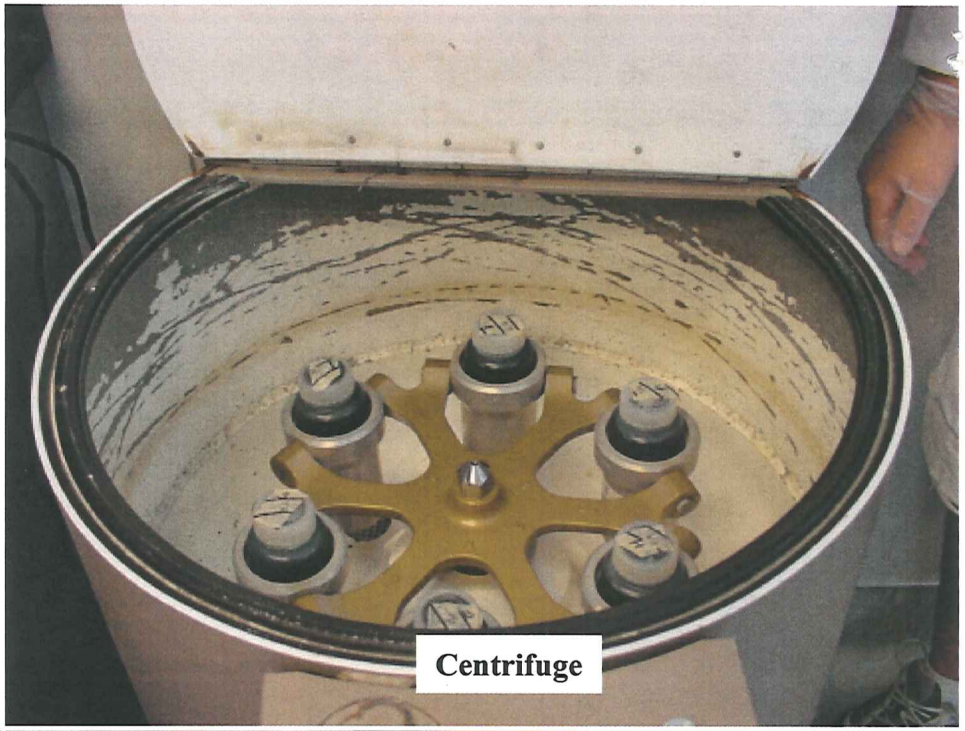
Location 7 (centrifuge outlet)

Location 8 (before falling into silo)



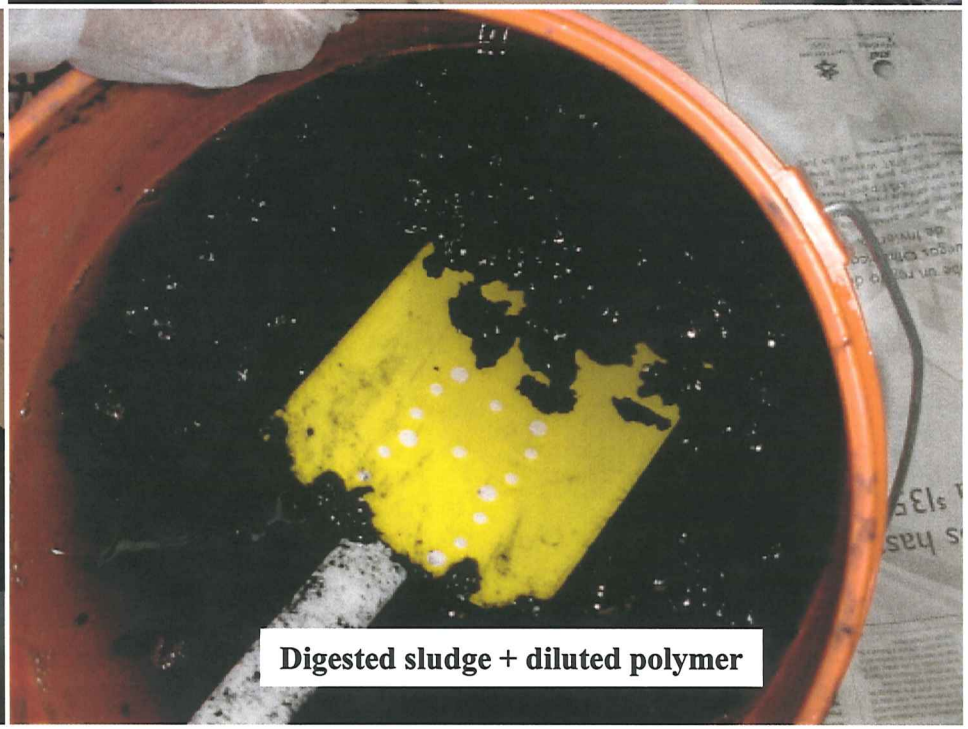
Location 9 (truck loading facility

CENTRIFUGE SIMULATION TESTING



Centrifuge

Mixing water diluted polymer with digested sludge



Digested sludge + diluted polymer