201 N. Civic Drive, #115
Walnut Creek, CA 94596-3864
tel: 925.937.9010
fax: 925-937-9026

Digester Cover and Mixing System Selection

Prepared for: San Jose/Santa Clara Water Pollution Control Plant

Project Title: FOG Evaluation, Digester Rehabilitation and Gas Line Replacement

Project No: 136242-003

Technical Memorandum 4.2

Subject: Digester Cover and Mixing System Selection

Date: September 30, 2010 (Revised: February 10, 2011)

To: Ravi Kachhapati, Project Manager

From: Steve Krugel, Project Manager

Rion Merlo, Project Engineer

Tim Banyai, Project Engineer

Rion Merlo, Ph.D., P.E., Project Engineer
Engineer in Responsible Charge, License No. C69030

Reviewed by: Steve Krugel, Senior Vice President, Project Manager

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. EXECUTIVE SUMMARY

As part of the San Jose/Santa Clara Water Pollution Control Plant's (WPCP) Pre-design Study of Digester Rehabilitation, Modifications and Gas Line Replacement, an evaluation of alternatives was conducted and recommendations made for cover and mixing system improvements for the existing digesters. From previous investigations in technical memorandum (TM) 3.3, it was determined that current active digester volume is degraded by poor mixing and significant grit buildup, which necessitates frequent digester cleaning. Routinely, four digesters are annually taken out of service for cleaning. When mixing systems are less than optimum, digestion capacity is limited; therefore, it is recommended that an increase in digestion capacity be achieved by implementing mixing system and cover upgrades.

This TM discusses different cover and mixing alternatives suitable for the WPCP digesters and, after screening alternatives, remaining options were evaluated in more detail. This evaluation involved: defining cover and mixing alternatives, screening to alternatives most suitable for the WPCP, and cost benefit analysis of short-listed cover and mixing systems.

The covers shortlisted for the digester upgrades included submerged fixed concrete; standard, non-submerged fixed steel; and rehabilitated and replaced Downes-type floating covers. The mixing systems short-listed for the existing digesters included internal (roof-mounted) mechanical draft tube (RDT) mixers; external pumped mixing; vortex ring/linear motion (LM) mixers; and focused flow mixers.

Based on the analysis of several potential future scenarios, the digester cover and mixer recommendations are as follows:

- If new digester covers are constructed, submerged fixed concrete covers would have the lowest net present value of the alternatives. Because these retrofits would also increase the volume of each digester, this approach also reduces the number of digesters needed. Although submerged fixed covers have a higher capital cost per digester compared to other alternatives, they are the recommended cover technology for any new covers.
- Replacing the existing covers with new submerged fixed concrete covers would have a lower net present value than rehabilitating the existing covers for continuous use, because of the reduced maintenance costs associated with new covers. The recommendation is made even stronger based on the fact that the submerged fixed covers will last considerably longer than other systems (whose replacement was assumed to be outside of the considered present worth time frame).
- Digesters that are upgraded should have a new mixing system installed.
- If the City does not implement struvite mitigation measures, confined gas mixing is the best apparent technology. Observations at the WPCP as well as other facilities has shown that unconfined gas mixing equipment is unaffected by struvite formation. Alternatively, RDT, focused flow or linear motion (LM) mixers could be pilot tested with the objective of determining if struvite formation will be an issue with them, without any struvite mitigation measures.
- If struvite mitigation measures are implemented, RDT mixers could be implemented immediately without any pilot testing of mixing systems. Currently, two existing digesters are recommended to be converted to pilot digesters. We recommend installing submerged fixed concrete covers on these pilot digesters. There is no benefit to pilot testing different cover technologies. The submerged fixed concrete covers should be designed so that RDT mixers, focused flow mixers, LM mixers and confined gas mixing using sequential lances are accommodated with appropriate cover access and mixer mounting requirements. This would allow the City flexibility in pilot testing mixing technologies.

2. INTRODUCTION

This TM is one in a series of TMs to be provided under Service Order Number (No.) 1for the WPCP Fats, Oils, and Grease (FOG) Program Evaluation and Enhancement Study, Pre-design Study of Digester Rehabilitation, Modifications and Gas Line Replacement, and Implementation Plan. The primary goal of Service Order No. 1 is to evaluate the 16 existing digesters and develop an implementation plan for digester modifications that rehabilitates digesters needed for reliable service through the 2030 planning period in a way that will not limit long-term options for future digestion processes that may be used at the WPCP.

This TM serves as the project deliverable for Task 4.2 of Service Order No.1. The primary purpose of this TM is to evaluate and recommend alternatives for rehabilitating the anaerobic digester covers and mixing systems. For details of design criteria to be used for analysis in Tasks 4, 5 and 6 of Service Order No. 1, TM 3.3, Design Criteria for Digester Modifications and Gas System Improvements should be referenced. TM 3.3 provides a road map of the general content of all TMs to be submitted under Tasks 4, 5 and 6.

2.1 TM 4.2 Organization

The general organization of this TM is as follows:

SECTION 1: EXECUTIVE SUMMARY

SECTION 2: INTRODUCTION

SECTION 3: DIGESTER COVER EVALUATION

SECTION 4: DIGESTER MIXER EVALUATION

SECTION 5: DIGESTER COVER AND MIXER RECOMMENDATION

2.2 Purpose and Scope of TM 4.2

The purpose and scope of this TM is to evaluate and compare alternatives for new digester mixing systems and covers for the existing 16 digesters. Digester cover alternatives defined in the scope of work include steel, concrete, aluminum, and composite material for submerged and non-submerged fixed covers and new floating covers. An important consideration of the cover selection and design is the type of mixing; and therefore, this TM includes the evaluation of digester mixing. Five types of digester mixing systems are evaluated in this TM: gas mixing, pump mixing, mechanical mixing (both external and internal draft tube), vortex ring /LM mixing, and focused flow mixing.

The existing covers have had structural damage and significant problems with corrosion. TM 4.1 provides a complete analysis of the structural and corrosion damage. Excessive foam accumulation or tilting of the floating covers has not been an issue, likely due to the moderate volatile solids (VS) loadings to the digesters. The existing gas mixing systems are inadequate as evidenced by the large amount of grit accumulation in the bottom of the digesters.

In the digester rehabilitation pre-scoping meeting on April 17, 2008 with the City of San Jose and Brown and Caldwell, digester gas mixing was considered less energy efficient and less flexible than other mixing alternatives and was eliminated from consideration for this project. There are safety and maintenance issues with operating gas mixing systems, which makes this alternative less desirable to the City. However, a new gas-mixing alternative is provided for reference in terms of cost in this TM and may provide a fallback alternative if struvite control is an issue with mechanical mixing and other alternatives prove ineffective.

3. DIGESTER COVER EVALUATION

This section presents an overview of the existing digester covers and the results of the digester cover condition assessment. In addition, several digester cover alternatives are identified and evaluated. Based on this analysis, a recommendation is made for covers types for further evaluation with mixer alternatives in Section 5.

3.1 Existing Digester Covers

The WPCP digesters have Downes ballasted floating covers that were installed when the digesters were constructed. Digesters 1 through 3 were installed in 1956; Digester 4 was installed in 1960; Digesters 5 and 6 were installed in 1961; Digesters 7 and 8 were installed in 1966; Digesters 9, 10 and 11 were installed in 1970; and Digesters 12 through 16 were installed in 1983. A photo of the existing digester covers is included in Figure 3-1.

Figure 3-1. Existing San Jose WPCP digester floating covers

3.1.1 Condition Assessments

As reported in the Infrastructure Condition Assessment (CH2MHill, May 2007), the existing covers have had significant problems with corrosion. Digesters 2, 4, 5, and 6 were out of service at the time of the assessment, partly due to structural damage to the floating covers. According to plant staff, all digesters have some level of corrosion.

A corrosion assessment was performed by V&A in October 2008 on Digesters 2, 4, 5, 6, and 8 (see TM 4.1 Structural Evaluation, Corrosion Protection, and Concrete). V&A identified the following cover concerns:

- The coating on the interior cover surfaces has failed.
- The interior cover of Digester 2 appeared to be corroded beyond superficial damage, with pitting and some holes observed on several parts of the structure. A condition rating of severely corroded with significant damage to structure was given to Digester 2.
- Surface corrosion was observed on the interior roof of Digesters 5, 6, and 8. A condition rating of some corrosion and structure exposure was given to these digesters. Digester 4 was not accessible from the inside due to the presence of groundwater in the digester.
- If the existing steel roofs are to remain in place, an application of 100 percent solids polyurethane or epoxy coating at a minimum dry film thickness of 80 millimeters is recommended for all digesters.

- The degree of corrosion and structural integrity of the digester cover is different for each of the 16 digesters. Some covers are in need of immediate replacement and others may have years of useful life remaining.

It should be noted that 40 years is a realistic useful life of metal structural components in wastewater process units, but only if the structural members are regularly recoated, typically on the order of every 5 years. Without regular inspection and recoating, the useful life of metal structural members can be well under 20 years. Covers on Digesters 7 and 8 (43 years old) and on Digesters 9, 10 and 11 (39 years old) could be considered to be at the end of their useful life. Corrosion and structural problems are likely to be found upon detailed inspection. Covers on Digesters 12 through 16 (26 years old) are approaching the end of their useful life and at a minimum, some corrosion should be expected.

3.1.2 Digester Cover Structural Analysis

Beyaz and Patel (B&P) and Brown and Caldwell completed a structural evaluation of the anaerobic digesters (see TM 4.1, Structural Evaluation, Corrosion Protection, and Concrete). The evaluation included a site visit on October 30, 2008 and completion of two structural models that were representative of the two general types of digesters at the WPCP. The overall conclusion was that the exterior concrete walls of the digesters above grade were in good condition, and that the concrete walls should not be adversely affected due to aging. In addition, the tops of the walls appear to be in good structural condition and, subject to structural capability analysis, should not pose a problem if a new fixed cover is installed in the future. The results of the structural analysis indicate the following.

- Without structural modifications, the maximum allowable liquid level in the digesters for a fixed cover (submerged or non-submerged) is 4.5 feet below the top of the wall. Compared to existing average operating liquid levels of 6 feet below the top of wall, this allowable liquid level would not reduce existing digester capacity as compared to current operating conditions.
- Large wall penetrations required for some new mixing systems and new maintenance access may be difficult and costly to install because of the closely spaced post-tensioned rods with turnbuckles and cast-in-place reinforcing, requiring restoration of the damaged post-tensioned rods and reinforcing.
- Wall penetrations below grade, if required, will require extensive excavation around the entire digester perimeter.

An analysis of the necessary requirements for new fixed domed steel and submerged fixed covers was performed. The fixed submerged cover analysis considered a new concrete cover with a gas dome in the center of the cover. The digesters were analyzed for a normal operating water surface elevation 3 feet above the top of the existing walls and the emergency overflow level at 2 feet above the normal operating water surface elevation. The maximum internal gas pressure was 16 inches of water column. Two representative digesters were considered for the analysis, Digester 4 and Digester 12. Digesters 4 through 11 are assumed to have the same structural characteristics as they have the same overall structural dimensions and assumed similar reinforcing. Digester 4 was built in 1960; it is 110-foot-diameter, 40-foot tall walls, and 10-inch thick walls. It is important to note that Digester 4 alone has a lower water surface elevation than the other 110-ft digesters because it is deeper in the ground. Digester 12, which represents Digesters 12 through 16, was built in 1983; it is 110-foot-diameter, 40-foot tall walls and 14-inch thick walls. Digesters 1 through 3 were not considered for analysis because they are the oldest and least amenable to structural upgrades and have a lower volume than the 110-ft digesters.

The following is the required rehabilitation for Digesters 4 through 16 for fixed domed steel and submerged fixed concrete covers:

- Provide additional pre-stressing hoop reinforcement around the tank walls for the top 25 feet of the digester walls. Digesters 4 through 11 would require greater reinforcement than Digesters 12 through 16 due to thinner walls. In addition, for Digester 4 only, provide additional pre-stressing hoop reinforcement around the tank walls from 10 feet below ground elevation to the top of the tank. This requires excavations 12 feet below the existing ground elevation all around the digester.

In addition to the rehabilitation listed above, submerged fixed concrete covers for Digesters 4 through 16 would require:

- Insulation on the digester walls above grade for the thermophilic operation, if used.
- 24-inch thick concrete cover with a hoop ring beam at the perimeter of the tank.
- Four 36-inch diameter concrete columns equally spaced inside the digester.
- 10 foot by 10 foot concrete pile cap for each column and possibly five – 24-inch-diameter drilled piers depending on the geotechnical investigation of the soil capacity under the digesters.
- 18-inch-diameter drilled piers around the perimeter of the inside face of the digesters spaced at 10 feet on center (the drilled piers may not be required depending on the geotechnical investigation of the soil capacity under the digesters).

3.2 Digester Cover Alternatives

Improvements to the digester covers should focus on achieving the following objectives:

- Good foam and scum control
- Good cover stability
- Compatibility with existing digester walls
- Compatibility with recommended mixing system
- Ease of operation and maintenance (O&M)
- Reliability and safety
- Cost effectiveness
- Capable of withstanding internal pressure from gas, and in the case of submerged fixed covers, sludge and foam

Replacing the covers will result in a structurally reliable and safe cover, and provide process reliability by increasing the number of digesters available for operation. Three types of digester covers are used commonly for anaerobic digesters: floating covers, fixed covers; and membrane gas holder covers. Floating covers may be fabricated from a variety of materials with the most common being steel frame with a welded steel roof. Fixed covers may be either submerged or non-submerged. Submerged fixed covers are designed to allow the normal operating surface of the sludge to be above the main cover, inside a central dome. Non-submerged covers require the operating surface to remain below the cover. Fixed covers may be constructed with concrete, aluminum, or composite materials; however, submerged fixed covers are typically only made of concrete to help ballast and withstand the internal upward forces of submergence. Membrane covers are made of polyvinyl chloride (PVC) composites and are used to store gas. Five floating, fixed, and membrane cover options were identified as potential alternatives at the WPCP. Variations may be available, but their function, cost, and implementation will be similar to and are represented by these types.

3.2.1 Alternative 1 - Standard Downes Floating Cover (Existing Cover)

The standard Downes type floating covers are ballasted to balance the buoyant forces of the digester fluid, the cover weight, and the gas dome pressure. The floating cover is designed with ballast to hold the digester gas pressure within a desired operating range. Gas, odor, and foam can escape around the perimeter of the floating digester cover. The standard design also has a relatively large gas/liquid interface, which permits the accumulation of foam and scum at the liquid surface. However, floating covers can be more heavily ballasted to reduce the gas/liquid interface. The advantages and disadvantages of this digester cover alternative are summarized in Table 3-1.

A concern with the existing digester cover type is fugitive emissions of digester gas and odors. In order for the digester cover to float freely, a nominal 6-inch annular space must exist between the tank wall and the cover. This gap exposes digesting sludge where gas can escape to the atmosphere. Digester gas can have relatively high concentrations of hydrogen sulfide (H_2S), which could have an impact on the site odor, air quality, and air permit regulations. However, to date, this has not been an issue at the WPCP. Escaping methane (CH_4) also is a significant greenhouse gas (GHG) emission and represents a small, but important loss of recoverable energy.

From an operational standpoint, the existing floating covers at the WPCP appear to work well. However, the internal and external structure of the covers currently have significant levels of corrosion, are in need of repair, and need to be cleaned and recoated periodically to prevent further issues with corrosion.

Table 3-1. Standard Downes Floating Cover Advantages and Disadvantages

Advantages	Disadvantages
• Annular space around digester cover acts as a safety feature that provides a pathway for foam to escape under severe conditions. • Allows for sludge storage capability when the cover travels up or down. Limited to travel above corbels. • Minimal potential for structural damage if digester is over-pumped (over-pressurized).	• Moderate gas/liquid interface allows scum and foam build-up that can lead to tank corrosion. • Cover life can be reduced significantly unless steel surfaces are recoated regularly (can be less than 20 years due to large exposure of underside of cover to gas/liquid interface). • Gas, odor, and foam release from annular space around floating cover. • Potential for condensate and foam accumulation under cover. Additional maintenance required to prevent overloading with foam. (Foam suppression sprays can be installed in the gas dome to mitigate this issue.) • Entry into internal cover is a confined space, and required for inspection/repair (and currently to assist with struvite removal). • Maintenance of flexible gas hoses is required. • Can be used for minimum sludge inventory control only. • Requires nitrogen gas purge for safety during emptying and filling. • Mixing alternatives limited to gas mixing, external or telescoping draft tube mixers, and external pumped mixing • Cover can tilt and become stuck in rapid sludge expansion or foaming event.

3.2.2 Alternative 2 - Floating Gasholder Cover

This alternative is similar to the standard floating cover with the addition of an extended skirt to permit digester gas storage within the void created by the added skirt. An example of a floating gasholder cover is presented in Figure 3-2. One manufactured example is the Eimco HydroSeal floating cover. This cover is ballasted to balance the buoyant forces of the digester fluid, the cover weight, and the gas dome pressure. The cover is fabricated with a metal and concrete support system that floats in a clean water trough constructed around the top of the digester. The main advantage of this type of system is that additional gas storage is provided, but because of the water seal, no gas, odor or foam can escape from the cover perimeter. If the foam level exceeds the existing wall, the ballast water system could be contaminated. However, the WPCP has gas storage (low pressure), so a cover that provides gas storage does not provide any benefit to San Jose. This alternative provides some sludge inventory storage.

The advantages and disadvantages of this digester cover alternative are summarized in Table 3-2. There are several major disadvantages to this type of system: the gas/liquid interface extends over the entire surface area of the digester; it has a high internal corrosion potential; high capital cost, and the volume of space to be purged with nitrogen to take the digester out of service is higher than other systems. The depth of the gas holder cover skirt will interfere with the digester overflow piping. In addition, the taller dome makes safe sampling of the digester contents difficult and will likely require additional wind load and seismic protection. Gas holder covers do not allow use of roof-mounted mixing systems.

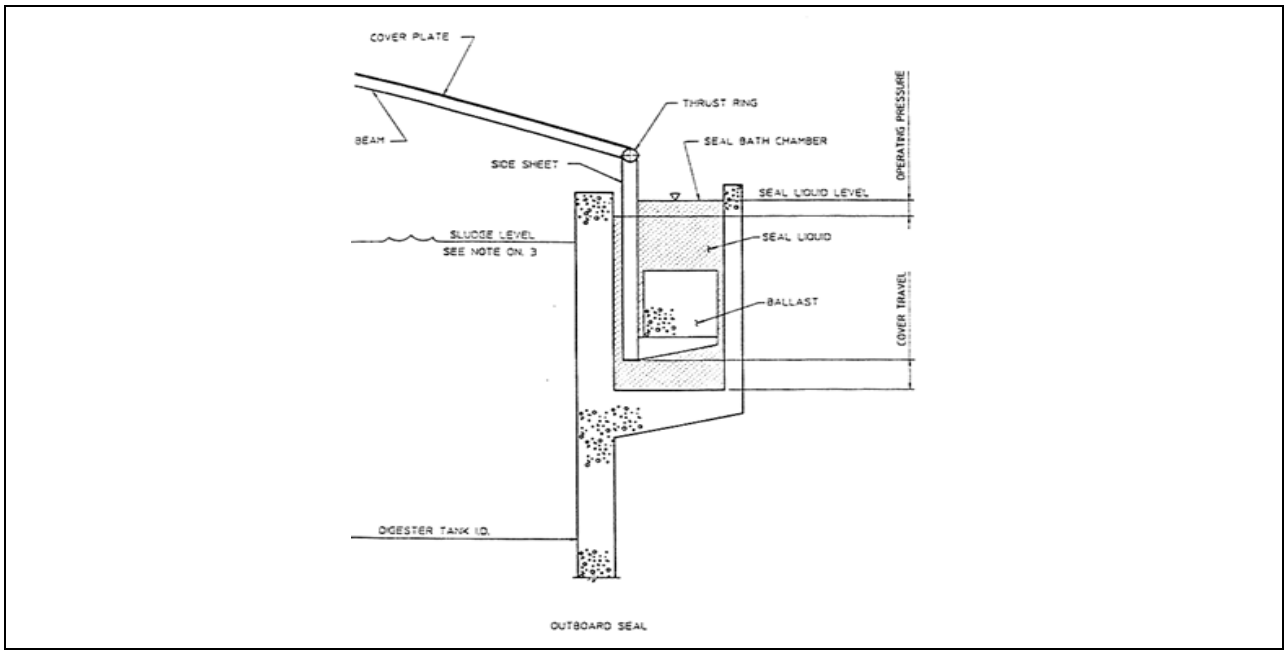

Figure 3-2. Schematic of a gasholder floating cover and gas seal

Table 3-2. Floating Gasholder Cover Advantages and Disadvantages	
Advantages	Disadvantages
• No odor or foam release if using water sealed configuration. • Can be used for sludge inventory control. • No danger of hydraulic overload	• Below corbel feed and bottom withdrawal provide potential for short circuiting. • Full diameter gas/liquid interface allows scum and foam buildup and promotes tank corrosion. • Limits digester mixing alternatives. • Cover life is very limited – some less than 10 years of service because of high in tank exposure; extremely high rainwater and condensate in attic can accelerate corrosion. • If liquid or foam tops digester wall, external water seal is contaminated. • Requires ballast to balance cover against internal gas pressure. If the roof becomes unbalanced, it can get jammed in the guiderails. • Requires large amount of nitrogen purge for safety during emptying and filling. • Skirt interferes with digester overflow piping. • Mixing alternatives limited to gas mixing, external draft tube mixers, and external pumped mixing

3.2.3 Alternative 3 – Standard (Non-Submerged) Fixed Cover (Flat or Dome)

Non-submerged fixed digester covers are structurally attached to the wall of the digester tank and can be flat or domed configuration. With the non-submerged configuration, the gas/liquid interface extends over the entire tank. For a flat roof type digester, in addition to the tank walls, the roof is supported on columns within the tanks for digesters the size of San Jose's digesters and these support columns can interfere with digester mixing patterns. In addition, flat covers are more difficult to protect structurally against digester vacuum conditions. For these reasons, flat fixed covers were eliminated from further consideration. For domed fixed covers, the cover and the center gas dome project above the top of wall and because of their shape are generally structurally self supporting without internal columns. They can be designed as a true arced dome or in a conical shape. Dome fixed covers offer many of the advantages of fixed covers. Specifically, they can allow for large gas headspace, eliminate odor emissions, and accommodate any mixing system. For these reasons, domed fixed covers are considered for further evaluation.

The advantages and disadvantages of this digester cover alternative are summarized in Table 3-3. The principal advantages of this type of system are: it does not permit gas, odor, or scum emissions from the digester; it can be used with any mixing system; and when combined with the appropriate mixing system, can be designed with headspace to provide inventory control and to provide space for storage capacity during rapid volume expansion or foaming events. Because fixed non-submerged covers are not usually designed for internal forces above design gas pressures, a rise in liquid level above the cover can have considerable structural implications with the potential for severe damage by a hydraulic overload if the emergency overflow should become blocked. Emergency overflow relief hatches can be installed as a means to mitigate this.

Table 3-3. Standard Fixed Cover Advantages and Disadvantages	
Advantages	Disadvantages
• No odor or foam release. • Easy to retrofit. • Can operate with all types of mixing. • Can be used for maximum inventory control-with gas atmosphere overflow.	• Large gas/liquid interface allows scum and foam build-up that can promote tank corrosion, use up active volume, and potentially entrain in the gas system. • Unless designed for pressurization, potential for dangerous cover hydraulic overload (if overflow sealed by digester sludge). However, an emergency overflow system and relief hatches can be designed to prevent this from happening. • If cover and exposed wall are concrete and are PVC or HDPE lined, life 40+ years; no lining, life 20+ years; cover concrete shrinkage cracks will leak gas if not lined. Metal covers can corrode and have more limited life without well-maintained coating system • Requires moderate nitrogen gas purge for safety during emptying and filling.

3.2.4 Alternative 4 - Submerged-Fixed Cover

The submerged-fixed cover addresses many of the drawbacks of other digester cover designs. Submerged-fixed digester covers are typically concrete and structurally attached to the wall of the digester tank to provide a means to withstand uplift forces of both the sludge and the gas pressure. In addition, the cover commonly has added weight required to help overcome the buoyant forces exerted by the digester contents and gas pressure. The cover and the center gas dome typically project above the top of wall and the liquid level in the digester is operated above the top of the wall within the gas dome to minimize the liquid/gas interface. The small liquid/gas interface area facilitates scum and foam control. Foam control methods consist of pumped, recirculated sludge spray that is directed at the liquid surface inside the dome. Digested sludge, floating scum, and foam residue is then automatically withdrawn on a continuous basis from the liquid surface of the digester dome. In typical designs, this surface withdrawal flows by gravity into a standpipe and a variable speed sludge removal pump removes the sludge from the standpipe based on sludge level in the standpipe. This system acts as a classifying selector, preventing foam buildup in the digester. In addition, a portion of the feed sludge, typically 40 to 50 percent, is withdrawn from the bottom of the digester and helps remove grit not suspended by the mixing system. Figure 3-3 presents an example schematic of a submerged fixed cover.

An emergency overflow weir and discharge pipe is provided in the dome as a safeguard to prevent overfilling or pressurization of the digester. Overfilling or over-pressuring of the digester could cause structural damage. This emergency overflow capability is critical and is designed to always be in service. The principal advantages and disadvantages of this digester cover alternative are summarized in Table 3-4.

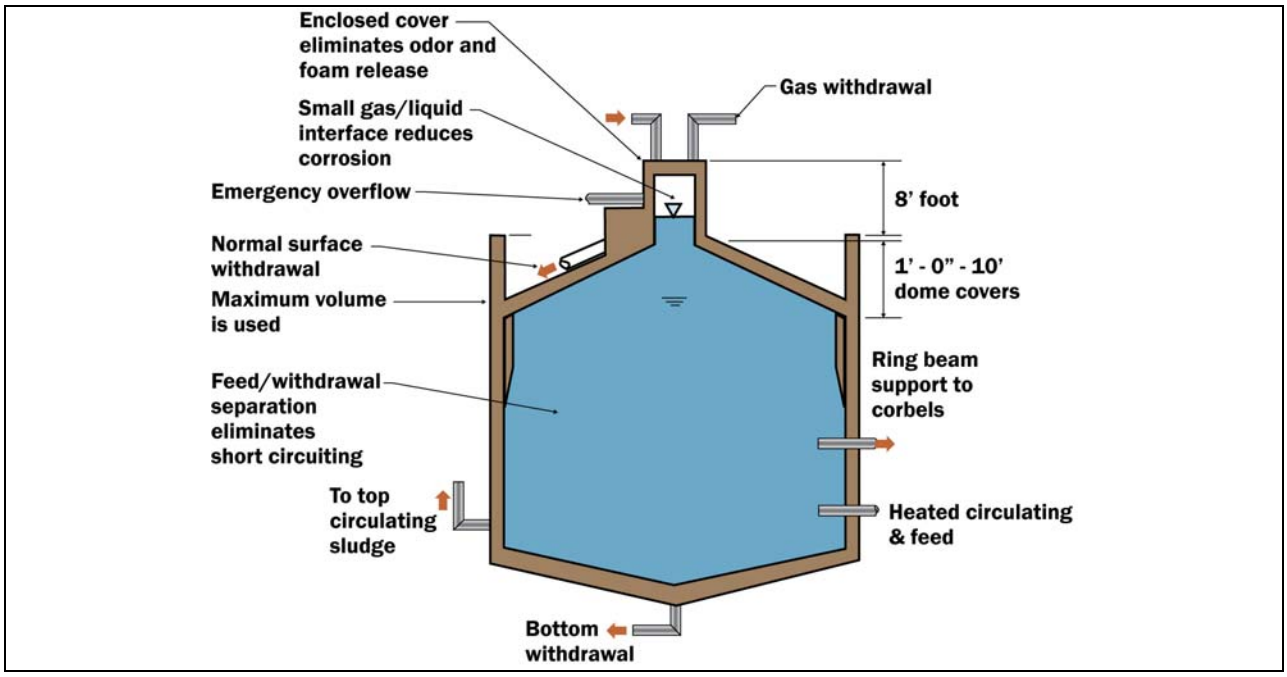

Figure 3-3. Schematic of a submerged fixed cover

Table 3-4. Submerged Fixed Cover Advantages and Disadvantages	
Advantages	Disadvantages
• No foam or odor release. • Continuous surface withdrawal eliminates foam and scum buildup. • Continuous bottom withdrawal, coordinated with surface withdrawal, helps remove grit. • Can operate with all types of mixing. • More digester active volume compared to that available with the other cover types. • Digester dewatering operation is safer because it is easier to purge small remaining gas volume with nitrogen. • Maintenance requirements are reduced because, except the relatively small dome, there are no interior spaces within the cover itself that are exposed to gas and potential corrosion. • Depending on structural design, could increase the volume of existing units by 15 to 20 percent; reducing the number of units required for retrofit.	• The cover is typically concrete which must be lined to prevent leakage through shrinkage cracks and prevent corrosion. • Structural damage can occur if the digester is overfilled. However, an emergency overflow system can be designed to prevent this from happening. • No inventory control within the tank. Tanks are operated full. Separate inventory required, if necessary. • Can be costly due to structural integration with digester walls

3.2.5 Alternative 5 - Membrane (Composite Material) Gasholder Covers

Figure 3-4 presents an example of a membrane gasholder cover. Two manufactured products have been considered that use a composite material for the digester cover: the Dystor® and DuoSphere™. Both are gasholder type cover systems. The Dystor® system is a gasholder cover design from Siemens/Envirex that uses a dome-shaped, engineered membrane system to store methane gas, provide for sludge storage, and prevent odors. The system includes two durable membranes. The outer membrane is cable restrained and

remains inflated in a fixed position. The inner membrane moves freely as it stores or releases gas generated from the anaerobic digestion process. A preset operating pressure is continuously maintained between the two membranes. This system can hold up to three times as much gas as conventional digester covers.

The DuoSphere™ system from WesTech is similar to the Dystor® and use a dome-shaped dual membrane system as well. The membranes are made with more durable material, PVC coated polyester fabric that is anchored to the concrete, so that cable reinforcing restraints are not necessary. There are limited installations with tank-mounted digester DuoSpheres™ in the United States.

The advantages and disadvantages of this digester cover alternative are summarized in Table 3-5. A disadvantage of using this type of gas storage is the lack of gas utilization control since these types of membrane gasholder covers can only signal when they are 100 percent full or 100 percent empty. This does not allow for a balance between the production of gas and gas utilization in gas appliances to be accomplished, as can be done with the existing gas storage facilities at San Jose where the gas storage volume can be automatically and continuously measured. Membrane covers have the potential for leaks that can result in significant replacement and maintenance costs. These covers do not allow for any roof-mounted mixing systems. Existing gas storage at the WPCP is considered adequate and there is no clear driver to install a gas holder cover at additional capital or operating cost.

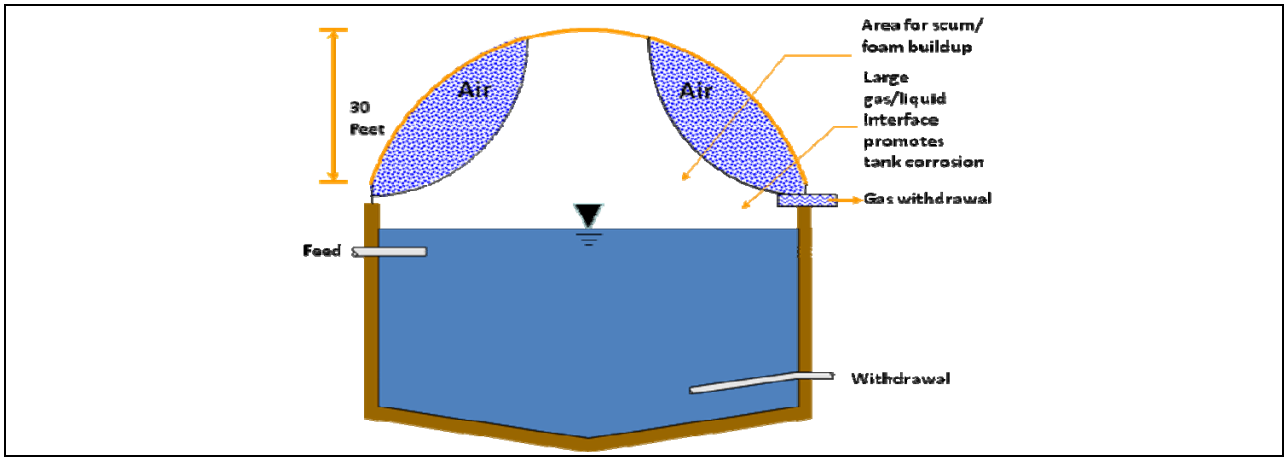

Figure 3-4. Example of a membrane cover

Table 3-5. Membrane Gasholder Cover Advantages and Disadvantages	
Advantages	Disadvantages
• No odor or foam release • Can be used for maximum inventory control. • Low capital and installation costs • Corrosion of cover is not an issue	• Full diameter gas/liquid interface allows scum and foam buildup. • Requires maximum nitrogen gas purge for safety during emptying and filling. • Membrane replacement and repair can result in high maintenance costs • Limited experience in digester cover applications • Danger of cover hydraulic overload and sludge overflow from the digester if overflow sealed by digester contents. • Limits digester mixing alternatives • Continuous energy consumption associated with blowers to maintain external membrane inflated

3.3 Digester Cover Materials

Standard materials used for digester covers are concrete and steel. Steel covers are typically used for floating or fixed non-submerged covers and concrete is used for fixed submerged covers. Alternative cover materials can be utilized for fixed covers and include:

- Fiberglass
- PVC membrane - in dual membrane gasholder system
- Aluminum
- Stainless steel

Typically, a fiberglass cover is not recommended for a digester application due to the combustibility of the material. Therefore, a fiberglass cover has not been evaluated in this TM. Membrane covers are discussed in Alternative 5 above. Aluminum covers are an alternative for the fixed dome cover alternative. There are few aluminum covers installed in digesters today. Design of aluminum covers to withstand gas pressures is difficult and expensive due to the poor stiffness of aluminum. In addition, there are corrosion issues to consider with aluminum in a digester environment. V&A Engineering was contacted regarding the use of aluminum covers for the WPCP digesters and they cautioned against the use of aluminum. Aluminum has a high potential for corrosion in anaerobic environments where hydrogen sulfide is present. Aluminum covers on dissolved air flotation thickeners where H_2S was present corroded through in 10 years at Duluth, Minnesota. In addition, aluminum is more difficult to coat for corrosion protection compared with steel. For these reasons, an aluminum cover was not considered further in this TM. Stainless steal covers are normally considered prohibitively expensive compared to steel or concrete. Therefore, further analyses of alternatives will assume either steel (for domed fixed covers) or concrete (for submerged fixed covers).

3.4 Digester Cover Alternatives Analysis

A preliminary screening of the five alternatives was performed. The remaining alternatives were evaluated further using a net present value analysis.

3.4.1 Initial Screening of Digester Cover Alternatives

The WPCP operates a separate digester gas storage system for gas control throughout the plant and does not need additional gas storage capabilities in their digesters. Therefore, a gasholder cover is not necessary. To combat internal corrosion problems, a cover configuration that minimizes the liquid/gas interface is more desirable. Each cover alternative was initially evaluated based on the following:

- ability to minimize this liquid/gas interface
- compatibility with mixing system alternatives
- structural limitations

Retrofitting the existing floating covers to remain in place for the remainder of their useful life is included as an alternative. Three different iterations of this alternative are presented, which include retaining the existing floating cover for 10 years and then replacing it with a new fixed steel cover; retaining the existing floating cover for 30 years and assuming minor structural repairs are necessary; and retaining the existing floating cover for 30 years and assuming major structural repairs are necessary. It is unclear which digesters this is a viable alternative for until material testing is completed on the existing covers. Initial screening of the digester cover alternatives is shown in Table 3-6.

Table 3-6. Initial Screening of Digester Cover Alternatives

Alternative	Comments	Action
1a - Standard Floating (Rehabilitate existing covers)	Provide a new fixed steel cover after 10 years	Retain for further analysis
1b - Standard Floating (Rehabilitate existing covers)	Retain the same cover for 30 years and assume minimal repairs are necessary	Retain for further analysis
1c - Standard Floating (Rehabilitate existing covers)	Retain the same cover for 30 years and assume major repairs are necessary	Retain for further analysis
1d - Standard Floating (New replacement covers)	Small gas/liquid interface with submerged applications	Retain for further analysis
2 - Gasholder Floating	Large gas/liquid interface; limits mixing alternatives; additional gas storage not needed at WPCP	Rejected
3a - Fixed Flat Concrete	Large gas/liquid interface; internal or external support columns; vacuum design problems	Rejected
3b - Fixed Steel	Moderate to large gas/liquid interface	Retain for further analysis
4 - Submerged Fixed Concrete	Minimum gas/liquid interface (at San Jose WPCP, structural modifications are necessary), internal or external support columns	Retain for further analysis
5 - Membrane Gasholder	Large gas/liquid interface; limits mixing alternatives; additional gas storage not needed at WPCP	Rejected

3.4.2 Digester Cover Net Present Value Analysis

The project costs for each of the alternatives where new covers are installed are summarized in Table 3-7. Costs for the fixed steel covers and submerged fixed covers were not determined for Digesters 1 through 3. Details on capital costs and net present value estimates for cover alternatives are provided in Attachment A. Installing new floating covers or new fixed steel covers have a similar project cost. The submerged fixed concrete cover is initially the most expensive of all of the alternatives due to the structural modifications; this option also has the lowest life cycle cost, however, due to significantly longer asset life and avoided future replacement requirements. For both the submerged fixed covers and fixed domed steel covers, the project costs are higher for Digesters 4 through 11 due to the increased structural requirements.

Table 3-7. Project Costs for Each Cover Alternative		
Alternative	Cover Project Cost for 100-ft Diameter Digester (million $)	Cover Project Cost for 110-ft Diameter Digester (million $)
1d - Standard Floating	3.86	4.21
3 - Fixed Steel	NA	4.41 (Digesters 4 – 11)[1] 4.20 (Digesters 12 – 16)[1]
4 - Submerged Fixed Concrete	NA	4.78 (Digesters 5 – 11)[1,2] 4.72 (Digesters 12 – 16)[1]

[1] Includes cost for structural modifications that would be necessary

[2] Digester 4 costs would be higher due to excavation that would be necessary

Project costs and the 30-year net present value cost estimates for the cover alternatives for the 110-ft diameter digesters are presented in Table 3-8 including costs for rehabilitating the existing covers. The O&M costs were estimated based on the existing digester covers at the WPCP. Of the new cover options, the submerged fixed concrete cover has the lowest net present value when compared to the floating covers and new steel fixed covers. Even though the submerged fixed concrete covers have a higher capital cost, there are less O&M costs associated with the cover operation. It should be noted that, if a longer period were considered for the net present value, submerged fixed covers would become even more favorable due to the expected long life of this cover type versus metal covers.

Table 3-7 also presents several rehabilitation alternatives. The condition of the existing covers varies between digesters. As a part of a sensitivity analysis, Table 3-7 presents two rehabilitation possibilities where the condition of the cover is poor (1c), which would require major structural repairs, and where the condition of the cover is moderate (1b), which would require minor structural repairs. The net present values of these two scenarios are $8.13 million and $7.54 million, respectively. For comparison, installing a new floating cover has a net present value of $9.65 million. Another possibility would be to perform minor structural modifications and completely replace the cover after 10 years with a new submerged fixed concrete covers. This has a lower net present value ($5.33 million) than the other rehabilitation scenarios. For the new cover alternatives, the submerged fixed cover has the lowest net present value ($5.76 million to $5.82 million) because it requires less maintenance and lasts considerably longer, compared to the other technologies. Because Digesters 5 through 11 are older, they have a higher net present value due to the increased project costs associated with the structural modifications.

Table 3-7. Planning Net Present Value for 110-ft Digester Cover Alternatives			
Description	Initial Capital Cost (million $)	Net Present Value (million $)	Cost Considerations and Assumptions
1a - Rehab - replace covers in 10 years	2.10	5.33	• Minor initial structural repairs, including recoating • Construct a new fixed concrete cover after 10 years (assume installation occurs on Digesters 4 – 11) • Inspection every 10 years • Spot liner repair every 10 years
1b - Rehab – low structural repairs	2.10	7.54	• Minor initial structural repairs, including recoating • Inspection every 5 years • Recoating every 5 years • New roof every 15 years
1c - Rehab - high structural repairs	2.70	8.13	• Major initial structural repairs, including recoating • Inspection every 5 years • Recoating every 5 years • New roof every 15 years
1d - Standard Floating (Digesters 4 - 16)	4.21	9.65	• Inspection every 5 years • Recoating every 5years • New roof every 15 years
3 - Fixed Steel (Digesters 4 – 11)	4.41	9.20	• Inspection every 5 years • Recoating every 5 years • New roof every 10 years
3 –Fixed Steel (Digesters 12 – 16)	4.20	8.98	• Inspection every 5 years • Recoating every 5 years • New roof every 10 years
4 - Submerged Fixed Concrete (Digesters 5 – 11)	4.78	5.82	• Inspection every 10 years • Spot liner repair every 10 years
4 - Submerged Fixed Concrete (Digesters 12 – 16)	4.72	5.76	• Inspection every 10 years • Spot liner repair every 10 years

3.5 Digester Cover Recommendation for Further Consideration

Based on the cover evaluation performed independent of the digester mixing selection, several conclusions can be made. Section 5 provides an analysis that considers both covers and mixers.

New floating covers are not recommended because the existing corrosion problems and maintenance issues with cover recoating would not be addressed by replacing the covers in-kind. Floating covers are subject to varying degrees of tipping and imbalance due to foaming problems. In addition, the annular space of the floating cover allows gas, VOC, and foam release. Currently, there are no means to mitigate this problem with floating partially submerged covers. All new VOC emission sources will be subject to BACT and offsets regulations.

For the covers that are not replaced with new covers, rehabilitation may be necessary. From a net present value analysis, it is more cost effective to replace the covers than perform the required frequent rehabilitation work on the existing covers to keep them running. Rehabilitating the existing floating covers for continued service through 2030 and beyond has a higher net present value than the other alternatives.

In current wastewater practice, fixed covers are more common in new installations than floating covers. Fixed covers, by design, are not subject to tipping or imbalance, but can be subject to structural damage if overfilled

and emergency overflows are plugged or over-pressurized. Submerged fixed covers allow for surface withdrawal and are the most effective at foam and scum removal. Submerged fixed covers have structural limitations with the existing digesters regarding maximum liquid level in the digesters and will require significant structural retrofits if the liquid level is raised above current maximum levels. For subsequent analysis, submerged fixed concrete covers and fixed steel covers are considered.

4. DIGESTER MIXER EVALUATION

This section discusses and evaluates the requirements for digester mixing. An overview of the existing digester mixing system is presented and the existing mixing system was evaluated based on typical design criteria. Several digester mixing alternatives are identified and are evaluated. Despite the benefits of improved mixing, the expense to install and operate the mixing system is substantial. A net present value analysis has been performed to quantify the benefits of mixing for comparison with the installation and operating costs. Based on this analysis, a recommendation is made for mixing upgrades. Recommended mixers are further evaluated in conjunction with various cover types in Section 5.

4.1 Digester Mixing Overview

The ability to maintain an active digester volume is critical to maintaining stable operation and good performance in anaerobic digestion and the digester mixing system plays a key role in this. Given the high design loading rates proposed for the WPCP digesters, the planned implementation of co-digestion with FOG and potentially other import materials, and higher feed solids concentrations that would result from a co-thickening DAFT upgrade, selection of an effective mixing system is critical for good digester performance.

Effective digester mixing maintains intimate contact between active biomass and incoming feed sludge, reduces short-circuiting, creates uniformity throughout the digester, minimizes formation of top scum layer and bottom solids deposition, and prevents stratification and temperature gradients. These benefits reduce the risk of digester upsets, which may be especially high when other digesters are offline for cleaning. A digester upset would represent a substantial cost to the treatment plant and create odors. Mixing improvements to the existing digesters would increase the digester active volume and reduce the required cleaning frequency. In addition, a well-mixed digester will achieve a higher degree of volatile solids reduction (VSR) and biogas production.

Mixing performance attaining greater than 95 percent active volume are achievable with many mixing technologies in clean digesters with sufficient power input. The ability to keep grit and scum in suspension and convey them to the point of sludge removal is a fundamental digestion design consideration. Additionally, different mixing systems have different characteristics with respect to creating or exacerbating the generation of foam. The proper design of tank configuration, mixing medium, and sludge withdrawal are all vital to effective, long-term digester performance.

4.2 Digester Mixing Criteria

Mixing performance is viewed by most designers in the wastewater industry exclusively from the perspective of active volume of the digester as measured with tracer studies and, more recently, computational fluid dynamic (CFD) modeling. This is a reasonable measure of the ability of the digester to be fully utilized by the microbial population when clean. However, this performance measure alone does not account for mixing system configurations that are more or less adept at preventing grit deposition or scum/foam entrainment and removal. No definitive performance measure for effectiveness of digester mixing has yet been defined by the wastewater industry that accounts for these important criteria. However, in an attempt to standardize the design of mixing systems, the wastewater industry has adapted typical design parameters (Table 4-1). It is generally accepted that with the criteria in Table 4-1, sufficient energy is imparted to keep grit adequately in suspension. However, energy alone is not enough; that energy must be appropriately distributed in such a way as to maintain mixing coverage throughout the entire vessel; or more specifically, to prevent grit deposition and surface foam accumulation. This is particularly important in larger digesters such as those at San Jose, where poor distribution can effectively mix some zones and leave others under mixed.

Table 4-1. Typical Design Parameters for Anaerobic Digester Mixing Systems[1]		
Parameter	Type of mixing system	Customary units
Unit power, hp/1,000 cf digester volume	Mechanical systems	0.2 to 0.3
Unit gas flow, cfm/1,000 cf	Gas mixing, unconfined	4.5 to 5
Unit gas flow, cfm/1,000 cf	Gas mixing, confined	5 to 7
Velocity gradient G, s^{-1}	All	50 to 80
Turnover time, minutes	Confined gas mixing and mechanical systems	20 to 30

[1] Information from Table 5 adapted from WEF (1987b) "Anaerobic Digesters Mixing Systems," *Journal Water Pollution Control Federation*, Vol. 59, p. 162, Water Environment Federation, Alexandria, VA.

The optimum digester configuration for effective mixing is the egg-shaped digester, with low energy input, proven long-term performance of continued high active volume, and no appreciable build-up of scum and grit. Recognizing that digester retrofit is limited to the tank configuration that exists, our approach is to study the best overall system configuration to effectively approximate this ideal.

Table 4-2 summarizes the results of a research paper that used CFD modeling to estimate the active volume of several full-scale digesters and also includes similar information from the literature and for the San Jose digesters. Active volume and turnover rate are compared to the digester mixing energy. As expected, higher active volume is achieved with higher mixing energy. Digesters that operate with G values[1] ranging from 71 to 97 s^{-1} are predicted to have active volumes of 99 percent or greater. Digesters with turnover rates below 60 minutes are also expected to have high active volumes, generally in the high 90 percentile. The Sacramento digester tests with 3 and 5 mixers operating seem at first glance to counter that, however, the center mixer was operated in the opposite direction as the peripheral mixers, and we believe this caused short circuiting. This highlights the importance of mixer configuration in addition to energy input. In general, the results in Table 4-2 suggest that a minimum mixing energy of 0.15 hp/1,000 cf (or 4 W/m^3) is necessary to supply sufficient mixing for high active volume. The existing San Jose digester mixing system provides approximately half of that energy input and its configuration with gas spargers located in the center reduces mixing influence on the periphery of the digesters.

Table 4-3 provides an important new look into the significance of energy input with respect to grit accumulation. Similar to the results in Table 4-2, Table 4-3 suggests that a minimum mixing energy of approximately 0.15 hp/1,000 cf is necessary to prevent grit accumulation. The one case (Central Virginia) that used slightly less mixing energy of 0.13 hp/1,000 cf with effective grit suspension used sequential mixing, rotating intensive mixing energy in zones sequentially around the digester. Again, configuration of the mixing system, including distribution of mixing elements within the digester is critical to gaining the most efficiency and best performance.

Historically, Brown and Caldwell has designed pumped or mechanical mixed digesters with a 30-minute turnover of digesters with all units operating, but allowing for rotation of mixer operation (operating half of the mixers at a time) and turndown of mixer speed. For gas mixing systems, Brown and Caldwell has typically designed for a minimum G value of 60 s^{-1} and a maximum value of 80 s^{-1}. For this project, we recommend a maximum of 60 minutes turnover rate to assure high active volume along with a minimum power input of 0.15 hp/1,000 cf combined with an appropriately distributed mixing configuration to assure grit suspension. For the existing digesters, the power input would need to be 52 hp per digester. It is important to note that these power requirements are determined using the volume of the digester cylinder (2.29 MG) plus the volume of the cone (0.26 MG). In addition, we recommend withdrawal of a significant proportion of the

[1] The G value is a relative measure of turbulence. It is defined as:

$$Gvalue := \sqrt{\frac{Power}{Volume \cdot Viscosity}}$$

daily sludge flow from the bottom of the digesters to continually remove grit from the bottom. (Note that the remainder of the sludge is recommended to be removed from the surface to remove scum and foam from the digester.) Using these two criteria (maximum 60 minute turnover and minimum energy input of 0.15 hp/1,000 cf) in tandem will assure a well mixed digester and significantly reduce grit deposition.

The existing San Jose digesters operate with limited gas mixing and pumped circulation used for digester heating, resulting in a low turnover rate and energy input (see Section 4.3) These digesters have not performed well from the perspective of grit deposition and preserving active volume at these extended turnover times and low energy input. Section 4.3 below discusses the existing mixing systems at the WPCP in greater detail.

Table 4-2. Digester Active Volume Results from Mixing Power Input							
Location	Mixer Type	Digester diameter, ft	Digester sidewater depth, ft	Power input per unit volume [4], W/m^3 (hp/1,000 cf)	Velocity gradient G, s^{-1}	Turnover rate, minutes	Active Volume Results
Simulation 1[1]	Mechanical draft tubes (4 draft tubes)	100	33	4.1 (0.16)	71	54	99.9
Simulation 2[1]	Mechanical draft tubes (1 draft tube)	45	24	6.9 (0.26)	97	29	99.2
Simulation 3[1]	Mechanical draft tubes (5 draft tubes)	110	33	6.3 (0.24)	88	42	99.9
Simulation 4[1]	Mechanical draft tubes (4 draft tubes)	70	24	5.7 (0.22)	88	24	99.6
Aberdeen[2]	Distributed sequential shear fusers (7 to 8% TS)	56	56	3.8 (0.14)	NT	NT	92.8
Sacramento[3]	Mechanical draft tubes (2 draft tubes)	115	43	2.7 (0.10) [5]	NT	102	90
Sacramento[3]	Mechanical draft tubes (3 draft tubes)	115	43	4.0 (0.15) [5]	NT	64	88 [7]
Sacramento[3]	Mechanical draft tubes (5 draft tubes)	115	43	6.7 (0.25) [5]	NT	39	88 [7]
San Jose, CA	Floor mounted shear fusers	110	34.2	2.2 (0.08) [5]	32	NT	75 – 88 [6]

[1] From Meroney, M.N,, Colorado, P.E., 2009, *CFD Simulation of Mechanical Draft Tube Mixing in Anaerobic Digester Tanks*, Water Research, 43, 1040-1050.

[2] Cumiskey, A., Dawson, M., Tillottson, M., (2003) *Thick Sludge Digestion – Research, Design, and Validation of Key Process Unit Operations,* WEF Residuals and Biosolids WEF Residuals and Biosolids Management Conference, Baltimore, Maryland.

[3] Lee, C.S., Johnston, J.R., (2001) *Anaerobic Digester Mixing Study at the Sacramento Regional Wastewater Treatment Plant*, California Clean Water Environment bulletin, winter, 2001

[4] Based on theoretical power draw except where noted by footnote 5

[5] Based on nameplate HP

[6] Theoretical active volume from Attachment A, TM 3.3, San Jose Digester Rehabilitation Project.

[7] Note: 3 and 5 draft tube cases operate countercurrent center draft tube which is creating dead zones.

NT – Not tested

Table 4-3. Digester Grit Deposition Results from Mixing Power Input						
Location	Mixer Type	Digester diameter, ft	Digester sidewater depth, ft	Power input per unit volume [2], W/m^3 (hp/1,000 cf)	Turnover rate, minutes	Grit Deposition Results
Texas[1]	Gas lance draft tube (one in center)	65	24.5	11.2 (0.43)	27	No grit accumulation. Slight increase in solids concentration in bottom 1 to 2 feet of digester
Texas[1]	Gas lance draft tube (one in center)	65	24.5	6.4 (0.24)	14	No grit accumulation. Slight increase in solids concentration in bottom 1 to 2 feet of digester
North central Illinois[1]	Gas lance draft tube (one in center)	60	20	1.9 (0.07)	NT	Dramatic solids buildup on bottom of digester, particularly around edges
Central Virginia[1]	Sequential, unconfined lances	40	20	3.5 (0.13)	NT	No grit buildup, uniform 4 percent solids throughout
Central Wisconsin[1]	Sequential, unconfined lances	60	24	1.7 (0.07)	NT	Lances 10 ft below liquid surface. Sludge thickness doubles from 2.5 to 5 % TS starting 4 to 6 ft below lances. Some grit settling, but not serious grit deposition.
Central Wisconsin[1]	Sequential, unconfined lances	60	24	2.5 (0.10)	NT	Lances 15.5 ft below liquid surface. Sludge thickness increases from 2.5 to 3.5 % TS starting 4 to 6 ft below lances. Some grit settling, but not serious grit deposition.
Southeastern Wisconsin[1]	Floor mounted shear fusers	60	26	1.7 (0.07)	NT	Severe grit accumulation from 2 to 6 feet, deeper around edges
Annacis Island, Vancouver, BC	Gas lance draft tubes (four draft tubes at third points from walls)	118	30	5.1 (0.19) 6.2 (0.24)[3]	20	Very little grit deposition after 10 years. Approximately 200 cf, which is equivalent to about 2 inches on bottom of digester.
WLSSD, Duluth, Minn.	Mechanical draft tubes (four, 10 hp draft tubes at third points from walls)	75	32	4.2 (0.16)[4] 7.5 (0.29)[3]	NT	Very little grit deposition after 10 years. Approximately 26 cf, which is equivalent to about ½ inch on bottom of digester.
North Davis Sewer District, Salt Lake City	Four external mechanical draft tubes	85	25	6.5 (0.25)[3]	NT	Very little grit after 5 years in operation
San Jose, CA	Floor mounted shear fusers	110	34.2	2.2 (0.08)[3]	NT	Severe grit deposition observed filling cone and 6 feet up sidewall on four year cleaning cycle.

[1] From Baumann, P.G., Huibregtse, G.L. (1982) *Evaluation and Comparison of Digester Gas Mixing Systems*, Journal Water Pollution Control Federation, 0043-1303, p.1194, Reprint 315-271-P10
[2] Based on theoretical power draw except where noted in footnote 3 or 4.
[3] Based on nameplate HP
[4] Estimated based on average amperage versus full load amperage
NT – Not tested
Notes: Pango sampler and velocity probes used by Baumann to get velocities and TS samples throughout digesters

4.3 Existing Digester Mixing

All WPCP digesters, with the exception of Digester 4, are equipped with unconfined gas mixing using bottom diffusers. Mixing equipment includes gas compressors, gas piping, and gas diffusers. The existing gas mixing compressor draws digester gas from the low pressure header and recirculates it to the digester. Cooling and sealing of the liquid ring gas compressor is provided by No. 2 Water. If there is a power failure, the water supply valves to all gas mixing compressors must be closed immediately to prevent water from accumulating in the gas piping. The recirculating gas from the gas mixing compressor is diffused through gas shear fuser diffusers located in a ring at the center of the floor of the digester. As the gas bubbles rise to the top, they create a rolling motion that mixes the sludge in the digester. Disadvantages of this type of mixing system are related to the bottom mounted shearfuser diffusers because they interfere with digester cleaning, require the digester be emptied for maintenance, and are subject to plugging. Plant staff has indicated historical issues with diffuser plugging. The gas piping manifold to the diffusers in Digester 7 is shown in Figure 4-1.

Digester 4 has not been in operation for some time due to ground settlement around the digester; however, this digester is equipped with confined gas mixing using a draft tube. Plant operations staff indicated that when Digester 4 was in operation, its mixing system performed the best and comparatively more gas production was observed from this digester.

Figure 4-1. Gas piping at Digester 7

The evaluation presented in TM 3.3 determined that the existing mixing system is not effectively mixing the entire digester volume and reduced active volume (estimated at 75 to 88 percent) requires more digesters to be operated to assure process loading criteria are met. In addition, the existing digesters experience severe grit and struvite accumulation so that active volume is not preserved by the existing systems (TM 3.3 and TM 4.6). As reported in the Infrastructure Condition Assessment (CH2MHill, May 2007), the existing mixing systems for all the digesters are worn and inadequate. Aboveground piping, equipment, drives, pumps, valves, and specialty equipment are in fair to poor condition. Plant staff has indicated that they are not completely satisfied with the gas compressors and the old compressors require a great deal of cooling water and maintenance. Poor performance of digester mixing has been evident in the large amount of grit deposited in the digesters.

As discussed above, Brown and Caldwell typically uses the G value to design digester gas mixing systems. We recommend a minimum G value of 60 s^{-1} and a maximum value of 80 s^{-1}. Table 4-4 summarizes the G value of the existing gas system and the recommended minimum and maximum gas flows. Assuming the gas flow of 200 cfm from each 30-hp gas compressor, the current G values are 36 s^{-1} and 32 s^{-1} for Digesters 1-3 and Digesters 4-16, respectively. These G values are significantly lower than the recommended values. Comparing the actual unit gas flow to the recommended unit gas flow for an unconfined gas mixing system given in Table 4-1, indicates that the existing gas mixing system is undersized with a capacity of approximately 30 percent of the recommended minimum design gas flows for mixing. In addition, as discussed in Section 4.2, the power input to the digesters is approximately half of the recommended value and diffuser location in the center of the digesters provides poor mixing energy distribution.

Replacement of the existing digester mixing system is recommended to improve digester performance and reduce maintenance.

Table 4-4. Existing and Recommended Gas Mixing System G values and Gas Flow Rates

Parameter	G Value, s^{-1}	Gas Flow, cfm
Existing		
Digesters 1 – 3	36	200
Digesters 4 – 16	32	200
Recommended		
Digesters 1 – 3	60 - 80	560 – 1,000
Digesters 4 – 16	60 - 80	700 – 1,240

4.4 Digester Mixing Alternatives

In this TM, improvements to the mixing system focus on achieving the following objectives:

- Minimizing the generation and/or accumulation of foam (important when FOG and food wastes are added to digester feedstock) and suspending grit to be removed with the sludge from the digester
- Effectively maintaining high active volume with low energy input (high efficiency)
- Maintaining compatibility with selected cover system
- Providing ease of O&M
- Providing reliability, flexibility, and safety
- Cost effective

Increasing mixing efficiency will result in a reduction in the amount of grit deposited in the digesters, more uniform temperature within the digesters, increased homogeneity, less build up of scum in the digesters, reduced odor, and better control of foaming. Many of these improvements will play an important role in the future if FOG and food wastes are included as feedstock to the digesters and the potential for foaming, scum, and stratified conditions are increased.

Five mixing systems are considered for rehabilitation of the existing digesters:

- New gas mixing system
- Mechanical draft tube mixers (internal and external)
- External pump mixing
- LM mixers
- Focused Flow Mixing

4.4.1 Alternative 1 – Gas Mixing

Gas mixing uses the buoyancy forces of gas bubbles rising through the digester to induce circulation and mixing. Digester gas is collected and circulated into a gas mixing device with a gas compressor. Common methods for introducing digester gas into the digester include unconfined (gas lances, bottom mounted diffusers, etc.) and confined (gas lances in draft tubes and gas pistons (bubble guns), etc.) gas mixing systems.

The mixing energy with unconfined gas mixing is focused at the depth of gas release and increases as bubbles rise to the surface and increase in size. With confined gas mixing (draft tubes) mixing energy can be directed to the bottom of the draft tube. Gas mixing has been found in some cases to exacerbate digester foaming. Compressor sizing and discharge pressure requirements are based on the submergence depth of the device introducing the gas into the digester. Digesters with high side water depth will have high discharge pressure requirements. In addition, bottom diffusers will have higher pressure requirements than gas lances. Discharge of gas at greater depths and increased pressures reduces bubble size; and therefore, reduces mixing intensity at depth versus near the surface. Nonetheless, bubble release near the bottom is preferred in unconfined gas mixing systems to assure mixing energy is applied at the bottom where grit settles. Often, significant maintenance is associated with gas compressors.

One advantage of some gas mixing systems is that they are not prone to struvite buildup on the mixing components. If struvite control measures are not implemented at San Jose (TM 4.6), gas mixing may prove one of the only viable alternatives for mixing upgrades. For this reason, gas mixing is retained for evaluation and the costs for a new gas mixing system are provided in section 4.5.3 for comparison purposes.

Due to the operational difficulties experienced with gas mixing, high maintenance requirements for compressor operation, potential for mixing gradients due to bubble compression at depth, and the potential for foaming problems, particularly with planned FOG input to the digesters, this option was not initially a preferred alternative. However, gas mixing is retained for further cost evaluation and comparison due to its potential benefits with respect to struvite buildup in the event struvite control measures are not implemented at the plant. Table 4-5 summarizes the advantages and disadvantages of gas mixing.

Table 4-5. Gas Mixing Advantages and Disadvantages

Advantages	Disadvantages
• Less prone to ragging • Flexibility to modify mixing pattern • Compressor redundancy can be designed into the system • Less prone to struvite formation on mixing components, particularly in unconfined systems	• Mixing efficiency affected by depth of submergence • In deep digesters, mixing at depth reduced over surface mixing due to bubble compression • Potential for surface debris accumulation • Potential for exacerbating foaming • Handling flammable gases requires specialized and explosion-proof equipment • Compressors require separate gas room designed to NFPA 820 requirements • Only mixes in upward direction • Frequent maintenance on gas compressors

4.4.2 Alternative 2 - Mechanical Draft Tube

Mechanical draft tube sludge mixers, such as those by Eimco, Westech, and Olympus Technologies, have a modest diameter vertical draft tube with a vertical mixer that can be reversed to either discharge through a top or bottom outlet location. A draft tube mixer is comprised of specially-designed, non-clog impeller inside a draft tube that extends from the surface to the bottom of the digester, such that digested sludge can be pumped efficiently up or down through the tube to provide mixing. The motor and gear box are mounted

externally above the draft tube with the impeller mounted on a vertical shaft extending into the draft tube. Small digesters can be effectively mixed with one draft tube, whereas large will require as many as five draft tubes and mixers. A crane would be required to remove the mixer for maintenance, but lubrication can be performed in place. Primary criteria are the same for all mixers: provide a turnover time less than one hour (30 minutes typically recommended by manufacturers). Flow rates for the mixer units can range from 7,600 to 23,000 gpm (5 to 20 horsepower motors) depending on what intensity of mixing is to be achieved and the number of installed mixers.

Draft tube mixers can be installed on the digester roof or externally through the side of the digester (see Figure 4-2). RDT mixers, like the one shown in Figure 4-3, are normally used with fixed covers where the draft tube is fixed internally to the digester bottom and supported by bracing; the mixer is mounted on the cover. This type of mixer can be used with floating covers where the mixer is installed on the digester roof with a short portion of the draft tube suspended from the floating cover. The remainder of the draft tube of slightly less diameter is fixed internally. As the digester floating cover moves up and down, the draft tube will function with a telescoping operation as the digester level changes.

An external draft tube (EDT) mixer, like the one shown in Figure 4-4, is installed externally from the digester roof, with two penetrations through the side of the digester. The mixer motor is mounted on the top of the digester, located on a platform, and the impeller suspends down into the draft tube below the digester operating liquid level.

The impeller for both RDT and EDT mixers can be operated in either the forward or reverse directions. This results in pumping up or down of the digester contents and allows for cleaning of debris from the impeller. This reversing ability can be beneficial for breaking up floating surface material. The impellers have helical blade configurations, as illustrated in Figure 4-5, to decrease the potential for debris accumulation. The advantages and disadvantages of draft tube mechanical mixing is summarized in Table 4-6.

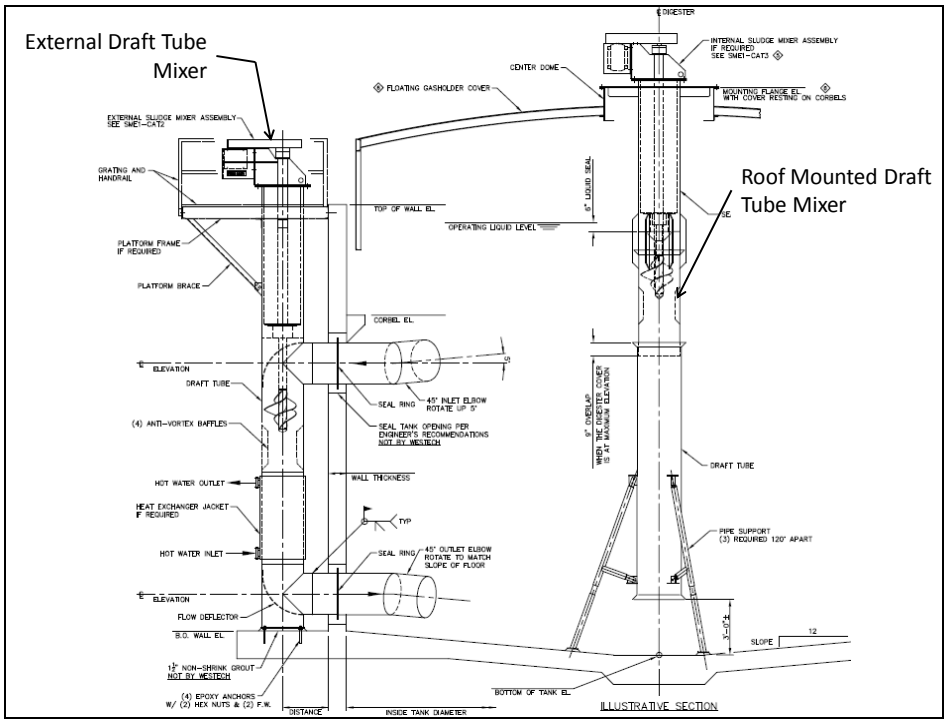

Figure 4-2. Typical section of external (left) and internal (right) draft tube mixers (Westech)

Figure 4-3. Photo of an RDT mixer

An RDT mixer motor installed on a digester floating cover (left);
RDT mixer and motor assembly (center); and three RDT mixers located on a digester cover (right).

Figure 4-4. Photo of an EDT mixer.

An EDT mixer (left) and shown from the inside of a digester (right). The mixer platform is located on the top of the digester deck. The upper draft tube penetration into the digester is shown above grade; the lower draft tube penetration into the digester wall is below grade. This installation has a heating jacket to provide heating of digester sludge.

Figure 4-5. Mechanical draft tube mixer impellers

Table 4-6. Draft Tube Mechanical Mixing Advantages and Disadvantages	
Advantages	Disadvantages
• Proven experience • Equipment can be serviced without taking digester out of service. • Unit responsibility is placed on supplier. • External draft tube can be fitted with heating. • High mixing effectiveness. • High energy efficiency. • Suitable for floating or fixed covers. • Rapid turnover time • Accessible equipment • Flexible operation (forward or reverse) • Does not require additional equipment gallery floor space • External equipment easy to access • Low foaming potential. • Flexible operation (reversible).	• Crane required to remove mixing unit for maintenance. • Main bearing and shaft seal in mixing unit has been a problem in the past with some models • Large diameter wall penetrations (for EDT mixers) are a structural challenge. • Careful vertical alignment required • With external mixers, large penetrations (approximately 30 inches) required through digester wall. • Can be prone to struvite accumulation on mixing components if digesters have high struvite formation potential

An example of a facility that has draft tube mixers is the North Davis Sewer District (NDSD) plant in Salt Lake City, Utah. NDSD has four existing digesters that are 85 ft diameter and 25 ft SWD with 1:4 cones. Two are used as primary digesters and are heated and were mixed with a pump mix system. The old pump mix system consisted of two 60 hp pumps (120 hp per digester) located 180 degrees apart that pulled suction through the wall near the connection with the floor and injected the sludge through an angled nozzle midway up the wall about 10 to 12 ft above the suction. The other two digesters are used as secondary digesters and are unheated and unmixed. New EDT mixers were installed to replace the pump mix system on the primary digesters in 2004. When the primary digesters were opened prior to construction, each had approximately 12 ft of grit accumulation at the sidewall (the whole cone plus half the cylinder volume was filled with grit). This was a typical grit accumulation every four years in the primary digesters and it took a couple of months for the plant staff to remove it. Four, 10-hp Eimco EDT mixers were installed at 90 degrees and the old pump mix was removed from each digester. Each mixer has a 27-inch tube, 24-inch impeller and capacity of 10,000 gpm. The turnover time is 30 minutes. One nozzle is near the floor and the other is about 12 ft up the wall just under the corbels. The draft tube nozzles are angled to induce rotation in the tank with the bottom one tilted down towards the cone while the top tilted up to the surface. They can operate in either upflow or down flow mode to sweep the cone or breakup the surface. The plant took each of the primary digesters out of service in the fall of 2009 for inspection (five years in service) and found very little grit. In this case, lower energy input (0.25 nameplate hp/1,000 cf) from a new, well-configured system easily outperformed a higher energy input system (0.76 hp/1,000 cf) that was poorly configured.

The Sacramento Regional County Sanitation District (SRCSD) has the first generation Eimco mixers installed on their digesters. These mixers were first generation mixers and were prone to O&M issues. Each digester has five, 20-hp EDT units and one, 20-hp RDT unit. We requested maintenance costs associated with the draft tube mixers. Assuming an hourly rate including benefits of $100, the total labor and parts cost associated with one digester is $160,000 over a 12 year period. This averages out to $13,500 per year. As mentioned previously, these mixers were first generation mixers; newer generation mixers are expected to have lower maintenance costs.

The Western Lake Superior Sanitary District in Duluth, Minnesota has 16 draft tube mixers of a later design and report a total maintence cost of $110,000 for all 16 mixers over a 9-year period. This is an average of less than $1,000 per mixer per year.

4.4.3 Alternative 3 - External Pumped Circulation

The external pumped circulation system consists of piping, valves, and one or more pumps that circulate the digester sludge through several suction and discharge points at various locations around the digester perimeter. The pumps and valves could be installed at ground level while the piping would be installed around the circumference of the tank leading to the discharge and suction locations or inside the tank. Isolation valves would enable maintenance personnel to remove the pumps without taking the digester out of service. Pump size, head characteristics, and drive size are dependent on the head character of the system (i.e. elbows, valves, pipe length, pipe diameter, etc.). Nozzles positioned inside the digester provide directional and high-velocity mixing. Manufacturer products for these systems include the Rotomix system by Vaughan and the Jetmix system by Liquid Dynamics. A typical proprietary pump nozzle mixing system is shown in Figure 4-6.

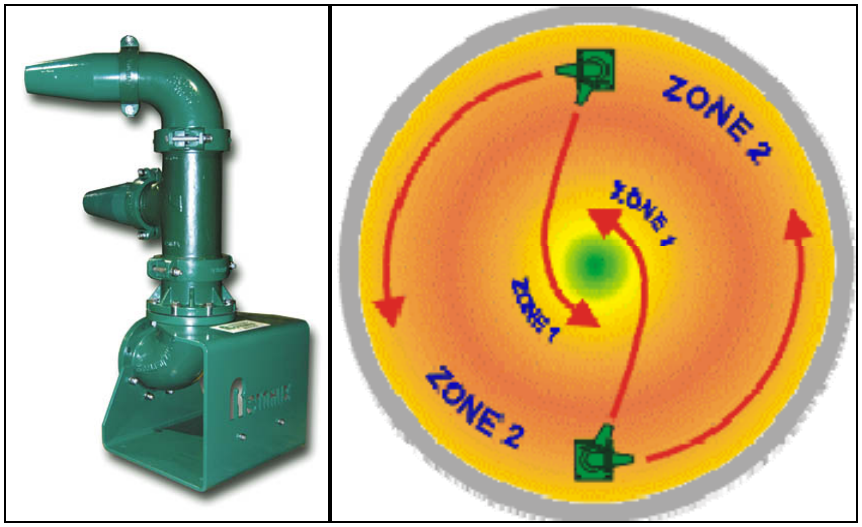

Figure 4-6. Typical proprietary pump nozzle mixing system

A jet-mix system such as Rotomix® or Jetmix ™ consist of chopper pumps designed to circulate digested sludge through a series of strategically placed jet nozzles within the tank. The nozzles provide a region of high fluid velocity that is designed to induce fluid flow within the digester, thus providing mixing. The nozzles are mounted generally on the tank floor to create a circular flow pattern. In Addition, nozzles can be placed at the surface to break up foam. Piping across the digester floor is exposed, and this exposed pipe may be prone to ragging or create obstacles during digester cleaning. This system is most effective for tanks with single cone bottoms, where the circular motion of the fluid within the digester will tend to convey grit and solids towards the center of the cone for removal. Pump nozzle mixing systems are generally easy to maintain due their lack of moving mechanical parts and external pumps.

To provide effective mixing, jet-mix systems usually require large amounts of mixing energy relative to other mixing technologies. Manufacturers claim that mixing energy is imparted on the body of digester contents in the form of induced flow and that mixing is greater than that calculated simply by the volume pumped. It is difficult to verify this claim without direct tracer testing. Due to the large size of the WPCP digesters, several large pumps would be required to provide mixing.

Systems relying on induced flow for mixing are particularly sensitive to sludge viscosity. While systems are designed to operate at 100 percent to provide a maximum degree of mixing, mixing efficiency decreases rapidly when the pump speed is turned down, especially with high solids applications such as thickened

sludge. The manufacturers design pumped nozzle mixing systems with CFD modeling, and accurate modeling requires a good understanding of sludge rheology and lack of material uniformity.

In 2006, Vaughan Co. Engineering performed a computer simulation in the WPCP digesters to determine if their Rotomix tank mixing system would effectively mix the 110-foot diameter tanks. These tanks are larger than the tanks typically suitable for the Rotamix system; however, based on the result of the computer simulation, Vaughan claims that the Rotamix system can achieve a bulk tank turnover rate of 17 times per hour and an active volume mixing of 98 percent. The advantages and disadvantages of external pumped circulation mixing are summarized in Table 4-7.

Table 4-7. External Pumped Circulation Mixing Advantages and Disadvantages

Advantages	Disadvantages
• Mixing energy easy to adjust, change flow to inlets/outlets. • Simple, reliable, measurable pumping technology • Pump and piping, equipment that staff has experience with. • Suitable for varying tank levels • Hydraulic mixing is less likely to aggravate foaming. • Piping can be tied directly into heating system. • High bottom scour velocity and circulation rotation can help clean floor. • Easily maintained and can be serviced without taking digester down. • Rapid turnover time is possible.	• Most applicable to smaller (<50 ft) digesters. • Poor mixing efficiency • Large pumps and piping requires substantial gallery space • Nozzle adjustment may be required to optimize mixing • Must drain digester to replace internal piping and nozzles • High velocities have caused foaming in some installations • Lack of information on optimal design • Piping inside the digester is located above the digester floor and is prone to ragging • More space requirements than gas systems due to high volume flow rate required, thus making pumps and piping large • Potential for dead spots • Multiple wall penetrations • Highest energy use • Susceptible to struvite buildup on mixing components if digesters have high struvite formation potential

4.4.4 Alternative 4 - Linear Motion Mixers

The LM mixer uses an external drive mounted on the roof of the digester and internal shaft with a specially-designed vortex ring disk or plate at the shaft end for mixing digester contents. The shaft cycles up and down at a rate of approximately 60 strokes per minute which produce toroid rings that move outward from the vortex generator. These rings create a rolling motion of digester contents. The contents are mixed by the creation of streams of vortex rings generated on each side of the plate. A vortex ring is basically a rotating ring of fluid moving through the body of the liquid – similar to a smoke ring moving through the air. These rings create a rolling motion of digester contents and create a turbulent liquid-core of micro and macro eddy currents and pulsating pressure waves. These currents are accelerated rapidly through a central opening of an vortex ring or hydro-disk that moves up and down through the liquid. These systems are designed to provide digester mixing with low energy requirements.

Vortex ring mixers from two different manufacturers are shown in Figure 4-7 and Figure 4-8. Both of these mixer manufacturers claim high energy efficiency; however, there is limited experience with these types of mixers in municipal applications and there are no applications for digesters the size of those at the WPCP. In addition there is no data available on grit deposition with these mixers after extended operation. The LM mixers have been used in the US and Canada for approximately 5 years and CFD analyses and tracer studies of these mixers has shown comparable mixing efficiency (active volume) to mechanical draft tube mixers with slightly less energy requirements (Black and Veatch, 2007). The advantages and disadvantages of LM mixing are summarized in Table 4-8.

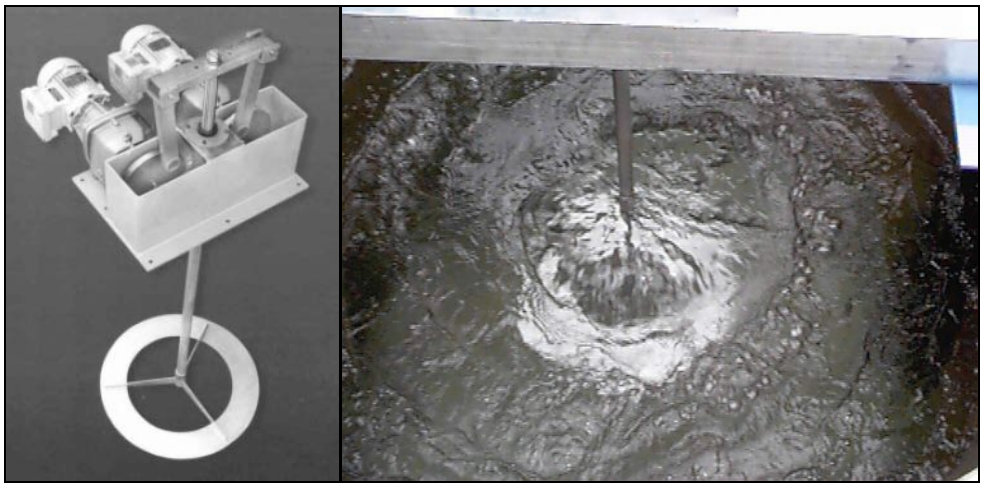

Figure 4-7. LM mixer (Manufactured by Bateman)

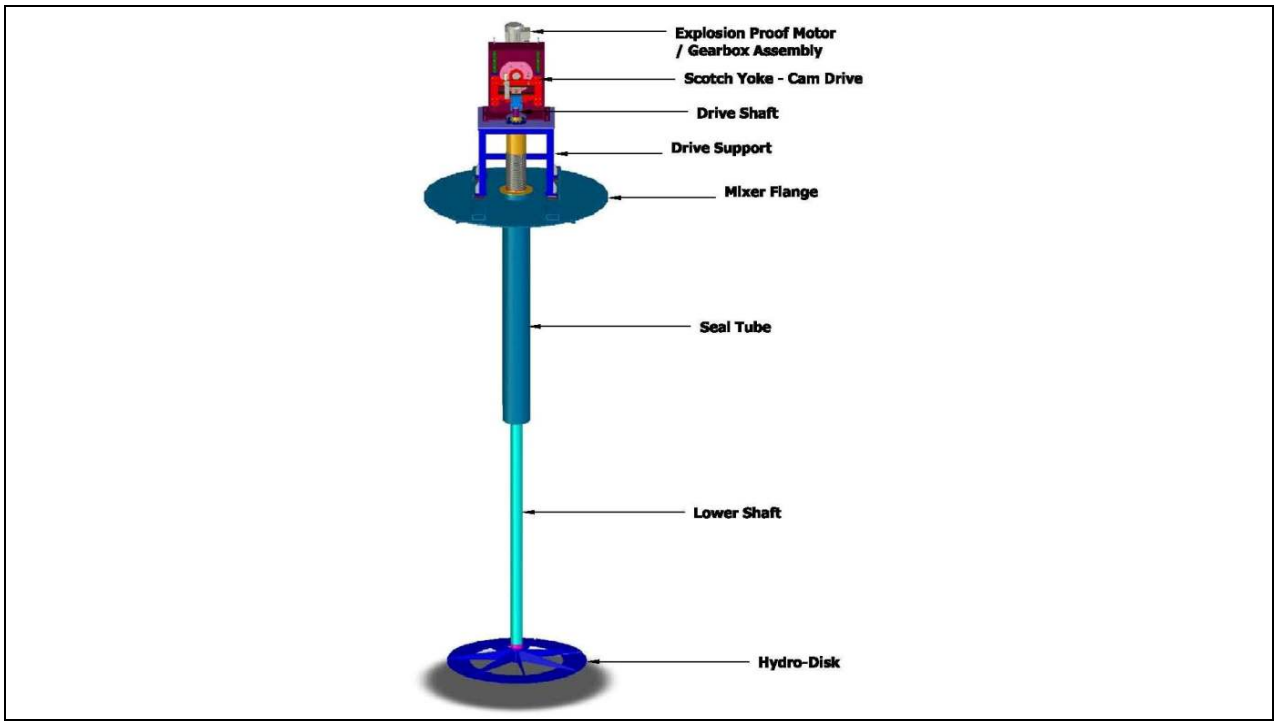

Figure 4-8. LM mixer (Manufactured by Eimco/Enersave)

Table 4-8. LM Mixing Advantages and Disadvantages	
Advantages	Disadvantages
• External drive mechanism for easy maintenance • Low potential for foaming • Unit responsibility is placed on supplier • High energy efficiency claimed by manufacturers • Simple design • Low operating cost	• Limited experience in municipal applications and none in digesters the size of those at the WPCP • Inability to observe mixing problems • Additional dynamic roof loading due to vertical thrusts from oscillating equipment • Most suitable for fixed digester covers. Unsynchronized operation may cause tipping of floating covers if multiple units • Potential for ragging • Large roof hatches needed for access to submerged plate • Struvite accumulation potential on mixer unknown • Grit suspension ability unknown in large digesters, but suspect due to low energy input recommended by manufacturers

Due to the limited experience with these types of mixers, a telephone survey was conducted with staff at three wastewater treatment plants using the Eimco/Enersave LM mixers to gather information regarding the performance. The following plants were contacted and a summary of survey results are given in Table 4-9:

- Ina Road Water Reclamation Facility, Tuscon, Arizona
- Greater Napanee Wastewater Treatment Plant, Napanee, Ontario, Canada
- Fort Erie Wastewater Treatment Plant, Fort Erie, Ontario, Canada

The maintenance strategy at the Ina Road Water Reclamation Facility, regarding the LM mixers, includes an entire spare mixer (not parts), which is installed in the one digester to be taken offline for maintenance that year. The mixer removed from the offline digester is maintained and repaired as needed to serve as the spare mixer for the next year's digester maintenance. Essentially, a refurbished mixer is installed in each digester every four years. Ina Road operations staff recently took a digester off line after 4 years of operation and did not find any grit accumulation. However, staff indicated that the plant's new headworks was in operation through that period, which has fine screening and a very good aerated grit system. They believe their lack of grit in the digester is directly related to the excellent removals at the headworks.

Table 4-9. Phone Survey Results for LM Mixer, Eimco/Enersave			
Item	Ina Road Water Reclamation Facility, Tuscon, Arizona	Greater Napanee Wastewater Treatment Plant, Napanee, Ontario, Canada	Fort Erie Wastewater Treatment Plant, Fort Erie, Ontario, Canada
Background Digester Information			
Diameter, ft	85	45	34
Volume, MG	1.5	0.26	---
Type of Cover	Fixed (2) Floating (2)	Fixed	Fixed, Fiberglass
Feedstock	PS and Thickened WAS	Thickened WAS	Thickened WAS
Typical solids feed, percent	2	4	4 to 6
Previous Mixing System	Mechanical draft tube mixing	Gas mixing with floor shearfusers	Mechanical draft tube mixing
LM Mixer Information			
Number of Mixers, total	4	1	1
Number of Mixers, per digester	1	1	1
Year Installed	2003	2006	2005
Horsepower of Mixer, hp	10	10	---
VFD	No	Yes	---
Performance Information			
Clogging or Ragging Issues	No	No	Unsure
Performance Difference at Varying Sludge Thickness	No	No	No
Gas Production, Volatile Acids, or Alkalinity Difference as Compared to Previous Mixing System	No Difference	No Difference	No Difference
Maintenance Issues	Minor issues. Maintenance they have performed includes the replacement of one motor (10hp) after 2 to 3 years, and replacement of yoke bearing plate after 4 years.	None. Have not taken digester out of service to date.	None until the past few months (beginning of 2009) when they experienced foaming problems with foam escaping through the shaft. Digester has not been taken out of service to date since retrofit with LM mixer.
Scum or Solids Buildup	No grit buildup in digesters after 4 years of operation	Unknown. Have not taken digester out of service to date.	Unknown. Have not taken digester out of service to date.
Foaming Issues	No	No	Yes (see discussion above)
Corrosion Issues	No	No	No
Overall Satisfaction	Very good. Mixers have saved them considerable electricity costs (from a total of 360 horsepower to 40 horsepower for the 4 digesters).	Very good. Maintenance has been significantly reduced from the previous gas mixing system.	Very good until the recent problems with foaming.

4.4.5 Alternative 5 - Focused Flow Mixing

Philadelphia Mixing Solutions has recently released a mixer they describe as a focused flow mixer that can be used in anaerobic digesters. The mixer is designed to be installed in the digester without a draft tube and the manufacturer claims that it has lower power requirements than a draft tube mixer or pump mixing system.

Figure 4-9 shows a picture of a focused flow mixer. For the digesters at San Jose, several mixers would be required to provide sufficient mixing. The focused flow mixer was developed for the oil and gas industry for mixing large bulk crude oil storage tanks to keep solids from depositing in the tanks and water from separating from the oil and settling on the bottom. The technology has been recently adapted to anaerobic digesters. The impeller is designed for maximum thrust and directs a core of liquid across the tank. Philadelphia Mixing Solutions has tested this mixer in their lab, run CFD modeling on it. The mixer rotation direction can be reversed to mitigate rag accumulation; however it will not provide the same mixing pattern when operated in reverse. Reversal would be solely for the purpose of removing rags. Table 4-10 summarizes the advantages and disadvantages of a focused flow mixer. Without confinement (draft tubes) or a continuously rising gas column as in gas mixing, we believe there is a potential for short circuiting and dissipation of energy prior to reaching the bottom of the digester. This may limit effectiveness in keeping grit in suspension even with otherwise adequate energy input. Full scale testing of this system is recommended before full implementation.

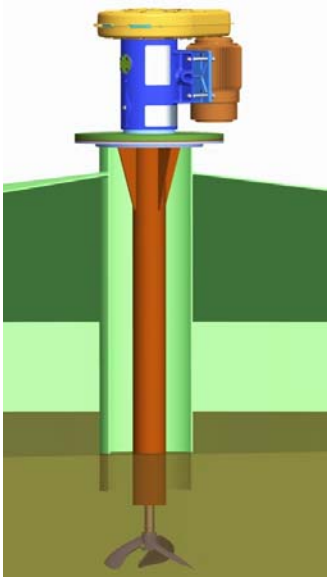

Figure 4-9. Focused Flow mixer (Manufactured by Philadelphia Mixing Solutions)

Table 4-10. Focused Flow Mixing Advantages and Disadvantages

Advantages	Disadvantages
• External drive mechanism for easy maintenance • Low potential for foaming • Unit responsibility is placed on supplier • High energy efficiency • Simple design • Low operating cost	• Limited experience in municipal applications and none in digesters the size of those at the WPCP • Inability to observe mixing problems • Most suitable for fixed digester covers • Potential for ragging • Struvite buildup potential on mixers unknown • Grit suspension ability unknown, but suspect due to low energy input recommended by manufacturers • Without confinement or continuously rising gas column, potential for short circuiting • Only effective for directing mixing energy in one direction

4.5 Digester Mixing Alternatives Analysis

Each of the digester mixing alternatives identified were evaluated using a preliminary screening step followed by a net present value analysis. Two future conditions are assumed: (1) struvite continues to be an issue at the WPCP and (2) struvite is no longer an issue at the WPCP due to mitigation measures. The results of this analysis were used to develop a digester mixing recommendation.

4.5.1 Digester Mixing and Struvite

The formation of struvite inside a digester can have impacts on the mixing equipment, depending on the technology. Because struvite formation potential increases at higher pH values, regions of turbulence can result in elevated struvite formation. Turbulence causes the release of carbon dioxide, which increases the pH. This is evidenced by the recent occurrence at the Dublin San Ramon Sanitation District (DSRSD) wastewater treatment plant shown in Figure 4-10. When maintenance staff removed a draft tube mixer from service for routine maintenance, they found excessive struvite formation on the draft tube impeller.

Figure 4-10. Draft tube mixer removed from DSRSD digester showing struvite that was removed.

The Colorado Springs treatment plant has two types of digester mixing. One set of digester is designed with unconfined gas lances for mixing, however the lances have not been used since 2002 and these digesters are mixed currently with pumped recirculation. These digesters do not have struvite formation in the recirculation piping and did not have struvite prior to 2002 when gas mixing was used.

Another newer set of digesters is mixed using mechanical draft tube mixers. The draft-tube-mixed digesters have significant struvite formation within the draft tube near the impeller as shown in Figure 4-11 and accumulation on the bottom of the digester when cleaned. The digesters are taken down for cleaning every two years; Figure 4-11 represents accumulation over a two-year period. Several years ago, plant staff began sludge removal from the bottom of the digesters and that has reduced bottom accumulation. The fact that struvite forms in the mechanically mixed digesters is likely due to the high turbulence at the mixer impeller where the sludge discharges at the top of the digester and an overall increase in pH that occurs at this point when carbon dioxide is released. Recently, plant staff reduced the speed of the mixers and they are hopeful of improvement in struvite buildup due to reduction in agitation.

Figure 4-11. Inside of a draft tube coated with struvite after two years of operation from the Colorado Springs wastewater treatment plant.

The Clean Water Services wastewater treatment plant in Durham, Oregon is another case study of note. This plant has historically had struvite formation in the solids processing equipment. Each digester is 707,000 gallons and is equipped with one, 30-hp propeller mixer that is unconfined (0.37 hp/1,000 cf). Figure 4-12 shows that although struvite does form in the digesters, it accumulates as loose piles in the digester corners, and does not form on the walls or on the mixer blade. The fact that struvite formation has not occurred on the mixer blade or the walls could be due to it not being confined and/or to a higher mixing energy.

Figure 4-12. Inside of a digester at Clean Water Services in Durham, Oregon showing no struvite on the mixer and significant struvite accumulation in loose piles

For pump mix systems, the suction losses to the mix pumps should be considerably higher than those for draft tubes and the struvite formation would be expected to be worse than for draft tubes; similar to existing recirculation lines, but at much higher flows and losses.

The San Jose WPCP digesters have had a history of struvite formation, as discussed in TM 4.6. Struvite has been observed to form at the following locations specific to the digesters:

- On the underside of the digester floating covers, near the liquid-gas interface
- On the inside walls of the digesters
- At the digester recirculation line valves
- In the digester sampling lines

Recognizing that struvite has been a serious issue at the WPCP, it is important to recognize that struvite formation may continue to be an issue at the WPCP. Implementing a struvite mitigation plan will require additional money that the City may or may not choose to spend. Therefore, the mixer analysis will make recommendations under two potential future scenarios: (1) struvite formation continues to occur at its current rate and (2) struvite formation no longer occurs.

Table 4-11 summarizes the results of empirical observation of struvite formation as it relates to mixing technology. Based on these observations, recommendations are made for technologies that will be considered for further evaluation in the event struvite continues to be an issue at the WPCP. Although gas mixing is not preferred by plant staff due to maintenance and safety issues, a gas system would not have any issue with respect to struvite forming on equipment. This is evidenced by the observations at the WPCP as well as at the Colorado Springs plant. For pump mixing, it can be assumed that struvite would form in the piping and nozzles because struvite has been observed to form in the San Jose WPCP digester recirculation lines and in the DSEPS wet well and export pipe. Both the LM mixer and the focused flow mixer do not have enough operation experience to know if struvite would be an issue. For these technologies, if selected, pilot testing is recommended before full implementation. Pilot testing of RDT mixers may also be warranted to determine whether struvite creates an untenable problem once mitigation ideas are tested, such as lining and coating draft tubes and mixers with materials such as Kynar, which have been shown to resist struvite adherence. Draft tubes used in a confined gas mixing system could be lined with Kynar, as well. If these technologies prove to be adversely affected by struvite, a new gas mixing system could be implemented.

Table 4-11. Summary of Appropriate Mixing Alternatives if Struvite Formation Continues as a Problem (no struvite mitigation)

Mixing System Type	Struvite Formation on Mixing Equipment?	Recommendation
1 - Gas Mixing	No	Consider for Analysis
2a - RDT Mixing	Yes	Consider for Analysis but Would Require Pilot Testing
2b - EDT Mixing	Yes	Consider for Analysis but Would Require Pilot Testing
3 - External Pumped Circulation	Yes	Reject
4 - LM Mixer	Unknown	Consider for Analysis but Would Require Pilot Testing
5 - Focused Flow Mixers	Unknown	Consider for Analysis but Would Require Pilot Testing

4.5.2 Initial Screening of Digester Mixing Alternatives with Struvite Mitigation

An initial screening of mixing alternatives was performed regarding the constructability and structural modifications required for each mixing alternative in the event a struvite control program is successfully implemented and struvite formation within the digester is no longer an issue at the WPCP. Initial screening of the digester mixing alternatives is shown in Table 4-12. Due to the large 42-inch diameter wall penetrations required for external draft tube mechanical (EDT) mixers (both above grade and below grade), this mixing alternative was eliminated from further analysis.

Table 4-12. Initial Screening of Digester Mixing Alternatives if Struvite Control Program is Successfully Implemented

Mixing System Type	Comments	Action
1 - Gas Mixing	Used for comparison with other alternatives	Retain for further analysis
2a - RDT Mixing	No wall penetrations	Retain for further analysis
2b - EDT Mixing	Large 42 inch diameter wall penetrations	Reject
3 - External Pumped Circulation	Smaller <18 inch diameter wall penetrations, all above grade	Retain for further analysis
4 - LM Mixer	No wall penetrations, pilot testing required	Retain for further analysis
5 - Focused Flow Mixers	No wall penetrations, pilot testing required	Retain for further analysis

4.5.3 Digester Mixing Net Present Value Analysis

Mixing system characteristics for the alternatives were obtained from the mixing system manufacturers and are summarized in Table 4-13 for comparison purposes. For LM and focused flow mixers, a cost estimate is provided assuming the manufacturer recommendations and using the 0.15 hp/1,000 cf criterion.

The project costs for each of the alternatives that were retained for further analysis are summarized in Table 4-14. Details on capital costs and net present value estimates for cover alternatives are provided in Attachment B. A project cost is provided for the 110-ft diameter digesters and the 100-ft diameter digesters. The focused flow mixers have the lowest project cost of all the alternatives. This is true for both the manufacturer recommended installation and the installation that meets the 0.15 hp/1,000 cf mixing criterion. The draft tube mixers and manufacturer recommended LM mixer installation have similar capital costs. If the LM mixer were installed to meet the mixing criterion, it would be the most expensive alternative. A new gas mixing system was the most expensive of all alternatives with the exception of the LM mixer to meet the mixing criterion.

Table 4-13. Comparison of Digester Mixing Alternatives [g]							
Item	1 – Gas Mixing	2a – Draft Tube Mechanical Mixers (RDT) [a]	3 – External Pumped Circulation [b]	4a – Vortex Ring/Linear Motion Mixers [c]	4b – Vortex Ring/Linear Motion Mixers	5a – Focused Flow Mixing	5b - Focused Flow Mixing
Minimum Energy Input Delivered, hp/1,000 cf	0.15	0.15	Recommended by manufacturer	Recommended by manufacturer	0.15	Recommended by manufacturer	0.15
Digesters 1 Through 3							
HP required to meet minimum energy input criterion	33	33	-	-	33	-	33
Mixing System, per digester							
Number of Compressors, Pumps, or Mixers	2	4	2 (1 duty, 1 backup)	1	4	3	3
Motor nameplate power, hp	20	15	75	12.5	12.5	5	15
Total Available HP/Digester	40	60	150	12.5 [e]	50	15 [e]	60
Digesters 4 Through 16							
HP required to meet minimum energy input criterion	54	54	-	-	54	-	54
Mixing System, per digester							
Number of Compressors/Pumps/Mixers	2	4	2 (1 duty, 1 backup)	1	5	4	5
Motor nameplate power, hp	30	20	125	12.5	15	10	15
Total Available HP/Digester	60	80	250	12.5 [e]	75 [f]	40 [e]	75

[a] Draft tube mechanical mixers (RDT) system represents information provided by WesTech Engineering, Inc.

[b] External pumped circulation system represents information provided by Vaughan Co, Inc. for a Rotamix system.

[c] Linear motion mixer system represents information provided by Eimco Water Technologies/Enersave.

[d] Available horsepower by digester volume utilizes maximum digester volume estimates.

[e] Considered inadequate by Brown and Caldwell to keep grit in suspension without long term testing

[f] Efficacy of multiple linear motion mixers in a single tank not known.

[g] Based on active volume with existing digester covers

Table 4-14. Capital Costs for Each Mixing Alternative [a]		
Alternative	Capital Cost for 100-ft Diameter Digester (million $)	Capital Cost for 110-ft Diameter Digester (million $)
1 - Gas Mixing	1.20	1.29
2a -RDT Mixing	0.66	0.97
3 - External Pumped Circulation	1.10	1.19
4a - LM Mixer (mfg recommendation)	0.75	0.77
4b - LM Mixer (at 0.15 hp/1,000 cf)	2.25	3.85
5a - Focused Flow Mixers (mfg recommendation)	0.33	0.46
5b - Focused Flow Mixers (at 0.15 hp/1,000 cf)	0.44	0.69

[a] Based on active volume with existing digester covers

Capital costs and the 30-year net present value cost estimates for the cover alternatives for the 110-ft diameter digesters are presented in Table 4-15. Table 4-15 shows that the LM mixer ($0.94 million) assuming manufacturer's recommendations has the lowest present worth value followed by the focused flow mixer ($1.00 million) assuming manufacturers recommendations. Both of these are newer technologies that we would recommend San Jose pilot test before implementation. The draft tube mixer ($1.82 million) has a lower net present value than the external pumped circulation ($2.75 million). A new gas mixing system has a net present value of $ 2.14 million.

If the 0.15 hp/1,000 cf mixing criterion is applied for the focused flow mixers, there is an increase in the net present value for the focused flow mixer (from $1.00 million to $1.55 million). However, it is still has a lower net present value than the other technologies. Conversely, the LM mixers have a significantly higher net present value than the other technologies ($4.70 million).

Table 4-15. Planning Net Present Value for 110-ft Digester Mixing Alternatives [a]

Description	Capital Project Cost (million $)	Net Present Value (million $) [b]	O&M Cost Considerations
1 - Gas Mixing	1.29	2.14	• 2, 30-hp compressors at 24 hours per day (52 hp delivered) • Annual maintenance
2a -RDT Mixing	0.97	1.82	• 4 mixers at 20-hp each at 24 hours per day (52 hp delivered) • Annual maintenance • Bearing replacement every 5 years
3 - External Pumped Circulation	1.19	2.75	• 125-hp mixer at 24 hours per day • Annual maintenance
4a - LM Mixer (mfg recommendation)	0.77	0.94	• One 12.5-hp mixer at 24 hours per day (10 hp delivered) • Annual maintenance
4b - LM Mixer (at 0.15 hp/1,000 cf)	3.85	4.70	• Five 12.5-hp mixer at 24 hours per day (52 hp delivered) • Annual maintenance
5a - Focused Flow Mixers (mfg recommendation)	0.46	1.00	• 4 mixers at 10-hp each at 24 hours per day (32 hp delivered) • Annual maintenance
5b - Focused Flow Mixers (at 0.15 hp/1,000 cf)	0.69	1.55	• 6 mixers at 10-hp each at 24 hours per day (52 hp delivered) • Annual maintenance

[g] Based on active volume with existing digester covers

[b] Power costs calculated assuming existing digester volume. Volume of cylinder and cone are considered for mixing.

4.6 Mixing System Recommendation for Further Consideration

Section 5 provides an analysis that considers both covers and mixers. Based on the mixing evaluation performed in Section 4, independent of the cover selection, several conclusions can be made.

If struvite formation is not mitigated in the future through one of the options discussed in TM 4.6 and it continues to be a problem at the WPCP, only gas mixing could be considered to have a low struvite formation potential without further pilot testing. All other of these technologies have a risk of significant impacts from struvite that could impede performance and significantly increase O&M costs. There are a

number of struvite mitigation options that are worthy of consideration with mechanical draft tube mixing. Lining and coating the draft tube and mixer impeller with a material such as Kynar that has been shown to resist struvite adherence may be successful. In addition, mixer direction may influence turbulence and the formation of struvite. The draft tube mixer could be pilot tested to determine if struvite formation can be mitigated with these or other methods. If not, it should be eliminated as a viable technology. From the empirical observations at Clean Water Services, an unconfined, impeller-type mixer appears to prevent struvite accumulating on the equipment. For this reason, the focused flow mixer appears to be a potentially good alternative to gas mixing. However, since this is a newer technology and there are concerns about the potential for limited energy transmittance to the bottom of the tanks, a pilot test should be conducted to confirm performance before this technology can be recommended for full scale application. For the LM mixer, struvite may form on the vortex ring and cause imbalances. Although one plant using an LM mixer has shown successful mixing over a four year period, including no grit deposition, this was on a much smaller digester in a plant with influent fine screening and excellent headworks grit removal. The LM mixer is not proven on tanks as large as those at San Jose or in any plant with heavy struvite formation potential. For these reasons, LM mixers should not be considered for full scale application without first pilot testing to confirm performance. If focused flow, LM, and draft tube mixers are not found to be viable technologies upon pilot testing, a new gas mixing system with confined or unconfined, sequentially operated gas lances (or spargers) and sufficient energy input (i.e. 0.15 hp/1,000 cf) should be implemented.

If struvite is mitigated in the future through one of the options discussed in TM 4.6 and the manufacturer-recommended installed power is sufficient, focused flow mixers and LM mixers would represent the lowest cost alternatives. However, until proven with full scale pilot tests, we believe the power requirements should be increased to a minimum of 0.15 hp/1,000 cf; the LM mixer would then become more expensive than other proven technologies. The focused flow mixer would still be less expensive than draft tube mixers or pump mixers. Therefore, for this and the issues discussed above regarding struvite formation, if the City were to consider either of these technologies, we would recommend a pilot test to confirm performance. We believe there is potential for short circuiting and energy dissipation with either of these technologies that may limit their effectiveness at keeping grit in suspension. If struvite control measures are successfully implemented and if the City decides to forgo pilot testing and wanted to upgrade mixing immediately, installation of RDT mixer is recommended.

If pilot testing is considered, we recommend pilot testing both the RDT mixers with selected struvite mitigation features and either the focused flow mixers or LM mixers. Pilot testing of any system with significant promised energy reduction (LM, vortex ring, or focused flow) should be performed over time to determine the effect of the system to prevent grit accumulation. This piloting should be run for at least 6 months followed by removing the digester from service and quantifying the amount of accumulated grit.

5. DIGESTER COVER AND MIXER RECOMMENDATION

Table 5-1 provides a summary of the digester cover and mixing alternatives that were identified for subsequent analysis in Sections 3 and 4. As shown in Table 5-1, six possible combinations are considered. This section provides an analysis to determine which cover and mixer combination is recommended for implementation over the next 20 years.

Table 5-1. Summary of Digester Cover and Mixer Technologies for Subsequent Analysis

Struvite Formation Occurs	Struvite Formation Does not Occur
1- Submerged Fixed Concrete Cover/Focused Flow Mixer[1]	1 - Submerged Fixed Concrete Cover/Focused Flow Mixer[1]
2 – Fixed Steel Cover/Focused Flow Mixer[1]	2 – Fixed Steel Cover/Focused Flow Mixer[1]
3- Submerged Fixed Concrete Cover/Gas Mixing	5 - Submerged Fixed Concrete Cover/RDT Mixer
4 – Fixed Steel Cover/Gas Mixing	6 - Fixed Steel Cover/RDT Mixer

[1]Assuming pilot testing determines the technology is sufficient

5.1 Impact of Digester Cover Selection

If the digesters were retrofitted with either fixed steel covers or submerged fixed concrete covers, additional digester volume would be realized. For the fixed steel covers, the digester volume (excluding the cone volume) would increase from 2.29 MG to 2.49 MG. For the submerged fixed concrete covers, the digester volume would be 2.89 MG. At the 2030 design condition, this would mean that only 9 digesters (including redundancy) would be required if all digesters had submerged fixed covers. The fixed steel digesters would still require 11 digesters (including redundancy), which is the same number if floating covers were retained and a new mixing system were installed. If the HRT criterion, which is the limiting criterion, is ignored and the VS loading criterion were used, then only 10 digesters would be necessary for the fixed steel covers.

Table 5-2 provides a summary of the costs for each of the alternatives identified in Table 5-1. Both capital and net present value are presented for each condition. The net present value analysis assumes that all digesters were converted immediately and is used for comparison sake. In reality, digester conversion would be staged as flows and loads increase and depending on cash flow.

The existing condition is presented for comparison. In this case, the digester covers would be rehabilitated for service throughout the 30-year project life and the existing gas mixing system would continue to remain in service. The existing condition has the lowest capital cost, but has the highest net present value ($140 million). In terms of total capital cost, submerged fixed concrete covers with focused flow mixers has the lowest capital expenditure and the lowest net present value. In general, conversion to submerged fixed concrete covers will have a lower project cost and net present value overall because there are two less digesters required at 2030 flows and loads. In addition to the lower project costs associated with submerged fixed covers, there will be a cost savings associated with maintaining two less digesters for 2030 design period. However, the total power costs are the same regardless of the cover technology because the same digester volume must be mixed using the mixing criterion (0.15 hp/1,000 cf). The difference would be the volume of each digester, but the total volume in service remains unchanged.

The analysis presented in Table 5-2 shows that conversion to submerged concrete covers can reduce the net present value by more than half of the existing operation. The conversion to submerged fixed covers cannot occur all at once. Therefore, the City will continue to pay the O&M costs attributed to the existing digesters. However, the high cost associated with the existing digesters shows that there is an incentive to convert the digesters to submerged fixed covers as soon as possible.

5.2 Digester Cover and Mixing Recommendation

The net present value analysis showed that if new digesters covers are constructed, submerged fixed concrete covers have a lower project cost over the life of the project because the volume increase reduces the number of digesters in service and have a very low annual maintenance cost. Although submerged fixed concrete covers have a higher project cost per digester compared to other alternatives, they are the recommended cover technology for any new covers.

All covers will not be replaced at the same time, which means that existing covers will require maintenance. The condition of the covers is variable; however, Digesters 4 through 16 are newer than Digesters 1 through 3. Therefore, any cover rehabilitation efforts should be focused on the newer digesters. Rather than rehabilitating covers to last for another 30 years, the next present value analysis showed that eventually replacing the covers with new submerged fixed concrete covers would have a lower cost for the long term due to the savings in maintenance costs associated with new covers.

Digesters that are upgraded with new submerged fixed concrete covers should have a new mixing system installed. Because of the long-term occurrence of struvite at the WPCP, the mixing system selection should consider that struvite may continue to be present. If the City does not implement struvite mitigation measures (i.e. anti-scaling chemicals discussed in TM 4.6), the focused flow mixers are the best apparent technology. However, this is a relatively new technology and there are concerns of short circuiting that may prevent transmitting energy to the digester floor to keep grit in suspension; this type of mixer should be pilot tested before full implementation. Likewise, LM mixers could be less costly and resist struvite formation, however they are unproven in larger digesters and pilot testing would be required to verify performance and required energy input to achieve comparable grit suspension as the other technologies. It is possible that struvite may not form on the RDT mixers; however, experience at other facilities has shown potential for significant formation. RDT mixers could be pilot tested with the objective of determining if struvite formation is an issue with struvite mitigation specific to the mixers, such as Kynar lining and coating. If these technologies are considered to be unsuccessful due to struvite formation or other performance issues, a new gas mixing system consisting of confined or unconfined, sequential gas lances (or spargers) and compressors sized for 0.15 hp/1,000 cf could be implemented. If struvite mitigation measures are implemented (i.e. anti-scaling chemicals discussed in TM 4.6), RDT mixers could be implemented immediately without any pilot testing.

Currently, four existing digesters are recommended to be upgraded with two assigned as pilot digesters. We recommend installing submerged fixed concrete covers on all four of these digesters. There is no benefit to pilot testing a different cover technology. The submerged fixed concrete covers could be designed so that RDT mixers, focused flow mixers, LM mixers, and confined gas mixing could be accommodated with appropriate cover access and mixer mounting requirements. This would allow the City some flexibility in pilot testing within two tanks with submerged fixed cover retrofits.

We recommend that confined gas mixing be initially installed in the two non-pilot digesters. This provides the greatest assurance of success with respect to avoiding struvite formation. We recommend that one pilot digester be upgraded with RDT mixers that are designed with specific struvite mitigation measures such as Kynar lining and coating. Further we recommend that the second pilot digester be designed with either focused flow or LM mixers. Of the two technologies, we believe that the focused flow mixers have a higher probability of success at the size of digester being upgraded for San Jose. However, the LM mixers, if successful, have a lower potential cost.

Table 5-2. Summary of Digester Cover and Mixer Technologies Costs

Alternative	Number of Digesters at 2030 (Design Import Loadings)	Cover Capital Cost per Digester ($ million)	Cover O&M[6] Net Present Value per Digester ($ million)	Mixer Capital Cost per Digester ($ million)	Mixer O&M[6] Net Present Value per Digester ($ million)[3]	Total Capital Cost for all Digesters ($ million)	Total Net Present Value for all Digesters ($ million)	Annualized O&M Cost ($ million per year)
Existing Conditions – No changes in the future[1]	16[1]	---	16 @ 8.13[2]	---	13 @ 0.73	---	140	6.23
1 - Submerged Fixed Concrete Cover/Focused Flow Mixer [4,5]	9	5 @ 4.72 4 @ 4.78	5 @ 5.82 4 @ 5.76	9 @ 0.86	7 @ 1.92 2 @ 0.90	50.5	67.4	0.76
2 – Fixed Steel Cover/Focused Flow Mixer[4,5]	11	5 @ 4.20 6 @ 4.41	5 @ 9.20 6 @ 8.98	11 @ 0.76	9 @ 1.69 2 @ 0.80	55.8	117	2.72
3- Submerged Fixed Concrete Cover/Gas Mixing[5]	9	5 @ 4.72 4 @ 4.78	5 @ 5.82 4 @ 5.76	9 @ 1.61	7 @ 2.66 2 @ 1.65	57.2	74.1	0.75
4 – Fixed Steel Cover/Gas Mixing[5]	11	5 @ 4.20 6 @ 4.41	5 @ 9.20 6 @ 8.98	11 @ 1.41	9 @ 2.34 2 @ 1.46	63.0	124	2.72
5 - Submerged Fixed Concrete Cover/RDT Mixer[4]	9	5 @ 4.72 4 @ 4.78	5 @ 5.82 4 @ 5.76	9 @ 1.22	7 @ 2.26 2 @ 1.25	53.7	70.5	0.75
6 - Fixed Steel Cover/RDT Mixer [4]	11	5 @ 4.20 6 @ 4.41	5 @ 9.20 6 @ 8.98	11 @ 1.07	9 @ 1.99 2 @ 1.10	59.2	120	2.71

[1]If no changes were made to the existing digesters, the design import material loading would require 17 digesters; there are only 16 digesters. Assume there is one less redundant digester.

[2] Assuming high structural repairs are required (Alternative 1c in Table 3-7)

[3] Assume redundant digesters are not mixed.

[4]Assuming pilot testing determines the technology is sufficient and using 0.15 hp/1,000 cf criterion.

[5]Motor sizes for mixing equipment will be higher due to increase in digester volume. Mixing costs for Alternatives 2, 4 and6 were increased by 10 percent; mixing costs for Alternative 1, 3 and 5 were increased by 25 percent.

[6]Includes replacement and repair (R&R)

6. REFERENCES

Baumann, P.G., Huibregtse, G.L. (1982) *Evaluation and Comparison of Digester Gas Mixing Systems*, Journal Water Pollution Control Federation, 0043-1303, p.1194, Reprint 315-271-P10

Black & Veatch, Pima County Wastewater Management, Ina Road Water Pollution Control Facility, Tucson, Arizona, "Comparing Hydraulic Mixing Efficiencies in an Anaerobic Digester by Rotary and Non-Rotary Mixer Systems", June 18, 2007.

CH2MHill, City of San Jose Environmental Services Department, *Infrastructure Condition Assessment*, May 2007.

Cumiskey, A., Dawson, M., Tillottson, M., (2003) *Thick Sludge Digestion – Research, Design, and Validation of Key Process Unit Operations,* WEF Residuals and Biosolids WEF Residuals and Biosolids Management Conference, Baltimore, Maryland.

Eftekharzadeh, S, Harrison, D., Marx, J.J., Wilson, T.E., (2006) *Applying Rheological Techniques to Upgrade Anaerobic Digesters and Handle High Solids Concentrations*, WEEF Residuals and Biosolids Management Conference, Cincinnati, Ohio

Meroney, M.N,, Colorado, P.E., 2009, *CFD Simulation of Mechanical Draft Tube Mixing in Anaerobic Digester Tanks*, Water Research, 43, 1040-1050.

V&A, San Jose Water Pollution Control Plant Digester Condition Assessment, Condition Assessment of Digesters 2, 4, 5, 6, and 8 – DRAFT, November 24, 2008.

Water Environment Federation (WEF), "Anaerobic Digesters Mixing Systems," *Journal Water Pollution Control Federation*, Vol. 59, p. 162, Alexandria, VA, 1987

ATTACHMENT A: DETAILED COSTS FOR COVER ALTERNATIVES

Digester - Clean & Recoat Existing Cover

Digester - Existing Cover - Adder for New Roof

Digester - Clean, Recoat & Major Refurb of Existing Cover

Digester - New Steel Floating Cover

Digester - New Steel Fixed Cover

Digester - Submerged Concrete Fixed

Net Present Value for Cover Alternatives

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester - Clean & Recoat Existing Cover
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	07
Estimate Revision Date:	2010-09-14
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester - Clean & Recoat Existing Cover

Description		Total w/ Markups Allocated
100-ft COVER - Existing - Clean & Recoat		1,391,727
100-FT DIGESTER		
01230 - Final Clean Up		274,005
02050 - Basic Site Materials & Methods		143,659
09900 - Paints & Coatings		297,108
13902 - Raise Dome		655,464
16050 - Basic Electrical Materials & Methods		21,491
	100-FT DIGESTER Total	1,391,727
110-ft COVER - Existing - Clean & Recoat		1,515,245
110-FT DIGESTER		
01230 - Final Clean Up		301,406
02050 - Basic Site Materials & Methods		209,689
09900 - Paints & Coatings		327,195
13902 - Raise Dome		655,464
16050 - Basic Electrical Materials & Methods		21,491
	110-FT DIGESTER Total	1,515,245

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester - Clean & Recoat Existing Cover
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	07
Estimate Revision Date:	2010-09-14
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester - Clean & Recoat Existing Cover

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft COVER - Existing - Clean & Recoat									
	100-FT DIGESTER									**647,597**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.0	lsum	85,470.88	19,206.76		22,822.36		127,500.00	127,500
	Final Clean Up Total									**127,500**
	02050 - Basic Site Materials & Methods									
	02060 - Site demolition									
9990	Complete Scaffolding	1.0	lsum	14,672.31	19,975.27	32,199.86			66,847.45	66,847
	Basic Site Materials & Methods Total									**66,847**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Coating - Epoxy. Underside of Cover	7,900.0	sqft			17.50			17.50	138,250
	Paints & Coatings Total									**138,250**
	13902 - Raise Dome									
	01590600 - Lifting and hoisting equipment rental without operators									
001	Raise Cover	1.0	lsum			305,000.00			305,000.00	305,000

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Raise Dome Total									**305,000**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.0	lsum			10,000.00			10,000.00	10,000
	Basic Electrical Materials & Methods Total									**10,000**

FOG Program Evaluation and Enhancement
Digester - Clean & Recoat Existing Cover

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft COVER - Existing - Clean & Recoat									
	110-FT DIGESTER									**705,072**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.0	lsum	94,017.97	21,127.44		25,104.59		140,250.00	140,250
	Final Clean Up Total									**140,250**
	02050 - Basic Site Materials & Methods									
	02060 - Site demolition									
9990	Complete Scaffolding	1.0	lsum	21,416.11	29,156.45	46,999.80			97,572.36	97,572
	Basic Site Materials & Methods Total									**97,572**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Coating - Epoxy. Underside of Cover	8,700.0	sqft			17.50			17.50	152,250
	Paints & Coatings Total									**152,250**
	13902 - Raise Dome									
	01590600 - Lifting and hoisting equipment rental without operators									
001	Raise Cover	1.0	lsum			305,000.00			305,000.00	305,000

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Raise Dome Total									**305,000**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.0	lsum			10,000.00			10,000.00	10,000
	Basic Electrical Materials & Methods Total									**10,000**

FOG Program Evaluation and Enhancement
Digester - Clean & Recoat Existing Cover

Category	Percent	Amount
100-ft COVER - Existing - Clean & Recoat Totals		
Labor	**7.40 %**	**100,143**
Material	**2.90 %**	**39,182**
Subcontractor	**35.89 %**	**485,450**
Equipment	**1.69 %**	**22,822**
Other		
User		
Net Costs		**647,597**
Demolition Costs	10.00 %	64,760
Misc Piping	5.00 %	32,380
Subtotal		**744,737**
Construction Contingency	25.00 %	186,184
Subtotal		**930,921**
Estimating Contingency	15.00 %	139,638
Subtotal		**1,070,560**
Engineering, Legal, and Admin	30.00 %	321,168
Total 100-ft COVER - Existing - Clean & Recoat		**1,391,727**

FOG Program Evaluation and Enhancement
Digester - Clean & Recoat Existing Cover

Category	Percent	Amount
110-ft COVER - Existing - Clean & Recoat Totals		
Labor	**8.53 %**	**115,434**
Material	**3.72 %**	**50,284**
Subcontractor	**38.02 %**	**514,250**
Equipment	**1.86 %**	**25,105**
Other		
User		
Net Costs		**705,072**
Demolition Costs	10.00 %	70,507
Misc Piping	5.00 %	35,254
Subtotal		**810,833**
Construction Contingency	25.00 %	202,708
Subtotal		**1,013,542**
Estimating Contingency	15.00 %	152,031
Subtotal		**1,165,573**
Engineering, Legal, and Admin	30.00 %	349,672
Total 110-ft COVER - Existing - Clean & Recoat		**1,515,245**

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester - Existing Cover - Adder For New Roof
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	07
Estimate Revision Date:	2010-09-14
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester - Existing Cover - Adder For New Roof

Description		Total w/ Markups Allocated
100-ft COVER - Existing - Adder for Roof Replacement		877,355
100-FT DIGESTER		
09900 - Paints & Coatings		297,108
13901 - New Roof		494,284
16050 - Basic Electrical Materials & Methods		85,963
	100-FT DIGESTER Total	877,355
110-ft COVER - Existing - Adder for Roof Replacement		842,970
110-FT DIGESTER		
09900 - Paints & Coatings		327,195
13901 - New Roof		494,284
16050 - Basic Electrical Materials & Methods		21,491
	110-FT DIGESTER Total	842,970

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester - Existing Cover - Adder For New Roof
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	07
Estimate Revision Date:	2010-09-14
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester - Existing Cover - Adder For New Roof

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft COVER - Existing - Adder for Roof Replacement									
	100-FT DIGESTER									**408,250**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Insulation/Coating - top of roof	7,900.0	sqft			17.50			17.50	138,250
	Paints & Coatings Total									**138,250**
	13901 - New Roof									
	01590600 - Lifting and hoisting equipment rental without operators									
001	New Roof	1.0	lsum			230,000.00			230,000.00	230,000
	New Roof Total									**230,000**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.0	lsum			40,000.00			40,000.00	40,000
	Basic Electrical Materials & Methods Total									**40,000**

FOG Program Evaluation and Enhancement
Digester - Existing Cover - Adder For New Roof

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft COVER - Existing - Adder for Roof Replacement									
	110-FT DIGESTER									**392,250**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Insulation/Coating - top of cover	8,700.0	sqft			17.50			17.50	152,250
	Paints & Coatings Total									**152,250**
	13901 - New Roof									
	01590600 - Lifting and hoisting equipment rental without operators									
001	New Roof	1.0	lsum			230,000.00			230,000.00	230,000
	New Roof Total									**230,000**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.0	lsum			10,000.00			10,000.00	10,000
	Basic Electrical Materials & Methods Total									**10,000**

FOG Program Evaluation and Enhancement
Digester - Existing Cover - Adder For New Roof

Category	Percent	Amount
100-ft COVER - Existing - Adder for Roof Replacement Totals		
Labor		
Material		
Subcontractor	**51.00 %**	**408,250**
Equipment		
Other		
User		
Net Costs		**408,250**
Demolition Costs	10.00 %	40,825
Misc Piping	5.00 %	20,413
Subtotal		**469,488**
Construction Contingency	25.00 %	117,372
Subtotal		**586,859**
Estimating Contingency	15.00 %	88,029
Subtotal		**674,888**
Engineering, Legal, and Admin	30.00 %	202,466
Total 100-ft COVER - Existing - Adder for Roof Replacement		**877,355**

FOG Program Evaluation and Enhancement
Digester - Existing Cover - Adder For New Roof

Category	Percent	Amount
110-ft COVER - Existing - Adder for Roof Replacement Totals		
Labor		
Material		
Subcontractor	**49.00 %**	**392,250**
Equipment		
Other		
User		
Net Costs		**392,250**
Demolition Costs	10.00 %	39,225
Misc Piping	5.00 %	19,613
Subtotal		**451,088**
Construction Contingency	25.00 %	112,772
Subtotal		**563,859**
Estimating Contingency	15.00 %	84,579
Subtotal		**648,438**
Engineering, Legal, and Admin	30.00 %	194,531
Total 110-ft COVER - Existing - Adder for Roof Replacement		**842,970**

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester - Clean, Recoat & Major Refurb Of Existing Cover
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	07
Estimate Revision Date:	2010-09-14
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester - Clean, Recoat & Major Refurb Of Existing Cover

Description		Total w/ Markups Allocated
100-ft COVER - Existing - Clean, Recoat & Major Structural Rehab		2,573,712
100-FT DIGESTER		
01230 - Final Clean Up		274,005
02050 - Basic Site Materials & Methods		143,659
02950 - Site Restoration & Rehabilitation		1,181,984
09900 - Paints & Coatings		297,108
13902 - Raise Dome		655,464
16050 - Basic Electrical Materials & Methods		21,491
	100-FT DIGESTER Total	2,573,712
110-ft COVER - Existing - Clean, Recoat & Major Structural Rehab		2,697,229
110-FT DIGESTER		
01230 - Final Clean Up		301,406
02050 - Basic Site Materials & Methods		209,689
02950 - Site Restoration & Rehabilitation		1,181,984
09900 - Paints & Coatings		327,195
13902 - Raise Dome		655,464
16050 - Basic Electrical Materials & Methods		21,491
	110-FT DIGESTER Total	2,697,229

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester - Clean, Recoat & Major Refurb Of Existing Cover
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	07
Estimate Revision Date:	2010-09-14
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester - Clean, Recoat & Major Refurb Of Existing Cover

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft COVER - Existing - Clean, Recoat & Major Structural Rehab									
	100-FT DIGESTER									**1,197,597**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.0	lsum	85,470.88	19,206.76		22,822.36		127,500.00	127,500
	Final Clean Up Total									**127,500**
	02050 - Basic Site Materials & Methods									
	02060 - Site demolition									
9990	Complete Scaffolding	1.0	lsum	14,672.31	19,975.27	32,199.86			66,847.45	66,847
	Basic Site Materials & Methods Total									**66,847**
	02950 - Site Restoration & Rehabilitation									
	02990400 - Site Restoration									
0001	Allowance, Major Structural Rehab	1.0	lsum			550,000.00			550,000.00	550,000
	Site Restoration & Rehabilitation Total									**550,000**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Coating - Epoxy. Underside of Cover	7,900.0	sqft			17.50			17.50	138,250

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Paints & Coatings Total									**138,250**
	13902 - Raise Dome									
	01590600 - Lifting and hoisting equipment rental without operators									
001	Raise Cover	1.0	lsum			305,000.00			305,000.00	305,000
	Raise Dome Total									**305,000**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.0	lsum			10,000.00			10,000.00	10,000
	Basic Electrical Materials & Methods Total									**10,000**

FOG Program Evaluation and Enhancement
Digester - Clean, Recoat & Major Refurb Of Existing Cover

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft COVER - Existing - Clean, Recoat & Major Structural Rehab									
	110-FT DIGESTER									**1,255,072**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.0	lsum	94,017.97	21,127.44		25,104.59		140,250.00	140,250
	Final Clean Up Total									**140,250**
	02050 - Basic Site Materials & Methods									
	02060 - Site demolition									
9990	Complete Scaffolding	1.0	lsum	21,416.11	29,156.45	46,999.80			97,572.36	97,572
	Basic Site Materials & Methods Total									**97,572**
	02950 - Site Restoration & Rehabilitation									
	02990400 - Site Restoration									
0001	Allowance, Major Structural Rehab	1.0	lsum			550,000.00			550,000.00	550,000
	Site Restoration & Rehabilitation Total									**550,000**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Coating - Epoxy. Underside of Cover	8,700.0	sqft			17.50			17.50	152,250

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Paints & Coatings Total									**152,250**
	13902 - Raise Dome									
	01590600 - Lifting and hoisting equipment rental without operators									
001	Raise Cover	1.0	lsum		305,000.00				305,000.00	305,000
	Raise Dome Total									**305,000**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.0	lsum		10,000.00				10,000.00	10,000
	Basic Electrical Materials & Methods Total									**10,000**

FOG Program Evaluation and Enhancement
Digester - Clean, Recoat & Major Refurb Of Existing Cover

Category	Percent	Amount
100-ft COVER - Existing - Clean, Recoat & Major Structural Rehab Totals		
Labor	**4.08 %**	**100,143**
Material	**1.60 %**	**39,182**
Subcontractor	**42.22 %**	**1,035,450**
Equipment	**0.93 %**	**22,822**
Other		
User		
Net Costs		**1,197,597**
Demolition Costs	10.00 %	119,760
Misc Piping	5.00 %	59,880
Subtotal		**1,377,237**
Construction Contingency	25.00 %	344,309
Subtotal		**1,721,546**
Estimating Contingency	15.00 %	258,232
Subtotal		**1,979,778**
Engineering, Legal, and Admin	30.00 %	593,933
Total 100-ft COVER - Existing - Clean, Recoat & Major Structural Rehab		**2,573,712**

FOG Program Evaluation and Enhancement
Digester - Clean, Recoat & Major Refurb Of Existing Cover

Category	Percent	Amount
110-ft COVER - Existing - Clean, Recoat & Major Structural Rehab Totals		
Labor	**4.71 %**	**115,434**
Material	**2.05 %**	**50,284**
Subcontractor	**43.39 %**	**1,064,250**
Equipment	**1.02 %**	**25,105**
Other		
User		
Net Costs		**1,255,072**
Demolition Costs	10.00 %	125,507
Misc Piping	5.00 %	62,754
Subtotal		**1,443,333**
Construction Contingency	25.00 %	360,833
Subtotal		**1,804,167**
Estimating Contingency	15.00 %	270,625
Subtotal		**2,074,791**
Engineering, Legal, and Admin	30.00 %	622,437
Total 110-ft COVER - Existing - Clean, Recoat & Major Structural Rehab		**2,697,229**

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester - New Steel Floating Cover
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	07
Estimate Revision Date:	2010-09-13
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

100-ft DIGESTERS
Cover - New Steel Floating Cover

110-ft DIGESTERS
Cover - New Steel Floating Cover

FOG Program Evaluation and Enhancement
Digester - New Steel Floating Cover

Description		Total w/ Markups Allocated
100-ft COVER - New Steel Floating		3,861,492
100-FT DIGESTER		
01230 - Final Clean Up		274,005
01500 - Temporary Facilities & Controls		138,400
05010 - Misc Metals		15,473
05500 - Metal Fabrications		67,591
07200 - Thermal Protection		260,037
09900 - Paints & Coatings		594,216
11000 - Equipment		2,417,695
14020 - Material handling		8,113
16050 - Basic Electrical Materials & Methods		85,963
	100-FT DIGESTER Total	3,861,492
110-ft COVER - New Steel Floating		4,214,035
110-FT DIGESTER		
01230 - Final Clean Up		301,406
01500 - Temporary Facilities & Controls		152,240
05010 - Misc Metals		17,085
05500 - Metal Fabrications		74,264
07200 - Thermal Protection		285,825
09900 - Paints & Coatings		654,390
11000 - Equipment		2,634,751
14020 - Material handling		8,113
16050 - Basic Electrical Materials & Methods		85,963
	110-FT DIGESTER Total	4,214,035

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester - New Steel Floating Cover
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	07
Estimate Revision Date:	2010-09-13
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft COVER - New Steel Floating									
	100-FT DIGESTER									**1,796,826**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.0	lsum	85,470.88	19,206.76		22,822.36		127,500.00	127,500
	Final Clean Up Total									**127,500**
	01500 - Temporary Facilities & Controls									
	01540750 - Scaffolding									
2550	Scaffolding, steel tubular, rented	1.0	lsum				64,400.00		64,400.00	64,400
	Temporary Facilities & Controls Total									**64,400**
	05010 - Misc Metals									
	05010 - Misc Metals									
0980	Connect outrigger supports	48.0	each	45.76	101.47		2.77		150.00	7,200
	Misc Metals Total									**7,200**
	05500 - Metal Fabrications									
	05520700 - Railing, Pipe									
0160	Railing, pipe, aluminum, dark anodized finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/4" dia, toe plate, shop fabricated	314.0	LF	19.25	79.75		1.17		100.16	31,451

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Metal Fabrications Total									**31,451**
	07200 - Thermal Protection									
	07240100 - Exterior Insulation Finish System									
0433	Crack and concrete surface repair	1.0	lsum	65,379.32	55,620.68				121,000.00	121,000
	Thermal Protection Total									**121,000**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Insulation/Coating - top of cover	7,900.0	sqft			17.50			17.50	138,250
0010	Coating - Epoxy. Underside of Cover	7,900.0	sqft			17.50			17.50	138,250
	Paints & Coatings Total									**276,500**
	11000 - Equipment									
	11010 - Process Equipment									
0930	Digester cover,steel,including installation, not incl insulation,coatings, flashing,100 ft dia	1.0	each	335,000.00	625,000.00		165,000.00		1,125,000.00	1,125,000
	Equipment Total									**1,125,000**
	14020 - Material handling									
	14020 - Material handling									
990	Crane, davit type, incl base	1.0	each	702.01	3,072.99				3,775.00	3,775
	Material handling Total									**3,775**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.0	lsum			40,000.00			40,000.00	40,000
	Basic Electrical Materials & Methods Total									**40,000**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft COVER - New Steel Floating									
	110-FT DIGESTER									**1,960,871**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.0	lsum	94,017.97	21,127.44		25,104.59		140,250.00	140,250
	Final Clean Up Total									**140,250**
	01500 - Temporary Facilities & Controls									
	01540750 - Scaffolding									
2550	Scaffolding, steel tubular, rented	1.0	lsum				70,840.00		70,840.00	70,840
	Temporary Facilities & Controls Total									**70,840**
	05010 - Misc Metals									
	05010 - Misc Metals									
0980	Connect outrigger supports	53.0	each	45.76	101.47		2.77		150.00	7,950
	Misc Metals Total									**7,950**
	05500 - Metal Fabrications									
	05520700 - Railing, Pipe									
0160	Railing, pipe, aluminum, dark anodized finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/4" dia, toe plate, shop fabricated	345.0	LF	19.25	79.75		1.17		100.16	34,556

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Metal Fabrications Total									**34,556**
	07200 - Thermal Protection									
	07240100 - Exterior Insulation Finish System									
0433	Crack and concrete surface repair	1.0	lsum	71,863.22	61,136.78				133,000.00	133,000
	Thermal Protection Total									**133,000**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Insulation/Coating - top of cover	8,700.0	sqft			17.50			17.50	152,250
0010	Coating - Epoxy. Underside of Cover	8,700.0	sqft			17.50			17.50	152,250
	Paints & Coatings Total									**304,500**
	11000 - Equipment									
	11010 - Process Equipment									
0930	Digester cover,steel,including installation, not incl insulation,coatings, flashing,110 ft dia	1.0	each	365,000.00	680,000.00		181,000.00		1,226,000.00	1,226,000
	Equipment Total									**1,226,000**
	14020 - Material handling									
	14020 - Material handling									
990	Crane, davit type, incl base	1.0	each	702.01	3,072.99				3,775.00	3,775
	Material handling Total									**3,775**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.0	lsum			40,000.00			40,000.00	40,000
	Basic Electrical Materials & Methods Total									**40,000**

FOG Program Evaluation and Enhancement
Digester - New Steel Floating Cover

Category	Percent	Amount
100-ft COVER - New Steel Floating Totals		
Labor	**13.17 %**	**494,793**
Material	**19.50 %**	**732,813**
Subcontractor	**8.42 %**	**316,500**
Equipment	**6.73 %**	**252,721**
Other		
User		
Net Costs		**1,796,826**
Demolition Costs	10.00 %	179,683
Misc Piping	5.00 %	89,841
Subtotal		**2,066,350**
Construction Contingency	25.00 %	516,588
Subtotal		**2,582,938**
Estimating Contingency	15.00 %	387,441
Subtotal		**2,970,379**
Engineering, Legal, and Admin	30.00 %	891,114
Total 100-ft COVER - New Steel Floating		**3,861,492**

FOG Program Evaluation and Enhancement
Digester - New Steel Floating Cover

Category	Percent	Amount
110-ft COVER - New Steel Floating Totals		
Labor	**14.39 %**	**540,649**
Material	**21.24 %**	**798,229**
Subcontractor	**9.17 %**	**344,500**
Equipment	**7.38 %**	**277,493**
Other		
User		
Net Costs		**1,960,871**
Demolition Costs	10.00 %	196,087
Misc Piping	5.00 %	98,044
Subtotal		**2,255,002**
Construction Contingency	25.00 %	563,751
Subtotal		**2,818,753**
Estimating Contingency	15.00 %	422,813
Subtotal		**3,241,566**
Engineering, Legal, and Admin	30.00 %	972,470
Total 110-ft COVER - New Steel Floating		**4,214,035**

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester - New Steel Fixed Cover
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	11
Estimate Revision Date:	2010-09-24
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

Description		Total w/ Markups Allocated
100-ft COVER - New Steel Fixed - Digesters 1 through 3		**3,946,467**
100-FT DIGESTER		
01230 - Final Clean Up		274,005
01500 - Temporary Facilities & Controls		138,400
03200 - Concrete Reinforcement		28,286
03300 - Cast-In-Place Concrete		170,589
05010 - Misc Metals		15,473
05500 - Metal Fabrications		67,591
07200 - Thermal Protection		260,037
09900 - Paints & Coatings		594,216
11000 - Equipment		2,250,068
14020 - Material handling		8,113
15010 - Misc. Mechanical		53,727
16050 - Basic Electrical Materials & Methods		85,963
	100-FT DIGESTER Total	3,946,467
110-ft COVER - New Steel Fixed - Digester 4		**4,413,844**
110-FT DIGESTER		
01230 - Final Clean Up		301,406
01500 - Temporary Facilities & Controls		152,240
03200 - Concrete Reinforcement		28,286
03300 - Cast-In-Place Concrete		187,640
05010 - Misc Metals		17,085
05500 - Metal Fabrications		74,264
07200 - Thermal Protection		285,825
09900 - Paints & Coatings		654,390
11000 - Equipment		2,559,533
14020 - Material handling		8,113
15010 - Misc. Mechanical		59,099
16050 - Basic Electrical Materials & Methods		85,963
	110-FT DIGESTER Total	4,413,844
110-ft COVER - New Steel Fixed - Digester 12		**4,197,917**

FOG Program Evaluation and Enhancement
Digester - New Steel Fixed Cover

Description		Total w/ Markups Allocated
110-FT DIGESTER		
01230 - Final Clean Up		301,406
01500 - Temporary Facilities & Controls		152,240
05010 - Misc Metals		17,085
05500 - Metal Fabrications		74,264
07200 - Thermal Protection		285,825
09900 - Paints & Coatings		654,390
11000 - Equipment		2,559,533
14020 - Material handling		8,113
15010 - Misc. Mechanical		59,099
16050 - Basic Electrical Materials & Methods		85,963
	110-FT DIGESTER Total	4,197,917

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester - New Steel Fixed Cover
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	11
Estimate Revision Date:	2010-09-24
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft COVER - New Steel Fixed - Digesters 1 through 3									
	100-FT DIGESTER									**1,836,367**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.00	lsum	85,470.88	19,206.76		22,822.36		127,500.00	127,500
	Final Clean Up Total									**127,500**
	01500 - Temporary Facilities & Controls									
	01540750 - Scaffolding									
2550	Scaffolding, steel tubular, rented	1.00	lsum				64,400.00		64,400.00	64,400
	Temporary Facilities & Controls Total									**64,400**
	03200 - Concrete Reinforcement									
	03230600 - Prestressing Steel									
1600	Prestressing steel, ungrouted strand, 200' span, 100 kip, post-tensioned in field	4,150.00	lb	1.56	0.62		0.99		3.17	13,162
	Concrete Reinforcement Total									**13,162**
	03300 - Cast-In-Place Concrete									
	03370300 - Gunite (Dry-Mix)									
0550	Gunite, dry mix, typical in place, 4" thick, include 2 X 2 mesh reinforcing, maximum	4,712.00	SF	12.63	1.94		2.28		16.85	79,378
	Cast-In-Place Concrete Total									**79,378**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	05010 - Misc Metals									
	05010 - Misc Metals									
0980	Connect outrigger supports	48.00	each	45.76	101.47		2.77		150.00	7,200
	Misc Metals Total									**7,200**
	05500 - Metal Fabrications									
	05520700 - Railing, Pipe									
0160	Railing, pipe, aluminum, dark anodized finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/4" dia, toe plate, shop fabricated	314.00	LF	19.25	79.75		1.17		100.16	31,451
	Metal Fabrications Total									**31,451**
	07200 - Thermal Protection									
	07240100 - Exterior Insulation Finish System									
0433	Crack and concrete surface repair	1.00	lsum	65,379.32	55,620.68				121,000.00	121,000
	Thermal Protection Total									**121,000**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Insulation/Coating - top of cover	7,900.00	sqft			17.50			17.50	138,250
0010	Coating - Epoxy. Underside of Cover	7,900.00	sqft			17.50			17.50	138,250
	Paints & Coatings Total									**276,500**
	11000 - Equipment									

FOG Program Evaluation and Enhancement
Digester - New Steel Fixed Cover

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	11010 - Process Equipment									
0930	Digester cover,steel,including installation, not incl insulation,coatings, flashing,100 ft dia	1.00	each	335,000.00	547,000.00		165,000.00		1,047,000.00	1,047,000
	Equipment Total									**1,047,000**
	14020 - Material handling									
	14020 - Material handling									
990	Crane, davit type, incl base	1.00	each	702.01	3,072.99				3,775.00	3,775
	Material handling Total									**3,775**
	15010 - Misc. Mechanical									
	15010 - Misc. Mechanical									
0440	Seal Cover - Oakum joint	1.00	lsum	13,416.68	11,583.32				25,000.00	25,000
	Misc. Mechanical Total									**25,000**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.00	lsum			40,000.00			40,000.00	40,000
	Basic Electrical Materials & Methods Total									**40,000**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft COVER - New Steel Fixed - Digester 4									
	110-FT DIGESTER									**2,053,846**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.00	lsum	94,017.97	21,127.44		25,104.59		140,250.00	140,250
	Final Clean Up Total									**140,250**
	01500 - Temporary Facilities & Controls									
	01540750 - Scaffolding									
2550	Scaffolding, steel tubular, rented	1.00	lsum				70,840.00		70,840.00	70,840
	Temporary Facilities & Controls Total									**70,840**
	03200 - Concrete Reinforcement									
	03230600 - Prestressing Steel									
1600	Prestressing steel, ungrouted strand, 200' span, 100 kip, post-tensioned in field	4,150.00	lb	1.56	0.62		0.99		3.17	13,162
	Concrete Reinforcement Total									**13,162**
	03300 - Cast-In-Place Concrete									
	03370300 - Gunite (Dry-Mix)									
0550	Gunite, dry mix, typical in place, 4" thick, include 2 X 2 mesh reinforcing, maximum	5,183.00	SF	12.63	1.94		2.28		16.85	87,313
	Cast-In-Place Concrete Total									**87,313**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	05010 - Misc Metals									
	05010 - Misc Metals									
0980	Connect outrigger supports	53.00	each	45.76	101.47		2.77		150.00	7,950
	Misc Metals Total									**7,950**
	05500 - Metal Fabrications									
	05520700 - Railing, Pipe									
0160	Railing, pipe, aluminum, dark anodized finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/4" dia, toe plate, shop fabricated	345.00	LF	19.25	79.75		1.17		100.16	34,556
	Metal Fabrications Total									**34,556**
	07200 - Thermal Protection									
	07240100 - Exterior Insulation Finish System									
0433	Crack and concrete surface repair	1.00	lsum	71,863.22	61,136.78				133,000.00	133,000
	Thermal Protection Total									**133,000**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Insulation/Coating - top of cover	8,700.00	sqft			17.50			17.50	152,250
0010	Coating - Epoxy. Underside of Cover	8,700.00	sqft			17.50			17.50	152,250
	Paints & Coatings Total									**304,500**
	11000 - Equipment									

FOG Program Evaluation and Enhancement
Digester - New Steel Fixed Cover

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	11010 - Process Equipment									
0930	Digester cover,steel,including installation, not incl insulation,coatings, flashing,110 ft dia	1.00	each	365,000.00	645,000.00		181,000.00		1,191,000.00	1,191,000
	Equipment Total									**1,191,000**
	14020 - Material handling									
	14020 - Material handling									
990	Crane, davit type, incl base	1.00	each	702.01	3,072.99				3,775.00	3,775
	Material handling Total									**3,775**
	15010 - Misc. Mechanical									
	15010 - Misc. Mechanical									
0440	Seal - Cover	1.00	lsum	14,758.35	12,741.65				27,500.00	27,500
	Misc. Mechanical Total									**27,500**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.00	lsum			40,000.00			40,000.00	40,000
	Basic Electrical Materials & Methods Total									**40,000**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft COVER - New Steel Fixed - Digester 12									
	110-FT DIGESTER									**1,953,371**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.00	lsum	94,017.97	21,127.44		25,104.59		140,250.00	140,250
	Final Clean Up Total									**140,250**
	01500 - Temporary Facilities & Controls									
	01540750 - Scaffolding									
2550	Scaffolding, steel tubular, rented	1.00	lsum				70,840.00		70,840.00	70,840
	Temporary Facilities & Controls Total									**70,840**
	05010 - Misc Metals									
	05010 - Misc Metals									
0980	Connect outrigger supports	53.00	each	45.76	101.47		2.77		150.00	7,950
	Misc Metals Total									**7,950**
	05500 - Metal Fabrications									
	05520700 - Railing, Pipe									
0160	Railing, pipe, aluminum, dark anodized finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/4" dia, toe plate, shop fabricated	345.00	LF	19.25	79.75		1.17		100.16	34,556
	Metal Fabrications Total									**34,556**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	07200 - Thermal Protection									
	07240100 - Exterior Insulation Finish System									
0433	Crack and concrete surface repair	1.00	lsum	71,863.22	61,136.78				133,000.00	133,000
	Thermal Protection Total									**133,000**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Insulation/Coating - top of cover	8,700.00	sqft			17.50			17.50	152,250
0010	Coating - Epoxy. Underside of Cover	8,700.00	sqft			17.50			17.50	152,250
	Paints & Coatings Total									**304,500**
	11000 - Equipment									
	11010 - Process Equipment									
0930	Digester cover,steel,including installation, not incl insulation,coatings, flashing,110 ft dia	1.00	each	365,000.00	645,000.00		181,000.00		1,191,000.00	1,191,000
	Equipment Total									**1,191,000**
	14020 - Material handling									
	14020 - Material handling									
990	Crane, davit type, incl base	1.00	each	702.01	3,072.99				3,775.00	3,775
	Material handling Total									**3,775**
	15010 - Misc. Mechanical									
	15010 - Misc. Mechanical									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0440	Seal - Cover	1.00	lsum	14,758.35	12,741.65				27,500.00	27,500
	Misc. Mechanical Total									**27,500**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.00	lsum			40,000.00			40,000.00	40,000
	Basic Electrical Materials & Methods Total									**40,000**

FOG Program Evaluation and Enhancement
Digester - New Steel Fixed Cover

Category	Percent	Amount
100-ft COVER - New Steel Fixed - Digesters 1 through 3 Totals		
Labor	**9.83 %**	**574,172**
Material	**11.60 %**	**678,110**
Subcontractor	**5.42 %**	**316,500**
Equipment	**4.58 %**	**267,585**
Other		
User		
Net Costs		**1,836,367**
Demolition Costs	10.00 %	183,637
Misc Piping	5.00 %	91,818
Subtotal		**2,111,822**
Construction Contingency	25.00 %	527,955
Subtotal		**2,639,777**
Estimating Contingency	15.00 %	395,967
Subtotal		**3,035,744**
Engineering, Legal, and Admin	30.00 %	910,723
Total 100-ft COVER - New Steel Fixed - Digesters 1 through 3		**3,946,467**

FOG Program Evaluation and Enhancement
Digester - New Steel Fixed Cover

Category	Percent	Amount
110-ft COVER - New Steel Fixed - Digester 4 Totals		
Labor	**10.74 %**	**627,316**
Material	**13.50 %**	**788,599**
Subcontractor	**5.90 %**	**344,500**
Equipment	**5.02 %**	**293,431**
Other		
User		
Net Costs		**2,053,846**
Demolition Costs	10.00 %	205,385
Misc Piping	5.00 %	102,692
Subtotal		**2,361,923**
Construction Contingency	25.00 %	590,481
Subtotal		**2,952,404**
Estimating Contingency	15.00 %	442,861
Subtotal		**3,395,264**
Engineering, Legal, and Admin	30.00 %	1,018,579
Total 110-ft COVER - New Steel Fixed - Digester 4		**4,413,844**
110-ft COVER - New Steel Fixed - Digester 12 Totals		

FOG Program Evaluation and Enhancement
Digester - New Steel Fixed Cover

Category	Percent	Amount
Labor	**9.50 %**	**555,407**
Material	**13.28 %**	**775,971**
Subcontractor	**5.90 %**	**344,500**
Equipment	**4.75 %**	**277,493**
Other		
User		
Net Costs		**1,953,371**
Demolition Costs	10.00 %	195,337
Misc Piping	5.00 %	97,669
Subtotal		**2,246,377**
Construction Contingency	25.00 %	561,594
Subtotal		**2,807,971**
Estimating Contingency	15.00 %	421,196
Subtotal		**3,229,167**
Engineering, Legal, and Admin	30.00 %	968,750
Total 110-ft COVER - New Steel Fixed - Digester 12		**4,197,917**

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester - Submerged Concrete Fixed Cover
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	12
Estimate Revision Date:	2010-09-27
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

110-ft DIGESTERS
Submerged Concrete Fixed Cover - Digester 4
Submerged Concrete Fixed Cover - Digester 5 through 11
Submerged Concrete Fixed Cover - Digester 12

Description		Total w/ Markups Allocated
110-ft COVER - Concrete Fixed - Digester 4		**5,399,085**
110-FT DIGESTER		
01230 - Final Clean Up		274,005
01500 - Temporary Facilities & Controls		281,092
01590 - Miscellaneous Equipment Rental without operators		34,600
01800 - Facility Operation		22,487
02200 - Site Preparation		415,504
02300 - Earthwork		274,015
02450 - Foundation & Load Bearing Elements		215,813
03050 - Basic Concrete Materials & Methods		624,088
03100 - Concrete Forms & Accessories		470,573
03200 - Concrete Reinforcement		992,538
03300 - Cast-In-Place Concrete		940,881
05010 - Misc Metals		17,085
05500 - Metal Fabrications		206,309
07200 - Thermal Protection		285,825
11000 - Equipment		79,544
14020 - Material handling		8,113
15001 - Pipe, Water Supply		118,198
15190 - CARBON STEEL PIPE, WELDED		40,832
15350 - Sleeves and escutcheons		11,620
16050 - Basic Electrical Materials & Methods		85,963
	110-FT DIGESTER Total	5,399,085
110-ft COVER - Concrete Fixed - Digester 5 through 11		**4,778,496**
110-FT DIGESTER		
01230 - Final Clean Up		274,005
01500 - Temporary Facilities & Controls		255,923
01590 - Miscellaneous Equipment Rental without operators		34,600
01800 - Facility Operation		22,487
02200 - Site Preparation		140,172
02450 - Foundation & Load Bearing Elements		215,813
03050 - Basic Concrete Materials & Methods		624,088
03100 - Concrete Forms & Accessories		463,890

Description		Total w/ Markups Allocated
03200 - Concrete Reinforcement		974,096
03300 - Cast-In-Place Concrete		919,934
05010 - Misc Metals		17,085
05500 - Metal Fabrications		206,309
07200 - Thermal Protection		285,825
11000 - Equipment		79,544
14020 - Material handling		8,113
15001 - Pipe, Water Supply		118,198
15190 - CARBON STEEL PIPE, WELDED		40,832
15350 - Sleeves and escutcheons		11,620
16050 - Basic Electrical Materials & Methods		85,963
	110-FT DIGESTER Total	4,778,496
110-ft COVER - Concrete Fixed - Digester 12		4,715,762
110-FT DIGESTER		
01230 - Final Clean Up		274,005
01500 - Temporary Facilities & Controls		255,923
01590 - Miscellaneous Equipment Rental without operators		34,600
01800 - Facility Operation		22,487
02200 - Site Preparation		140,172
02450 - Foundation & Load Bearing Elements		215,813
03050 - Basic Concrete Materials & Methods		624,088
03100 - Concrete Forms & Accessories		463,890
03200 - Concrete Reinforcement		911,362
03300 - Cast-In-Place Concrete		919,934
05010 - Misc Metals		17,085
05500 - Metal Fabrications		206,309
07200 - Thermal Protection		285,825
11000 - Equipment		79,544
14020 - Material handling		8,113
15001 - Pipe, Water Supply		118,198
15190 - CARBON STEEL PIPE, WELDED		40,832
15350 - Sleeves and escutcheons		11,620
16050 - Basic Electrical Materials & Methods		85,963
	110-FT DIGESTER Total	4,715,762

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester - Submerged Concrete Fixed Cover
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	12
Estimate Revision Date:	2010-09-27
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

110-ft DIGESTERS
Submerged Concrete Fixed Cover - Digester 4
Submerged Concrete Fixed Cover - Digester 5 through 11
Submerged Concrete Fixed Cover - Digester 12

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft COVER - Concrete Fixed - Digester 4									
	110-FT DIGESTER									**2,512,298**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.00	lsum	85,470.88	19,206.76		22,822.36		127,500.00	127,500
	Final Clean Up Total									**127,500**
	01500 - Temporary Facilities & Controls									
	01520550 - Field Office Expense									
0050bc	Allowance - Underground Utility Protection	1.00	lsum	8,712.00	3,000.00				11,712.00	11,712
	01540750 - Scaffolding									
2550	Scaffolding, steel tubular, rented	1.00	lsum				99,176.00		99,176.00	99,176
6610	Scaffolding, steel tubular, heavy duty shoring for elevated slab forms, floor area, rent/month of materials only, to 14'-8" high	6.40	Csf		43.00				43.00	275
	01540950 - Daily Crane Crews									
0600	Crane crew, daily use for small jobs, 100-ton truck-mounted hydraulic crane, portal to portal	5.00	days	1,197.26			2,729.64		3,926.90	19,635
	Temporary Facilities & Controls Total									**130,798**
	01590 - Miscellaneous Equipment Rental without operators									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	01590600 - Lifting and hoisting equipment rental without operators									
2100D	Rent crane truck mount, cable 8x4 drive 90 ton, 15' radius - Rent per month	1.00	mnth				16,100.00		16,100.00	16,100
	Miscellaneous Equipment Rental without operators Total									**16,100**
	01800 - Facility Operation									
	01832230 - Concrete Facilities Maintenance									
1030	Patching concrete, walls, incl. chipping, cleaning & epoxy grout	600.00	SF	9.29	8.15				17.44	10,464
	Facility Operation Total									**10,464**
	02200 - Site Preparation									
	02210200 - Core Drilling									
1300	Concrete core drilling, core, reinforced concrete slab, 12" diameter, up to 6" thick slab, includes bit, layout and set up	58.00	EA	91.07	27.00		10.82		128.88	7,475
1350	Concrete core drilling, core, reinforced concrete slab, 12" diameter, up to 6" thick slab, includes bit, layout and set up, each added inch thick in same hole, add	348.00	EA	4.87	4.35		0.58		9.81	3,413
	02220240 - Minor Site Demolition									
3390	Process Equipment and Piping - Remove, Store and Reinstall	1.00	Job	35,152.00			7,184.32		42,336.32	42,336
	02220250 - Demolish, Remove Pavement And Curb									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
5400	Demolish, remove pavement & curb, remove concrete, plain, 7" to 24" thick, excludes hauling and disposal fees	16.00	CY	74.62			34.06		108.68	1,739
	02220330 - Selective Demolition, Dump Charges									
9999	Dump Charge, typical urban city, fees only, bldg constr mat'ls	30.00	ton					33.00	33.00	990
	02220360 - Selective Demolition, Saw Cutting									
0400	Concrete sawing, concrete slabs, mesh reinforcing, up to 3" deep	640.00	LF	1.02	0.49		0.44		1.95	1,251
0420	Concrete sawing, concrete, existing slab, mesh reinforcing, for each additional inch of depth over 3"	3,200.00	LF	0.63	0.16		0.27		1.06	3,383
	02240900 - Wellpoints									
0200	Dewatering Allowance	1.00	lsum	90,000.00					90,000.00	90,000
	02250400 - Sheet Piling									
0100	Sheet piling, steel, 22 psf, 15' excavation, drive, extract and salvage, excludes wales	22.00	ton	793.83	505.00		594.56		1,893.39	41,655
2500	Sheet piling, wales, connections and struts, 2/3 salvage	4.00	ton		275.00				275.00	1,100
	Site Preparation Total									**193,342**
	02300 - Earthwork									
	02315120 - Backfill, Structural									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
4420	**[2x] Backfill, structural, common earth, 200 H.P. dozer, 300' haul**	**1,150.00**	**L.C.Y.**	**1.07**			**1.59**		**2.66**	**3,064**
	02315310 - Compaction, General									
7000	**[5x] Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate**		**E.C.Y.**							
8100	Compaction, 4 passes, 6" to 11", 4" lifts, rammer tamper	812.00	E.C.Y.	6.70			0.72		7.43	6,030
	02315462 - Excavation, Structural									
0500	Structural excavation for minor structures, bank measure, heavy soil or clay, 6' to 12' deep, hand pits	812.00	B.C.Y.	145.60					145.60	118,229
	02315492 - Hauling									
0009	**[2x] Loading Trucks, F.E. Loader, 3 C.Y.**	**22.00**	**cuyd**	**0.81**			**1.10**		**1.91**	**42**
4498	**[2x] Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 20 CY truck, cycle 20 miles, 45 MPH, no loading equipment**	**22.00**	**L.C.Y.**	**2.68**			**3.65**		**6.33**	**139**
	02315610 - Excavating, Trench									
1000	Excavating, trench or continuous footing, common earth, 1 1/2 C.Y. excavator, 10' to 14' deep, excludes sheeting or dewatering		B.C.Y.	1.96			1.73		3.69	
	02315640 - Utility Bedding									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0100	**[2x] Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction**		**L.C.Y.**		**43.50**				**43.50**	
	Earthwork Total									**127,504**
	02450 - Foundation & Load Bearing Elements									
	02455100 - Cast-In-Place Concrete Piles									
0110	Uncased drilled concrete piers, thin wall shell pile, straight sided, 16 ga., 8" diameter, 5.8 lb./L.F., priced using 200 piles, 60' long, unless specified otherwise, excludes pile caps, mobilization, or reinforcing	870.00	vlft	6.84	9.25		1.36		17.45	15,185
1200	Uncased drilled concrete piers, friction pile, fluted tapered steel, 4000 psi concrete, 7 ga., 50' long, 24" diameter, priced using 200 piles, 60' long, unless specified otherwise, excludes pile caps, mobilization, or reinforcing	1,200.00	vlft	13.20	55.20		2.64		71.03	85,237
	Foundation & Load Bearing Elements Total									**100,422**
	03050 - Basic Concrete Materials & Methods									
	03060850 - Waterproofing And Dampproofing									
9000	Membrane lining, HDPE	11,000.00	sqft			26.40			26.40	290,400
	Basic Concrete Materials & Methods Total									**290,400**
	03100 - Concrete Forms & Accessories									
	03110420 - Forms In Place, Elevated Slabs									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
1500	C.I.P. concrete forms, elevated slab, flat plate, plywood, 15' to 20' high ceilings, includes shoring, erecting, bracing, stripping and cleaning	640.00	SF	6.77	1.67				8.44	5,400
2350	C.I.P. concrete forms, elevated slab, flat slab with drop panels, 20' to 35' high ceilings, 4 use, includes shoring, erecting, bracing, stripping and cleaning	9,503.32	SF	13.48	5.95				19.43	184,619
	03110445 - Forms In Place, Slab On Grade									
3050	**[2x] C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes erecting, bracing, stripping and cleaning**	**2,301.15**	**sfca**	**6.07**	**0.74**				**6.81**	**15,666**
3550	C.I.P. concrete forms, slab on grade, depressed, edge, wood, 12" to 24" high, 4 use, includes erecting, bracing, stripping and cleaning	239.07	LF	12.25	0.76				13.01	3,110
	03150860 - Waterstop									
0600	Waterstop, hydrophylic, 3/8" thick x 9" wide	345.58	LF	8.01	4.50				12.51	4,324
0600	Waterstop, PVC, ribbed, with center bulb, 3/8" thick x 9" wide	644.00	LF	4.58	4.50				9.08	5,847
	Concrete Forms & Accessories Total									**218,967**
	03200 - Concrete Reinforcement									
	03210600 - Reinforcing In Place									
0602	**[3x] Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories**	**193,998.28**	**lb**	**0.92**	**0.56**				**1.48**	**287,823**
2000	**[3x] Reinforcing steel, unload and sort, add to base**	**114.89**	**ton**	**68.90**			**8.54**		**77.44**	**8,897**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
2210	**[3x] Reinforcing steel, crane cost for handling, average, add**	**114.89**	**ton**	**74.53**			**9.30**		**83.82**	**9,630**
2430	Reinforcing steel, in place, dowels, deformed, 2' long, #6, A615, grade 60	4,012.81	EA	3.17	2.56				5.73	23,007
2450	**[2x] Reinforcing steel, in place, dowels, deformed, A615, grade 60, longer and heavier, add**	**31,761.93**	**lb**	**2.53**	**0.61**				**3.14**	**99,831**
2520	Reinforcing steel, in place, dowels, smooth, 12" long, 5/8" diameter, A615, grade 60	330.00	EA	9.14	1.15				10.29	3,394
	03230600 - Prestressing Steel									
1600	Prestressing steel, ungrouted strand, 200' span, 100 kip, post-tensioned in field	9,204.00	lb	1.56	0.62		1.00		3.18	29,265
	Concrete Reinforcement Total									**461,847**
	03300 - Cast-In-Place Concrete									
	03310220 - Concrete, Ready Mix Normal Weight									
0300	**[3x] Structural concrete, ready mix, normal weight, 4000 PSI, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments**	**814.38**	**CY**		**106.00**				**106.00**	**86,324**
	03310240 - Concrete In Place									
0010	Equipment mounts, misc structural, etc. - Allowance	1.00	lsum			150,000.00			150,000.00	150,000

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
1020	Structural concrete, in place, column, square, avg reinforcing, 36" x 36", includes forms(4 uses), reinforcing steel, and finishing	42.00	CY	601.11	505.00		35.67		1,141.78	47,955
	03310700 - Placing Concrete									
1500	Structural concrete, placing, elevated slab, pumped, 6" to 10" thick, includes vibrating, excludes material	59.26	CY	23.07			5.34		28.41	1,684
1650	Structural concrete, placing, elevated slab, with crane and bucket, over 10" thick, includes vibrating, excludes material	703.95	CY	57.46			9.94		67.40	47,447
4650	Structural concrete, placing, slab on grade, pumped, over 6" thick, includes vibrating, excludes material	51.17	CY	20.01			4.62		24.62	1,260
	03350300 - Finishing Floors									
0150	**[3x] Concrete finishing, floors, manual screed, bull float, manual float, broom finish**	**14,288.12**	**SF**	**1.11**					**1.11**	**15,828**
	03370300 - Gunite (Dry-Mix)									
0550	Gunite, dry mix, typical in place, 4" thick, include 2 X 2 mesh reinforcing, maximum	5,183.00	SF	12.63	1.94		2.28		16.85	87,313
	Cast-In-Place Concrete Total									**437,810**
	05010 - Misc Metals									
	05010 - Misc Metals									
0980	Connect outrigger supports	53.00	each	45.76	101.47		2.77		150.00	7,950
	Misc Metals Total									**7,950**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	05500 - Metal Fabrications									
	05514500 - Ladder									
1390	Ladder, shop fabricated, alternating tread stair, aluminum, 68 deg	8.00	vlft	23.40	206.00				229.40	1,835
	05520700 - Railing, Pipe									
0160	Railing, pipe, aluminum, dark anodized finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/4" dia, toe plate, shop fabricated	345.00	LF	19.25	79.75		1.17		100.16	34,556
	05580950 - Miscellaneous Fabrication									
	Fabricated gas dome, 316 SS, 12' diameter, 10'H, w/lid, flg conn.	1.00	ea	8,361.40	50,000.00		1,246.56		59,607.96	59,608
	Metal Fabrications Total									**96,000**
	07200 - Thermal Protection									
	07240100 - Exterior Insulation Finish System									
0433	Crack and concrete surface repair	1.00	lsum	71,863.22	61,136.78				133,000.00	133,000
	Thermal Protection Total									**133,000**
	11000 - Equipment									
	11010 - Process Equipment									
001	Overflow u-tube assembly, complete	1.00	each	8,513.24	28,500.00				37,013.24	37,013
	Equipment Total									**37,013**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	14020 - Material handling									
	14020 - Material handling									
990	Crane, davit type, incl base	1.00	each	702.01	3,072.99				3,775.00	3,775
	Material handling Total									**3,775**
	15001 - Pipe, Water Supply									
	15001002 - Water Supply, Ductile Iron Pipe									
3140	Piping, fittings & accessories - sludge withdrawal	1.00	lsum	16,921.27	34,364.32		3,714.41		55,000.00	55,000
	Pipe, Water Supply Total									**55,000**
	15190 - CARBON STEEL PIPE, WELDED									
	15190 - Pipe, steel									
B0500	Manway, 30"	2.00	each	2,020.51	7,045.21		434.28		9,500.00	19,000
	CARBON STEEL PIPE, WELDED Total									**19,000**
	15350 - Sleeves and escutcheons									
	15350 - Sleeves and escutcheons									
0110	Pipe sleeve/port. 8"	4.00	each	412.93	411.60				824.53	3,298
0130	Pipe sleeve/port. 12"	2.00	each	512.60	541.80				1,054.40	2,109
	Sleeves and escutcheons Total									**5,407**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0100	Electrical and Instrumentation	1.00	lsum			40,000.00			40,000.00	40,000
	Basic Electrical Materials & Methods Total									**40,000**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft COVER - Concrete Fixed - Digester 5 through 11									
	110-FT DIGESTER									**2,223,526**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.00	lsum	85,470.88	19,206.76		22,822.36		127,500.00	127,500
	Final Clean Up Total									**127,500**
	01500 - Temporary Facilities & Controls									
	01540750 - Scaffolding									
2550	Scaffolding, steel tubular, rented	1.00	lsum				99,176.00		99,176.00	99,176
6610	Scaffolding, steel tubular, heavy duty shoring for elevated slab forms, floor area, rent/month of materials only, to 14'-8" high	6.40	Csf		43.00				43.00	275
	01540950 - Daily Crane Crews									
0600	Crane crew, daily use for small jobs, 100-ton truck-mounted hydraulic crane, portal to portal	5.00	days	1,197.26			2,729.64		3,926.90	19,635
	Temporary Facilities & Controls Total									**119,086**
	01590 - Miscellaneous Equipment Rental without operators									
	01590600 - Lifting and hoisting equipment rental without operators									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
2100D	Rent crane truck mount, cable 8x4 drive 90 ton, 15' radius - Rent per month	1.00	mnth				16,100.00		16,100.00	16,100
	Miscellaneous Equipment Rental without operators Total									**16,100**
	01800 - Facility Operation									
	01832230 - Concrete Facilities Maintenance									
1030	Patching concrete, walls, incl. chipping, cleaning & epoxy grout	600.00	SF	9.29	8.15				17.44	10,464
	Facility Operation Total									**10,464**
	02200 - Site Preparation									
	02210200 - Core Drilling									
1300	Concrete core drilling, core, reinforced concrete slab, 12" diameter, up to 6" thick slab, includes bit, layout and set up	58.00	EA	91.07	27.00		10.82		128.88	7,475
1350	Concrete core drilling, core, reinforced concrete slab, 12" diameter, up to 6" thick slab, includes bit, layout and set up, each added inch thick in same hole, add	348.00	EA	4.87	4.35		0.58		9.81	3,413
	02220240 - Minor Site Demolition									
3390	Process Equipment and Piping - Remove, Store and Reinstall	1.00	Job	35,152.00			7,184.32		42,336.32	42,336
	02240900 - Wellpoints									
0200	Dewatering Allowance	1.00	lsum	12,000.00					12,000.00	12,000
	Site Preparation Total									**65,225**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	02450 - Foundation & Load Bearing Elements									
	02455100 - Cast-In-Place Concrete Piles									
0110	Uncased drilled concrete piers, thin wall shell pile, straight sided, 16 ga., 8" diameter, 5.8 lb./L.F., priced using 200 piles, 60' long, unless specified otherwise, excludes pile caps, mobilization, or reinforcing	870.00	vlft	6.84	9.25		1.36		17.45	15,185
1200	Uncased drilled concrete piers, friction pile, fluted tapered steel, 4000 psi concrete, 7 ga., 50' long, 24" diameter, priced using 200 piles, 60' long, unless specified otherwise, excludes pile caps, mobilization, or reinforcing	1,200.00	vlft	13.20	55.20		2.64		71.03	85,237
	Foundation & Load Bearing Elements Total									**100,422**
	03050 - Basic Concrete Materials & Methods									
	03060850 - Waterproofing And Dampproofing									
9000	Membrane lining, HDPE	11,000.00	sqft			26.40			26.40	290,400
	Basic Concrete Materials & Methods Total									**290,400**
	03100 - Concrete Forms & Accessories									
	03110420 - Forms In Place, Elevated Slabs									
1500	C.I.P. concrete forms, elevated slab, flat plate, plywood, 15' to 20' high ceilings, includes shoring, erecting, bracing, stripping and cleaning	640.00	SF	6.77	1.67				8.44	5,400

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
2350	C.I.P. concrete forms, elevated slab, flat slab with drop panels, 20' to 35' high ceilings, 4 use, includes shoring, erecting, bracing, stripping and cleaning	9,503.32	SF	13.48	5.95				19.43	184,619
	03110445 - Forms In Place, Slab On Grade									
3050	**[2x] C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes erecting, bracing, stripping and cleaning**	**2,301.15**	**sfca**	**6.07**	**0.74**				**6.81**	**15,666**
	03150860 - Waterstop									
0600	Waterstop, hydrophylic, 3/8" thick x 9" wide	345.58	LF	8.01	4.50				12.51	4,324
0600	Waterstop, PVC, ribbed, with center bulb, 3/8" thick x 9" wide	644.00	LF	4.58	4.50				9.08	5,847
	Concrete Forms & Accessories Total									**215,857**
	03200 - Concrete Reinforcement									
	03210600 - Reinforcing In Place									
0602	**[2x] Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories**	**181,478.94**	**lb**	**0.95**	**0.56**				**1.51**	**273,990**
2000	**[2x] Reinforcing steel, unload and sort, add to base**	**106.62**	**ton**	**71.04**			**8.54**		**79.57**	**8,484**
2210	**[2x] Reinforcing steel, crane cost for handling, average, add**	**106.62**	**ton**	**76.83**			**9.30**		**86.13**	**9,183**
2450	**[2x] Reinforcing steel, in place, dowels, deformed, A615, grade 60, longer and heavier, add**	**31,761.93**	**lb**	**2.53**	**0.61**				**3.14**	**99,831**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
2520	Reinforcing steel, in place, dowels, smooth, 12" long, 5/8" diameter, A615, grade 60	330.00	EA	9.14	1.15				10.29	3,394
	03230600 - Prestressing Steel									
1600	Prestressing steel, ungrouted strand, 200' span, 100 kip, post-tensioned in field	18,408.00	lb	1.56	0.62		0.99		3.17	58,383
	Concrete Reinforcement Total									**453,266**
	03300 - Cast-In-Place Concrete									
	03310220 - Concrete, Ready Mix Normal Weight									
0300	**[2x] Structural concrete, ready mix, normal weight, 4000 PSI, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments**	**763.21**	**CY**		**106.00**				**106.00**	**80,900**
	03310240 - Concrete In Place									
0010	Equipment mounts, misc structural, etc. - Allowance	1.00	lsum			150,000.00			150,000.00	150,000
1020	Structural concrete, in place, column, square, avg reinforcing, 36" x 36", includes forms(4 uses), reinforcing steel, and finishing	42.00	CY	601.11	505.00		35.67		1,141.78	47,955
	03310700 - Placing Concrete									
1500	Structural concrete, placing, elevated slab, pumped, 6" to 10" thick, includes vibrating, excludes material	59.26	CY	23.07			5.34		28.41	1,684
1650	Structural concrete, placing, elevated slab, with crane and bucket, over 10" thick, includes vibrating, excludes material	703.95	CY	57.46			9.94		67.40	47,447

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	03350300 - Finishing Floors									
0150	**[2x] Concrete finishing, floors, manual screed, bull float, manual float, broom finish**	**10,143.32**	**SF**	**1.26**					**1.26**	**12,765**
	03370300 - Gunite (Dry-Mix)									
0550	Gunite, dry mix, typical in place, 4" thick, include 2 X 2 mesh reinforcing, maximum	5,183.00	SF	12.63	1.94		2.28		16.85	87,313
	Cast-In-Place Concrete Total									**428,063**
	05010 - Misc Metals									
	05010 - Misc Metals									
0980	Connect outrigger supports	53.00	each	45.76	101.47		2.77		150.00	7,950
	Misc Metals Total									**7,950**
	05500 - Metal Fabrications									
	05514500 - Ladder									
1390	Ladder, shop fabricated, alternating tread stair, aluminum, 68 deg	8.00	vlft	23.40	206.00				229.40	1,835
	05520700 - Railing, Pipe									
0160	Railing, pipe, aluminum, dark anodized finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/4" dia, toe plate, shop fabricated	345.00	LF	19.25	79.75		1.17		100.16	34,556
	05580950 - Miscellaneous Fabrication									
	Fabricated gas dome, 316 SS, 12' diameter, 10'H, w/lid, flg conn.	1.00	ea	8,361.40	50,000.00		1,246.56		59,607.96	59,608

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Metal Fabrications Total									**96,000**
	07200 - Thermal Protection									
	07240100 - Exterior Insulation Finish System									
0433	Crack and concrete surface repair	1.00	lsum	71,863.22	61,136.78				133,000.00	133,000
	Thermal Protection Total									**133,000**
	11000 - Equipment									
	11010 - Process Equipment									
001	Overflow u-tube assembly, complete	1.00	each	8,513.24	28,500.00				37,013.24	37,013
	Equipment Total									**37,013**
	14020 - Material handling									
	14020 - Material handling									
990	Crane, davit type, incl base	1.00	each	702.01	3,072.99				3,775.00	3,775
	Material handling Total									**3,775**
	15001 - Pipe, Water Supply									
	15001002 - Water Supply, Ductile Iron Pipe									
3140	Piping, fittings & accessories - sludge withdrawal	1.00	lsum	16,921.27	34,364.32		3,714.41		55,000.00	55,000
	Pipe, Water Supply Total									**55,000**
	15190 - CARBON STEEL PIPE, WELDED									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	15190 - Pipe, steel									
B0500	Manway, 30"	2.00	each	2,020.51	7,045.21		434.28		9,500.00	19,000
	CARBON STEEL PIPE, WELDED Total									**19,000**
	15350 - Sleeves and escutcheons									
	15350 - Sleeves and escutcheons									
0110	Pipe sleeve/port. 8"	4.00	each	412.93	411.60				824.53	3,298
0130	Pipe sleeve/port. 12"	2.00	each	512.60	541.80				1,054.40	2,109
	Sleeves and escutcheons Total									**5,407**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.00	lsum			40,000.00			40,000.00	40,000
	Basic Electrical Materials & Methods Total									**40,000**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft COVER - Concrete Fixed - Digester 12									
	110-FT DIGESTER									**2,194,334**
	01230 - Final Clean Up									
	01230 - Final Clean Up									
0030	Drain, cleanup and prepare interior tank, interior of digester, drain final 20% of tank capacity, clean.	1.00	lsum	85,470.88	19,206.76		22,822.36		127,500.00	127,500
	Final Clean Up Total									**127,500**
	01500 - Temporary Facilities & Controls									
	01540750 - Scaffolding									
2550	Scaffolding, steel tubular, rented	1.00	lsum				99,176.00		99,176.00	99,176
6610	Scaffolding, steel tubular, heavy duty shoring for elevated slab forms, floor area, rent/month of materials only, to 14'-8" high	6.40	Csf		43.00				43.00	275
	01540950 - Daily Crane Crews									
0600	Crane crew, daily use for small jobs, 100-ton truck-mounted hydraulic crane, portal to portal	5.00	days	1,197.26			2,729.64		3,926.90	19,635
	Temporary Facilities & Controls Total									**119,086**
	01590 - Miscellaneous Equipment Rental without operators									
	01590600 - Lifting and hoisting equipment rental without operators									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
2100D	Rent crane truck mount, cable 8x4 drive 90 ton, 15' radius - Rent per month	1.00	mnth				16,100.00		16,100.00	16,100
	Miscellaneous Equipment Rental without operators Total									**16,100**
	01800 - Facility Operation									
	01832230 - Concrete Facilities Maintenance									
1030	Patching concrete, walls, incl. chipping, cleaning & epoxy grout	600.00	SF	9.29	8.15				17.44	10,464
	Facility Operation Total									**10,464**
	02200 - Site Preparation									
	02210200 - Core Drilling									
1300	Concrete core drilling, core, reinforced concrete slab, 12" diameter, up to 6" thick slab, includes bit, layout and set up	58.00	EA	91.07	27.00		10.82		128.88	7,475
1350	Concrete core drilling, core, reinforced concrete slab, 12" diameter, up to 6" thick slab, includes bit, layout and set up, each added inch thick in same hole, add	348.00	EA	4.87	4.35		0.58		9.81	3,413
	02220240 - Minor Site Demolition									
3390	Process Equipment and Piping - Remove, Store and Reinstall	1.00	Job	35,152.00			7,184.32		42,336.32	42,336
	02240900 - Wellpoints									
0200	Dewatering Allowance	1.00	lsum	12,000.00					12,000.00	12,000
	Site Preparation Total									**65,225**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	02450 - Foundation & Load Bearing Elements									
	02455100 - Cast-In-Place Concrete Piles									
0110	Uncased drilled concrete piers, thin wall shell pile, straight sided, 16 ga., 8" diameter, 5.8 lb./L.F., priced using 200 piles, 60' long, unless specified otherwise, excludes pile caps, mobilization, or reinforcing	870.00	vlft	6.84	9.25		1.36		17.45	15,185
1200	Uncased drilled concrete piers, friction pile, fluted tapered steel, 4000 psi concrete, 7 ga., 50' long, 24" diameter, priced using 200 piles, 60' long, unless specified otherwise, excludes pile caps, mobilization, or reinforcing	1,200.00	vlft	13.20	55.20		2.64		71.03	85,237
	Foundation & Load Bearing Elements Total									**100,422**
	03050 - Basic Concrete Materials & Methods									
	03060850 - Waterproofing And Dampproofing									
9000	Membrane lining, HDPE	11,000.00	sqft			26.40			26.40	290,400
	Basic Concrete Materials & Methods Total									**290,400**
	03100 - Concrete Forms & Accessories									
	03110420 - Forms In Place, Elevated Slabs									
1500	C.I.P. concrete forms, elevated slab, flat plate, plywood, 15' to 20' high ceilings, includes shoring, erecting, bracing, stripping and cleaning	640.00	SF	6.77	1.67				8.44	5,400

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
2350	C.I.P. concrete forms, elevated slab, flat slab with drop panels, 20' to 35' high ceilings, 4 use, includes shoring, erecting, bracing, stripping and cleaning	9,503.32	SF	13.48	5.95				19.43	184,619
	03110445 - Forms In Place, Slab On Grade									
3050	**[2x] C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes erecting, bracing, stripping and cleaning**	**2,301.15**	**sfca**	**6.07**	**0.74**				**6.81**	**15,666**
	03150860 - Waterstop									
0600	Waterstop, hydrophylic, 3/8" thick x 9" wide	345.58	LF	8.01	4.50				12.51	4,324
0600	Waterstop, PVC, ribbed, with center bulb, 3/8" thick x 9" wide	644.00	LF	4.58	4.50				9.08	5,847
	Concrete Forms & Accessories Total									**215,857**
	03200 - Concrete Reinforcement									
	03210600 - Reinforcing In Place									
0602	**[2x] Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories**	**181,478.94**	**lb**	**0.95**	**0.56**				**1.51**	**273,990**
2000	**[2x] Reinforcing steel, unload and sort, add to base**	**106.62**	**ton**	**71.04**			**8.54**		**79.57**	**8,484**
2210	**[2x] Reinforcing steel, crane cost for handling, average, add**	**106.62**	**ton**	**76.83**			**9.30**		**86.13**	**9,183**
2450	**[2x] Reinforcing steel, in place, dowels, deformed, A615, grade 60, longer and heavier, add**	**31,761.93**	**lb**	**2.53**	**0.61**				**3.14**	**99,831**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
2520	Reinforcing steel, in place, dowels, smooth, 12" long, 5/8" diameter, A615, grade 60	330.00	EA	9.14	1.15				10.29	3,394
	03230600 - Prestressing Steel									
1600	Prestressing steel, ungrouted strand, 200' span, 100 kip, post-tensioned in field	9,204.00	lb	1.56	0.62		0.99		3.17	29,191
	Concrete Reinforcement Total									**424,074**
	03300 - Cast-In-Place Concrete									
	03310220 - Concrete, Ready Mix Normal Weight									
0300	**[2x] Structural concrete, ready mix, normal weight, 4000 PSI, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments**	**763.21**	**CY**		**106.00**				**106.00**	**80,900**
	03310240 - Concrete In Place									
0010	Equipment mounts, misc structural, etc. - Allowance	1.00	lsum			150,000.00			150,000.00	150,000
1020	Structural concrete, in place, column, square, avg reinforcing, 36" x 36", includes forms(4 uses), reinforcing steel, and finishing	42.00	CY	601.11	505.00		35.67		1,141.78	47,955
	03310700 - Placing Concrete									
1500	Structural concrete, placing, elevated slab, pumped, 6" to 10" thick, includes vibrating, excludes material	59.26	CY	23.07			5.34		28.41	1,684
1650	Structural concrete, placing, elevated slab, with crane and bucket, over 10" thick, includes vibrating, excludes material	703.95	CY	57.46			9.94		67.40	47,447

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	03350300 - Finishing Floors									
0150	**[2x] Concrete finishing, floors, manual screed, bull float, manual float, broom finish**	**10,143.32**	**SF**	**1.26**					**1.26**	**12,765**
	03370300 - Gunite (Dry-Mix)									
0550	Gunite, dry mix, typical in place, 4" thick, include 2 X 2 mesh reinforcing, maximum	5,183.00	SF	12.63	1.94		2.28		16.85	87,313
	Cast-In-Place Concrete Total									**428,063**
	05010 - Misc Metals									
	05010 - Misc Metals									
0980	Connect outrigger supports	53.00	each	45.76	101.47		2.77		150.00	7,950
	Misc Metals Total									**7,950**
	05500 - Metal Fabrications									
	05514500 - Ladder									
1390	Ladder, shop fabricated, alternating tread stair, aluminum, 68 deg	8.00	vlft	23.40	206.00				229.40	1,835
	05520700 - Railing, Pipe									
0160	Railing, pipe, aluminum, dark anodized finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/4" dia, toe plate, shop fabricated	345.00	LF	19.25	79.75		1.17		100.16	34,556
	05580950 - Miscellaneous Fabrication									
	Fabricated gas dome, 316 SS, 12' diameter, 10'H, w/lid, flg conn.	1.00	ea	8,361.40	50,000.00		1,246.56		59,607.96	59,608

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Metal Fabrications Total									**96,000**
	07200 - Thermal Protection									
	07240100 - Exterior Insulation Finish System									
0433	Crack and concrete surface repair	1.00	lsum	71,863.22	61,136.78				133,000.00	133,000
	Thermal Protection Total									**133,000**
	11000 - Equipment									
	11010 - Process Equipment									
001	Overflow u-tube assembly, complete	1.00	each	8,513.24	28,500.00				37,013.24	37,013
	Equipment Total									**37,013**
	14020 - Material handling									
	14020 - Material handling									
990	Crane, davit type, incl base	1.00	each	702.01	3,072.99				3,775.00	3,775
	Material handling Total									**3,775**
	15001 - Pipe, Water Supply									
	15001002 - Water Supply, Ductile Iron Pipe									
3140	Piping, fittings & accessories - sludge withdrawal	1.00	lsum	16,921.27	34,364.32		3,714.41		55,000.00	55,000
	Pipe, Water Supply Total									**55,000**
	15190 - CARBON STEEL PIPE, WELDED									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	15190 - Pipe, steel									
B0500	Manway, 30"	2.00	each	2,020.51	7,045.21		434.28		9,500.00	19,000
	CARBON STEEL PIPE, WELDED Total									**19,000**
	15350 - Sleeves and escutcheons									
	15350 - Sleeves and escutcheons									
0110	Pipe sleeve/port. 8"	4.00	each	412.93	411.60				824.53	3,298
0130	Pipe sleeve/port. 12"	2.00	each	512.60	541.80				1,054.40	2,109
	Sleeves and escutcheons Total									**5,407**
	16050 - Basic Electrical Materials & Methods									
	16055300 - Electrical Demolition									
0100	Electrical and Instrumentation	1.00	lsum			40,000.00			40,000.00	40,000
	Basic Electrical Materials & Methods Total									**40,000**

FOG Program Evaluation and Enhancement
Digester - Submerged Concrete Fixed Cover

Category	Percent	Amount
110-ft COVER - Concrete Fixed - Digester 4 Totals		
Labor	**16.42 %**	**1,137,941**
Material	**9.71 %**	**673,058**
Subcontractor	**6.93 %**	**480,400**
Equipment	**3.17 %**	**219,910**
Other	**0.01 %**	**990**
User		
Net Costs		**2,512,298**
Demolition Costs	10.00 %	251,230
Misc Piping	5.00 %	125,615
Subtotal		**2,889,143**
Construction Contingency	25.00 %	722,286
Subtotal		**3,611,428**
Estimating Contingency	15.00 %	541,714
Subtotal		**4,153,143**
Engineering, Legal, and Admin	30.00 %	1,245,943
Total 110-ft COVER - Concrete Fixed - Digester 4		**5,399,085**

FOG Program Evaluation and Enhancement
Digester - Submerged Concrete Fixed Cover

Category	Percent	Amount
110-ft COVER - Concrete Fixed - Digester 5 through 11 Totals		
Labor	**12.87 %**	**891,998**
Material	**9.23 %**	**639,839**
Subcontractor	**6.93 %**	**480,400**
Equipment	**3.05 %**	**211,289**
Other		
User		
Net Costs		**2,223,526**
Demolition Costs	10.00 %	222,353
Misc Piping	5.00 %	111,176
Subtotal		**2,557,055**
Construction Contingency	25.00 %	639,264
Subtotal		**3,196,318**
Estimating Contingency	15.00 %	479,448
Subtotal		**3,675,766**
Engineering, Legal, and Admin	30.00 %	1,102,730
Total 110-ft COVER - Concrete Fixed - Digester 5 through 11		**4,778,496**

FOG Program Evaluation and Enhancement
Digester - Submerged Concrete Fixed Cover

Category	Percent	Amount
110-ft COVER - Concrete Fixed - Digester 12 Totals		
Labor	**12.66 %**	**877,643**
Material	**9.15 %**	**634,133**
Subcontractor	**6.93 %**	**480,400**
Equipment	**2.92 %**	**202,159**
Other		
User		
Net Costs		**2,194,334**
Demolition Costs	10.00 %	219,433
Misc Piping	5.00 %	109,717
Subtotal		**2,523,485**
Construction Contingency	25.00 %	630,871
Subtotal		**3,154,356**
Estimating Contingency	15.00 %	473,153
Subtotal		**3,627,509**
Engineering, Legal, and Admin	30.00 %	1,088,253
Total 110-ft COVER - Concrete Fixed - Digester 12		**4,715,762**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Covers - 110 ft dia
Life Cycle Alternative Cost Analysis ($000s)
Alternative 1a - Rehab - replace covers in 10 years

	Year																												
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
New Submerged Fixed covers (D4)											4,778,496																			
Total capital outlays											**4,778,496**																			
Annual Running Costs:																														
5 yr inspection	2,800					2,800																								
10 yr inspection																					2,800									
Total running costs						**2,800**															**2,800**									
R&R Costs:																														
Recoating						1,515,245																								
Spot Recoating																					688,608									
Recoat plus minor structural repairs	2,106,237																													
Total refurbishments						**1,515,245**															**688,608**									
Net Benefit/(cost)						**(1,518,045)**					**(4,778,496)**										**(691,408)**									

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Covers - 110 ft dia
Life Cycle Alternative Cost Analysis ($000s)
Alternative 1b - Rehab - initial low repairs

	Year																												
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Annual Running Costs:																														
5 yr inspection						2,800					2,800					2,800					2,800					2,800				
Total running costs						**2,800**					**2,800**					**2,800**					**2,800**					**2,800**				
R&R Costs:																														
Recoating						1,515,245					1,515,245					1,515,245					1,515,245					1,515,245				
New Roof																842,970														
Recoat plus minor structural repairs	2,106,237																													
Total refurbishments						**1,515,245**					**1,515,245**					**2,358,215**					**1,515,245**					**1,515,245**				
Net Benefit/(cost)						**(1,518,045)**					**(1,518,045)**					**(2,361,015)**					**(1,518,045)**					**(1,518,045)**				

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Covers - 110 ft dia
Life Cycle Alternative Cost Analysis ($000s)
Alternative 1c - Rehab - initial high repairs

	Year																												
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Annual Running Costs:																														
5 yr inspection						2,800					2,800					2,800					2,800					2,800				
Total running costs						**2,800**					**2,800**					**2,800**					**2,800**					**2,800**				
R&R Costs:																														
Recoating						1,515,245					1,515,245					1,515,245					1,515,245					1,515,245				
New Roof																842,970														
Recoat plus major structural repairs	2,697,229																													
Total refurbishments						**1,515,245**					**1,515,245**					**2,358,215**					**1,515,245**					**1,515,245**				
Net Benefit/(cost)						**(1,518,045)**					**(1,518,045)**					**(2,361,015)**					**(1,518,045)**					**(1,518,045)**				

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Covers - 110 ft dia
Life Cycle Alternative Cost Analysis ($000s)
Alternative 1d - New Floating Cover

	Year																												
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	4,214,035																													
Total capital outlays	**4,214,035**																													
Annual Running Costs:																														
5 yr inspection						2,800					2,800					2,800					2,800					2,800				
Total running costs						**2,800**					**2,800**					**2,800**					**2,800**					**2,800**				
R&R Costs:																														
Recoating						1,515,245					1,515,245					1,515,245					1,515,245					1,515,245				
New Roof																842,970														
Total refurbishments						**1,515,245**					**1,515,245**					**2,358,215**					**1,515,245**					**1,515,245**				
Net Benefit/(cost)	**(4,214,035)**					**(1,518,045)**					**(1,518,045)**					**(2,361,015)**					**(1,518,045)**					**(1,518,045)**				

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Covers - 110 ft dia
Life Cycle Alternative Cost Analysis ($000s)
Alternative 3b - New Fixed Steel Dome Cover (D4-11)

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	4,413,844																													
Total capital outlays	**4,413,844**																													
Annual Running Costs:																														
5-yr inspections						2,800					2,800					2,800					2,800					2,800				
Total running costs						**2,800**					**2,800**					**2,800**					**2,800**					**2,800**				
R&R Costs:																														
Drain and prepare interior						301,406					301,406					301,406					301,406					301,406				
Re-coat top and interior						654,390					654,390					654,390					654,390					654,390				
Scaffolding						152,240					152,240					152,240					152,240					152,240				
Install New Roof											842,970										842,970									
Total refurbishments						**1,108,036**					**1,951,006**					**1,108,036**					**1,951,006**					**1,108,036**				
Net Benefit/(cost)	**(4,413,844)**					**(1,110,836)**					**(1,953,806)**					**(1,110,836)**					**(1,953,806)**					**(1,110,836)**				

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Covers - 110 ft dia
Life Cycle Alternative Cost Analysis ($000s)
Alternative 3c - New Fixed Steel Dome Cover (D12-16)

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	4,197,917																													
Total capital outlays	**4,197,917**																													
Annual Running Costs:																														
5-yr inspections						2,800					2,800					2,800					2,800					2,800				
Total running costs						**2,800**					**2,800**					**2,800**					**2,800**					**2,800**				
R&R Costs:																														
Drain and prepare interior						301,406					301,406					301,406					301,406					301,406				
Re-coat top and interior						654,390					654,390					654,390					654,390					654,390				
Scaffolding						152,240					152,240					152,240					152,240					152,240				
Install New Roof											842,970										842,970									
Total refurbishments						**1,108,036**					**1,951,006**					**1,108,036**					**1,951,006**					**1,108,036**				
Net Benefit/(cost)	**(4,197,917)**					**(1,110,836)**					**(1,953,806)**					**(1,110,836)**					**(1,953,806)**					**(1,110,836)**				

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Covers - 110 ft dia
Life Cycle Alternative Cost Analysis ($000s)
Alternative 4a - New Submerged Fixed Concrete Cover (D5-11)

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	4,778,496																													
Total capital outlays	**4,778,496**																													
Annual Running Costs:																														
10 yr inspection											2,800										2,800									
Total running costs											**2,800**										**2,800**									
R&R Costs:																														
Spot recoating											688,608										688,608									
Total refurbishments											**688,608**										**688,608**									
Net Benefit/(cost)	**(4,778,496)**										**(691,408)**										**(691,408)**									

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Covers - 110 ft dia
Life Cycle Alternative Cost Analysis ($000s)
Alternative 4b - New Submerged Fixed Concrete Cover (D12-16)

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	4,715,762																													
Total capital outlays	**4,715,762**																													
Annual Running Costs:																														
10 yr inspection											2,800										2,800									
Total running costs											**2,800**										**2,800**									
R&R Costs:																														
Spot recoating											688,608										688,608									
Total refurbishments											**688,608**										**688,608**									
Net Benefit/(cost)	**(4,715,762)**										**(691,408)**										**(691,408)**									

ATTACHMENT B: DETAILED COSTS FOR MIXING ALTERNATIVES

Digester Mixers - Gas Mixing System

Digester Mixers - Draft Tube

Digester Mixers - Pump Mixing

Digester Mixers - Focused Flow

Digester Mixers - Single Vortex Ring

Digester Mixers - Multiple Vortex Ring

Net Present Value for Mixer Alternatives

SUMMARY ESTIMATE REPORT
WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester Mixers - Gas Mixing System
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	10
Estimate Revision Date:	2011-01-27
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

City of San Jose

FOG Program Evaluation and Enhancement
Digester Mixers - Gas Mixing System

Description		Total w/ Markups Allocated
100-ft MIXING - Gas Mixing		1,196,217
100-FT DIGESTER		
15 - Mechanical		1,196,217
	100-FT DIGESTER Total	1,196,217
110-ft MIXING - Gas Mixing		1,285,214
110-FT DIGESTER		
15 - Mechanical		1,285,214
	110-FT DIGESTER Total	1,285,214
	Grand Total	2,481,431

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester Mixers - Gas Mixing System
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	10
Estimate Revision Date:	2011-01-27
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

City of San Jose

FOG Program Evaluation and Enhancement
Digester Mixers - Gas Mixing System

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft MIXING - Gas Mixing									
	100-FT DIGESTER									**457,226**
	15100 - Building Services Piping									
	15107690 - Pipe, Grooved-Joint Steel Fittings & Valves									
8280	Pipe, fittings and valves, valve, butterfly, stainless steel trim, grooved joint, 4" pipe size, add 1 coupling (material only) per joint for installed price, includes 2 position handle, excludes joint coupling material	24.0	EA	37.31	320.00				357.31	8,575
	Building Services Piping Total									**8,575**
	15200 - Process Piping									
	15200065 - Pipe, Black Steel Welded									
0370	Gas Mixing Draft/Eductor Tube, 48" Steel w/ Tenemic Coating	4.0	ea	5,501.68	6,314.05		2,483.68		14,299.41	57,198
	15200212 - Pipe, 316 Stainless Steel									
0150	Pipe, SS, A778, weld, Sched. 10S, type 316L, 4" dia.	60.0	lnft	28.32	16.64		1.20		46.16	2,770
0170	Pipe, SS, A778, weld, Sched. 10S, type 316L, 8" dia.	330.0	lnft	46.01	42.39		1.96		90.36	29,819
	15200217 - Fittings, 316 Stainless Steel									
1200	Fittings, SS, A774, butt weld jt, type 316L,sched. 10S,fitting, smooth flow,4"	20.0	each	660.10	28.13		28.05		716.28	14,326
1220	Fittings, SS, A774, butt weld jt, type 316L,sched. 10S, 90<elb, smooth flow,8"	18.0	each	1,032.62	138.00		43.88		1,214.50	21,861
2270	Fittings, SS, A774, butt weld jt, type 316L,Sched. 10S, Tee, 8"	4.0	each	1,544.95	247.50		65.65		1,858.10	7,432
5100	Gas Mixing Lance	24.0	each	6,306.00	1,428.00		200.00		7,934.00	190,416
5270	Fittings, SS, butt weld jt, type 316L, Stub Ends, 4" w flange	64.0	each	549.33	79.04		23.34		651.71	41,709
5290	Fittings, SS, butt weld jt, type 316L, Stub Ends,w flange 8"	8.0	each	720.48	127.64		30.62		878.74	7,030
	Process Piping Total									**372,561**
	15400 - Plumbing Fixtures & Equipment									
	15440800 - Pumps, Sewage Ejector									
3160	Compressor, Gas, 20-hp. Digester Gas.	2.0	EA	5,726.03	31,200.00		1,118.89		38,044.93	76,090
	Plumbing Fixtures & Equipment Total									**76,090**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft MIXING - Gas Mixing									
	110-FT DIGESTER									**491,243**
	15100 - Building Services Piping									
	15107690 - Pipe, Grooved-Joint Steel Fittings & Valves									
8280	Pipe, fittings and valves, valve, butterfly, stainless steel trim, grooved joint, 4" pipe size, add 1 coupling (material only) per joint for installed price, includes 2 position handle, excludes joint coupling material	24.0	EA	37.31	320.00				357.31	8,575
	Building Services Piping Total									**8,575**
	15200 - Process Piping									
	15200065 - Pipe, Black Steel Welded									
0370	Gas Mixing Draft/Eductor Tube, 60" Steel w/ Tenemic Coating	4.0	ea	6,709.37	7,700.06		3,028.87		17,438.30	69,753
	15200212 - Pipe, 316 Stainless Steel									
0150	Pipe, SS, A778, weld, Sched. 10S, type 316L, 4" dia.	60.0	lnft	28.32	16.64		1.20		46.16	2,770
0170	Pipe, SS, A778, weld, Sched. 10S, type 316L, 8" dia.	330.0	lnft	46.01	42.39		1.96		90.36	29,819
	15200217 - Fittings, 316 Stainless Steel									
1200	Fittings, SS, A774, butt weld jt, type 316L,sched. 10S,fitting, smooth flow,4"	20.0	each	660.10	28.13		28.05		716.28	14,326
1220	Fittings, SS, A774, butt weld jt, type 316L,sched. 10S, 90<elb, smooth flow,8"	18.0	each	1,032.62	138.00		43.88		1,214.50	21,861
2270	Fittings, SS, A774, butt weld jt, type 316L,Sched. 10S, Tee, 8"	4.0	each	1,544.95	247.50		65.65		1,858.10	7,432
5100	Gas Mixing Lance	24.0	each	6,306.00	1,428.00		200.00		7,934.00	190,416
5270	Fittings, SS, butt weld jt, type 316L, Stub Ends, 4" w flange	64.0	each	549.33	79.04		23.34		651.71	41,709
5290	Fittings, SS, butt weld jt, type 316L, Stub Ends,w flange 8"	8.0	each	720.48	127.64		30.62		878.74	7,030
	Process Piping Total									**385,116**
	15400 - Plumbing Fixtures & Equipment									
	15440800 - Pumps, Sewage Ejector									
3160	Compressor, Gas, 30-hp. Digester Gas.	2.0	EA	7,341.07	40,000.00		1,434.48		48,775.55	97,551
	Plumbing Fixtures & Equipment Total									**97,551**

FOG Program Evaluation and Enhancement
Digester Mixers - Gas Mixing System

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Grand Total									**948,469**

FOG Program Evaluation and Enhancement
Digester Mixers - Gas Mixing System

Category	Percent	Amount	Hours
110-ft MIXING - Gas Mixing Totals			
Labor	**30.53 %**	**289,532**	**3,347.9**
Material	**18.75 %**	**177,857**	
Subcontractor			
Equipment	**2.52 %**	**23,854**	**1,305.5**
Other			
User			
Net Costs		**491,243**	
Demolition	10.00 %	49,124	
Support Structure/Mounting/Platform	5.00 %	24,562	
Misc Piping	5.00 %	24,562	
Electrical/Instrumentation	20.00 %	98,249	
Construction Contingency	25.00 %	171,935	
Subtotal		**859,675**	
Estimating Contingency	15.00 %	128,951	
Subtotal		**988,626**	
Engineering, Legal, and Admin	30.00 %	296,588	
Total 110-ft MIXING - Gas Mixing		**1,285,214**	
100-ft MIXING - Gas Mixing Totals			
Labor	**29.68 %**	**281,471**	**3,243.4**
Material	**16.31 %**	**154,713**	

FOG Program Evaluation and Enhancement
Digester Mixers - Gas Mixing System

Category	Percent	Amount	Hours
Subcontractor			
Equipment	**2.22 %**	**21,042**	**1,282.2**
Other			
User			
Net Costs		**457,226**	
Demolition	10.00 %	45,723	
Support Structure/Mounting/Platform	5.00 %	22,861	
Misc Piping	5.00 %	22,861	
Electrical/Instrumentation	20.00 %	91,445	
Construction Contingency	25.00 %	160,029	
Subtotal		**800,145**	
Estimating Contingency	15.00 %	120,022	
Subtotal		**920,167**	
Engineering, Legal, and Admin	30.00 %	276,050	
Total 100-ft MIXING - Gas Mixing		**1,196,217**	

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester Mixers - Draft Tube
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	08
Estimate Revision Date:	2010-09-17
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester Mixers - Draft Tube

Description		Total w/ Markups Allocated
100-ft MIXING - Draft Tube		663,045
100-FT DIGESTER		
11000 - Equipment		663,045
	100-FT DIGESTER Total	663,045
110-ft MIXING - Draft Tube		972,598
110-FT DIGESTER		
11000 - Equipment		972,598
	110-FT DIGESTER Total	972,598

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester Mixers - Draft Tube
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	08
Estimate Revision Date:	2010-09-17
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft MIXING - Draft Tube									
	100-FT DIGESTER									**253,433**
	11000 - Equipment									
	11010 - Process Equipment									
1461DS	Mixer, digester draft tube, 10hp	4.00	each	4,129.44	58,700.00		528.88		63,358.32	253,433
	Equipment Total									**253,433**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft MIXING - Draft Tube									
	110-FT DIGESTER									**371,753**
	11000 - Equipment									
	11010 - Process Equipment									
1461DS	Mixer, digester draft tube, 15hp	4.00	each	5,309.28	87,100.00		528.88		92,938.16	371,753
	Equipment Total									**371,753**

FOG Program Evaluation and Enhancement
Digester Mixers - Draft Tube

Category	Percent	Amount
100-ft MIXING - Draft Tube Totals		
Labor	**2.64 %**	**16,518**
Material	**37.56 %**	**234,800**
Subcontractor		
Equipment	**0.34 %**	**2,116**
Other		
User		
Net Costs		**253,433**
Demolition	10.00 %	25,343
Support Structure/Mounting/Platform	5.00 %	12,672
Misc Piping	5.00 %	12,672
Electrical/Instrumentation	20.00 %	50,687
Construction Contingency	25.00 %	88,702
Subtotal		**443,508**
Estimating Contingency	15.00 %	66,526
Subtotal		**510,034**
Engineering, Legal, and Admin	30.00 %	153,010
Total 100-ft MIXING - Draft Tube		**663,045**

FOG Program Evaluation and Enhancement
Digester Mixers - Draft Tube

Category	Percent	Amount
110-ft MIXING - Draft Tube Totals		
Labor	**3.40 %**	**21,237**
Material	**55.73 %**	**348,400**
Subcontractor		
Equipment	**0.34 %**	**2,116**
Other		
User		
Net Costs		**371,753**
Demolition	10.00 %	37,175
Support Structure/Mounting/Platform	5.00 %	18,588
Misc Piping	5.00 %	18,588
Electrical/Instrumentation	20.00 %	74,351
Construction Contingency	25.00 %	130,113
Subtotal		**650,567**
Estimating Contingency	15.00 %	97,585
Subtotal		**748,152**
Engineering, Legal, and Admin	30.00 %	224,446
Total 110-ft MIXING - Draft Tube		**972,598**

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester Mixers - Pump Mixing
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	08
Estimate Revision Date:	2010-09-22
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester Mixers - Pump Mixing

Description		Total w/ Markups Allocated
100-ft MIXING - Pump Mixing		1,102,962
100-FT DIGESTER		
09900 - Paints & Coatings		26,163
11000 - Equipment		500,249
15001 - Sludge Piping		285,028
15050 - Basic Materials & Methods		10,470
15255 - Valves, iron body		146,135
15280 - Valves, plug		102,069
15330 - Flexible connectors		25,306
15350 - Sleeves and escutcheons		7,543
	100-FT DIGESTER Total	1,102,962
110-ft MIXING - Pump Mixing		1,187,515
110-FT DIGESTER		
09900 - Paints & Coatings		26,163
11000 - Equipment		555,832
15001 - Sludge Piping		313,999
15050 - Basic Materials & Methods		10,470
15255 - Valves, iron body		146,135
15280 - Valves, plug		102,069
15330 - Flexible connectors		25,306
15350 - Sleeves and escutcheons		7,543
	110-FT DIGESTER Total	1,187,515

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester Mixers - Pump Mixing
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	08
Estimate Revision Date:	2010-09-22
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft MIXING - Pump Mixing									
	100-FT DIGESTER									**421,581**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Misc Paint - Piping, Support Structure, etc. - Allowance	1.00	lsum			10,000.00			10,000.00	10,000
	Paints & Coatings Total									**10,000**
	11000 - Equipment									
	11010 - Process Equipment									
0650	Rotamix tank mixing system incl (2) chopper pumps, 10 nozzles	1.00	each	30,018.49	161,190.00				191,208.49	191,208
	Equipment Total									**191,208**
	15001 - Sludge Piping									
	15001002 - Ductile Iron Pipe									
2060	Ductile iron pipe, cement lined, mechanical joint, no fittings, 18' lengths, 8" diameter, class 50, excludes excavation or backfill	110.00	LF	22.18	19.70		4.89		46.77	5,144

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
2140	Ductile iron pipe, cement lined, mechanical joint, no fittings, 18' lengths, 16" diameter, class 50, excludes excavation or backfill	225.00	LF	40.59	45.50		8.97		95.06	21,388
2170	Ductile iron pipe, cement lined, mechanical joint, no fittings, 18' lengths, 20" diameter, class 50, excludes excavation or backfill	45.00	LF	51.92	67.00		11.40		130.32	5,864
2180	Ductile iron pipe, cement lined, mechanical joint, no fittings, 18' lengths, 24" diameter, class 50, excludes excavation or backfill	55.00	LF	62.30	86.00		13.84		162.13	8,917
8040	Piping, fitting, 90 degree bend or elbow, mechanical joint, ductile iron, cement lined, 8" diameter, class 50 water piping	2.00	EA	219.04	425.00				644.04	1,288
8120	Piping, fitting, 90 degree bend or elbow, mechanical joint, ductile iron, cement lined, 16" diameter, class 50 water piping	2.00	EA	405.88	1,900.00		89.71		2,395.60	4,791
8160	Piping, fitting, 90 degree bend or elbow, mechanical joint, ductile iron, cement lined, 20" diameter, class 50 water piping	5.00	EA	517.26	4,250.00		113.49		4,880.76	24,404
8180	Piping, fitting, 90 degree bend or elbow, mechanical joint, ductile iron, cement lined, 24" diameter, class 50 water piping	2.00	EA	632.42	4,675.00		138.35		5,445.78	10,892
8240	Piping, fitting, wye or tee, ductile iron, cement lined, mechanical joint, 8" diameter, class 50 water piping	4.00	EA	327.60	620.00				947.60	3,790

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
8320	Piping, fitting, wye or tee, ductile iron, cement lined, mechanical joint, 16" diameter, class 50 water piping	2.00	EA	604.10	1,875.00		134.03		2,613.13	5,226
8360	Piping, fitting, wye or tee, ductile iron, cement lined, mechanical joint, 20" diameter, class 50 water piping	2.00	EA	774.01	7,675.00		170.78		8,619.79	17,240
	Sludge Piping Total									**108,945**
	15050 - Basic Materials & Methods									
	15060300 - Pipe Hangers And Supports									
0160	Pipe hanger / support, bracket, steel, wall, medium, welded,	20.00	EA	23.09	177.00				200.09	4,002
	Basic Materials & Methods Total									**4,002**
	15255 - Valves, iron body									
	15255 - Valves, iron body									
1510	Valves, iron body, swing check, silent type,125 lb, flgd, 20" size	2.00	each	3,487.01	24,441.30				27,928.31	55,857
	Valves, iron body Total									**55,857**
	15280 - Valves, plug									
	15280 - Valves, plug									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0260	Valves, semi-steel, lubricated plug valve, flanged, 200 psi, 20" pipe	4.00	each	1,903.35	7,850.00				9,753.35	39,013
	Valves, plug Total									**39,013**
	15330 - Flexible connectors									
	15330 - Flexible connectors									
0130	Connectors, flex, Dresser type, 20" dia.	2.00	each	417.86	504.00				921.86	1,844
309	Connectors, flex, dismantling Joint, 20"	2.00	each	745.27	3,169.17				3,914.43	7,829
	Flexible connectors Total									**9,673**
	15350 - Sleeves and escutcheons									
	15350 - Sleeves and escutcheons									
0110	Pipe sleeve, stl, wtr stop, 12" L w/link seal, 12" dia for 8" carrier	4.00	each	196.63	196.00				392.63	1,571
0170	Pipe sleeve, stl, wtr stop, 12" L w/link seal, 30" dia for 24" carrier	1.00	each	442.43	870.00				1,312.43	1,312
	Sleeves and escutcheons Total									**2,883**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft MIXING - Pump Mixing									
	110-FT DIGESTER									**452,014**
	09900 - Paints & Coatings									
	09000 - B & C Div 9 Coating Systems									
0010	Misc Paint - Piping, Support Structure, etc. - Allowance	1.00	lsum			10,000.00			10,000.00	10,000
	Paints & Coatings Total									**10,000**
	11000 - Equipment									
	11010 - Process Equipment									
0650	Rotamix tank mixing system incl (2) chopper pumps, 14 nozzles	1.00	each	33,353.88	179,100.00				212,453.88	212,454
	Equipment Total									**212,454**
	15001 - Sludge Piping									
	15001002 - Ductile Iron Pipe									
2060	Ductile iron pipe, cement lined, mechanical joint, no fittings, 18' lengths, 8" diameter, class 50, excludes excavation or backfill	140.00	LF	22.18	19.70		4.89		46.77	6,547

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
2140	Ductile iron pipe, cement lined, mechanical joint, no fittings, 18' lengths, 16" diameter, class 50, excludes excavation or backfill	260.00	LF	40.59	45.50		8.97		95.06	24,716
2170	Ductile iron pipe, cement lined, mechanical joint, no fittings, 18' lengths, 20" diameter, class 50, excludes excavation or backfill	50.00	LF	51.92	67.00		11.40		130.32	6,516
2180	Ductile iron pipe, cement lined, mechanical joint, no fittings, 18' lengths, 24" diameter, class 50, excludes excavation or backfill	60.00	LF	62.30	86.00		13.84		162.13	9,728
8040	Piping, fitting, 90 degree bend or elbow, mechanical joint, ductile iron, cement lined, 8" diameter, class 50 water piping	2.00	EA	219.04	425.00				644.04	1,288
8120	Piping, fitting, 90 degree bend or elbow, mechanical joint, ductile iron, cement lined, 16" diameter, class 50 water piping	2.00	EA	405.88	1,900.00		89.71		2,395.60	4,791
8160	Piping, fitting, 90 degree bend or elbow, mechanical joint, ductile iron, cement lined, 20" diameter, class 50 water piping	6.00	EA	517.26	4,250.00		113.49		4,880.76	29,285
8180	Piping, fitting, 90 degree bend or elbow, mechanical joint, ductile iron, cement lined, 24" diameter, class 50 water piping	2.00	EA	632.42	4,675.00		138.35		5,445.78	10,892
8240	Piping, fitting, wye or tee, ductile iron, cement lined, mechanical joint, 8" diameter, class 50 water piping	4.00	EA	327.60	620.00				947.60	3,790

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
8320	Piping, fitting, wye or tee, ductile iron, cement lined, mechanical joint, 16" diameter, class 50 water piping	2.00	EA	604.10	1,875.00		134.03		2,613.13	5,226
8360	Piping, fitting, wye or tee, ductile iron, cement lined, mechanical joint, 20" diameter, class 50 water piping	2.00	EA	774.01	7,675.00		170.78		8,619.79	17,240
	Sludge Piping Total									**120,019**
	15050 - Basic Materials & Methods									
	15060300 - Pipe Hangers And Supports									
0160	Pipe hanger / support, bracket, steel, wall, medium, welded,	20.00	EA	23.09	177.00				200.09	4,002
	Basic Materials & Methods Total									**4,002**
	15255 - Valves, iron body									
	15255 - Valves, iron body									
1510	Valves, iron body, swing check, silent type,125 lb, flgd, 20" size	2.00	each	3,487.01	24,441.30				27,928.31	55,857
	Valves, iron body Total									**55,857**
	15280 - Valves, plug									
	15280 - Valves, plug									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0260	Valves, semi-steel, lubricated plug valve, flanged, 200 psi, 20" pipe	4.00	each	1,903.35	7,850.00				9,753.35	39,013
	Valves, plug Total									**39,013**
	15330 - Flexible connectors									
	15330 - Flexible connectors									
0130	Connectors, flex, Dresser type, 20" dia.	2.00	each	417.86	504.00				921.86	1,844
309	Connectors, flex, dismantling Joint, 20"	2.00	each	745.27	3,169.17				3,914.43	7,829
	Flexible connectors Total									**9,673**
	15350 - Sleeves and escutcheons									
	15350 - Sleeves and escutcheons									
0110	Pipe sleeve, stl, wtr stop, 12" L w/link seal, 12" dia for 8" carrier	4.00	each	196.63	196.00				392.63	1,571
0170	Pipe sleeve, stl, wtr stop, 12" L w/link seal, 30" dia for 24" carrier	1.00	each	442.43	870.00				1,312.43	1,312
	Sleeves and escutcheons Total									**2,883**

FOG Program Evaluation and Enhancement
Digester Mixers - Pump Mixing

Category	Percent	Amount
100-ft MIXING - Pump Mixing Totals		
Labor	**8.58 %**	**75,126**
Material	**37.81 %**	**330,992**
Subcontractor	**1.14 %**	**10,000**
Equipment	**0.62 %**	**5,463**
Other		
User		
Net Costs		**421,581**
Demolition	10.00 %	42,158
Support Structure/Mounting/Platform	5.00 %	21,079
Misc Piping	5.00 %	21,079
Electrical/Instrumentation	20.00 %	84,316
Construction Contingency	25.00 %	147,553
Subtotal		**737,767**
Estimating Contingency	15.00 %	110,665
Subtotal		**848,432**
Engineering, Legal, and Admin	30.00 %	254,530
Total 100-ft MIXING - Pump Mixing		**1,102,962**

FOG Program Evaluation and Enhancement
Digester Mixers - Pump Mixing

Category	Percent	Amount
110-ft MIXING - Pump Mixing Totals		
Labor	**9.32 %**	**81,635**
Material	**40.67 %**	**356,101**
Subcontractor	**1.14 %**	**10,000**
Equipment	**0.70 %**	**6,164**
Other		
User		
Net Costs		**453,900**
Demolition	10.00 %	45,390
Support Structure/Mounting/Platform	5.00 %	22,695
Misc Piping	5.00 %	22,695
Electrical/Instrumentation	20.00 %	90,780
Construction Contingency	25.00 %	158,865
Subtotal		**794,325**
Estimating Contingency	15.00 %	119,149
Subtotal		**913,473**
Engineering, Legal, and Admin	30.00 %	274,042
Total 110-ft MIXING - Pump Mixing		**1,187,515**

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	08
Estimate Revision Date:	2010-09-22
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options

Description		Total w/ Markups Allocated
100-ft MIXING - 3 Focused Flow Mixers		331,706
100-FT DIGESTER		
11000 - Equipment		307,344
16400 - Low-Voltage Distribution		24,362
	100-FT DIGESTER Total	331,706
100-ft MIXING - 4 Focused Flow Mixers		442,275
100-FT DIGESTER		
11000 - Equipment		409,792
16400 - Low-Voltage Distribution		32,483
	100-FT DIGESTER Total	442,275
110-ft MIXING - 4 Focused Flow Mixers		460,030
110-FT DIGESTER		
11000 - Equipment		427,547
16400 - Low-Voltage Distribution		32,483
	110-FT DIGESTER Total	460,030
110-ft MIXING - 6 Focused Flow Mixers		690,046
110-FT DIGESTER		
11000 - Equipment		641,321
16400 - Low-Voltage Distribution		48,725
	110-FT DIGESTER Total	690,046

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	08
Estimate Revision Date:	2010-09-22
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft MIXING - 3 Focused Flow Mixers									
	100-FT DIGESTER									**126,787**
	11000 - Equipment									
	11010 - Process Equipment									
1461DS	Mixer, digester, Focused Flow - 10hp, StStl shaft & impeller	3.00	each	4,129.44	34,500.00		528.88		39,158.32	117,475
	Equipment Total									**117,475**
	16400 - Low-Voltage Distribution									
	16440640 - Motor Control Center									
0100	Motor control center, starters, class 1, type B, comb. MCP, FVNR, with control XFMR, size 1, 10 HP, 12" high, incl starters & structures	3.00	EA	441.49	2,662.50				3,103.99	9,312
	Low-Voltage Distribution Total									**9,312**

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft MIXING - 4 Focused Flow Mixers									
	100-FT DIGESTER									**169,049**
	11000 - Equipment									
	11010 - Process Equipment									
1461DS	Mixer, digester, Focused Flow - 10hp, StStl shaft & impeller	4.00	each	4,129.44	34,500.00		528.88		39,158.32	156,633
	Equipment Total									**156,633**
	16400 - Low-Voltage Distribution									
	16440640 - Motor Control Center									
0100	Motor control center, starters, class 1, type B, comb. MCP, FVNR, with control XFMR, size 1, 10 HP, 12" high, incl starters & structures	4.00	EA	441.49	2,662.50				3,103.99	12,416
	Low-Voltage Distribution Total									**12,416**

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft MIXING - 4 Focused Flow Mixers									
	110-FT DIGESTER									**175,836**
	11000 - Equipment									
	11010 - Process Equipment									
1461DS	Mixer, digester, Focused Flow - 10hp, StStl shaft & impeller	4.00	each	4,326.08	36,000.00		528.88		40,854.96	163,420
	Equipment Total									**163,420**
	16400 - Low-Voltage Distribution									
	16440640 - Motor Control Center									
0100	Motor control center, starters, class 1, type B, comb. MCP, FVNR, with control XFMR, size 1, 10 HP, 12" high, incl starters & structures	4.00	EA	441.49	2,662.50				3,103.99	12,416
	Low-Voltage Distribution Total									**12,416**

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft MIXING - 6 Focused Flow Mixers									
	110-FT DIGESTER									**263,754**
	11000 - Equipment									
	11010 - Process Equipment									
1461DS	Mixer, digester, Focused Flow - 10hp, StStl shaft & impeller	6.00	each	4,326.08	36,000.00		528.88		40,854.96	245,130
	Equipment Total									**245,130**
	16400 - Low-Voltage Distribution									
	16440640 - Motor Control Center									
0100	Motor control center, starters, class 1, type B, comb. MCP, FVNR, with control XFMR, size 1, 10 HP, 12" high, incl starters & structures	6.00	EA	441.49	2,662.50				3,103.99	18,624
	Low-Voltage Distribution Total									**18,624**

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options

Category	Percent	Amount
100-ft MIXING - 3 Focused Flow Mixers Totals		
Labor	**1.86 %**	**13,713**
Material	**15.16 %**	**111,488**
Subcontractor		
Equipment	**0.22 %**	**1,587**
Other		
User		
Net Costs		**126,787**
Demolition	10.00 %	12,679
Support Structure/Mounting/Platform	5.00 %	6,339
Misc Piping	5.00 %	6,339
Electrical/Instrumentation	20.00 %	25,357
Construction Contingency	25.00 %	44,375
Subtotal		**221,877**
Estimating Contingency	15.00 %	33,282
Subtotal		**255,159**
Engineering, Legal, and Admin	30.00 %	76,548
Total 100-ft MIXING - 3 Focused Flow Mixers		**331,706**

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options

Category	Percent	Amount
100-ft MIXING - 4 Focused Flow Mixers Totals		
Labor	**2.49 %**	**18,284**
Material	**20.21 %**	**148,650**
Subcontractor		
Equipment	**0.29 %**	**2,116**
Other		
User		
Net Costs		**169,049**
Demolition	10.00 %	16,905
Support Structure/Mounting/Platform	5.00 %	8,452
Misc Piping	5.00 %	8,452
Electrical/Instrumentation	20.00 %	33,810
Construction Contingency	25.00 %	59,167
Subtotal		**295,836**
Estimating Contingency	15.00 %	44,375
Subtotal		**340,212**
Engineering, Legal, and Admin	30.00 %	102,063
Total 100-ft MIXING - 4 Focused Flow Mixers		**442,275**

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options

Category	Percent	Amount
110-ft MIXING - 4 Focused Flow Mixers Totals		
Labor	**2.59 %**	**19,070**
Material	**21.03 %**	**154,650**
Subcontractor		
Equipment	**0.29 %**	**2,116**
Other		
User		
Net Costs		**175,836**
Demolition	10.00 %	17,584
Support Structure/Mounting/Platform	5.00 %	8,792
Misc Piping	5.00 %	8,792
Electrical/Instrumentation	20.00 %	35,167
Construction Contingency	25.00 %	61,543
Subtotal		**307,713**
Estimating Contingency	15.00 %	46,157
Subtotal		**353,870**
Engineering, Legal, and Admin	30.00 %	106,161
Total 110-ft MIXING - 4 Focused Flow Mixers		**460,030**

FOG Program Evaluation and Enhancement
Digester Mixers - Focused Flow Options

Category	Percent	Amount
110-ft MIXING - 6 Focused Flow Mixers Totals		
Labor	**3.89 %**	**28,605**
Material	**31.54 %**	**231,975**
Subcontractor		
Equipment	**0.43 %**	**3,173**
Other		
User		
Net Costs		**263,754**
Demolition	10.00 %	26,375
Support Structure/Mounting/Platform	5.00 %	13,188
Misc Piping	5.00 %	13,188
Electrical/Instrumentation	20.00 %	52,751
Construction Contingency	25.00 %	92,314
Subtotal		**461,569**
Estimating Contingency	15.00 %	69,235
Subtotal		**530,804**
Engineering, Legal, and Admin	30.00 %	159,241
Total 110-ft MIXING - 6 Focused Flow Mixers		**690,046**

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester Mixers - Single Vortex Ring Plunger
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	08
Estimate Revision Date:	2010-09-17
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester Mixers - Single Vortex Ring Plunger

Description		Total w/ Markups Allocated
100-ft MIXING - 1 Vortex Ring Plunger		748,877
100-FT DIGESTER		
11000 - Equipment		748,877
	100-FT DIGESTER Total	748,877
110-ft MIXING - 1 Vortex Ring Plunger		770,289
110-FT DIGESTER		
11000 - Equipment		770,289
	110-FT DIGESTER Total	770,289

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester Mixers - Single Vortex Ring Plunger
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	08
Estimate Revision Date:	2010-09-17
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

100-ft DIGESTERS
Mixers - Single Vortex Ring Plunger

110-ft DIGESTERS
Mixers - Single Vortex Ring Plunger

FOG Program Evaluation and Enhancement
Digester Mixers - Single Vortex Ring Plunger

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft MIXING - 1 Vortex Ring Plunger									
	100-FT DIGESTER									**286,241**
	11000 - Equipment									
	11010 - Process Equipment									
1461[	Mixer - 12.5 hp LM16 Linear Motion Mixer	1.00	each	43,260.80	242,451.00		528.88		286,240.68	286,241
	Equipment Total									**286,241**

FOG Program Evaluation and Enhancement
Digester Mixers - Single Vortex Ring Plunger

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft MIXING - 1 Vortex Ring Plunger									
	110-FT DIGESTER									**294,425**
	11000 - Equipment									
	11010 - Process Equipment									
1461[	Mixer - 12.5 hp LM16 Linear Motion Mixer	1.00	each	43,260.80	250,635.00		528.88		294,424.68	294,425
	Equipment Total									**294,425**

FOG Program Evaluation and Enhancement
Digester Mixers - Single Vortex Ring Plunger

Category	Percent	Amount
100-ft MIXING - 1 Vortex Ring Plunger Totals		
Labor	**7.45 %**	**43,261**
Material	**41.75 %**	**242,451**
Subcontractor		
Equipment	**0.09 %**	**529**
Other		
User		
Net Costs		**286,241**
Demolition	10.00 %	28,624
Support Structure/Mounting/Platform	5.00 %	14,312
Misc Piping	5.00 %	14,312
Electrical/Instrumentation	20.00 %	57,248
Construction Contingency	25.00 %	100,184
Subtotal		**500,921**
Estimating Contingency	15.00 %	75,138
Subtotal		**576,059**
Engineering, Legal, and Admin	30.00 %	172,818
Total 100-ft MIXING - 1 Vortex Ring Plunger		**748,877**

FOG Program Evaluation and Enhancement
Digester Mixers - Single Vortex Ring Plunger

Category	Percent	Amount
110-ft MIXING - 1 Vortex Ring Plunger Totals		
Labor	**7.45 %**	**43,261**
Material	**43.16 %**	**250,635**
Subcontractor		
Equipment	**0.09 %**	**529**
Other		
User		
Net Costs		**294,425**
Demolition	10.00 %	29,442
Support Structure/Mounting/Platform	5.00 %	14,721
Misc Piping	5.00 %	14,721
Electrical/Instrumentation	20.00 %	58,885
Construction Contingency	25.00 %	103,049
Subtotal		**515,243**
Estimating Contingency	15.00 %	77,286
Subtotal		**592,530**
Engineering, Legal, and Admin	30.00 %	177,759
Total 110-ft MIXING - 1 Vortex Ring Plunger		**770,289**

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY ESTIMATE REPORT WITH MARK-UPS ALLOCATED

FOG Program Evaluation and Enhancement
Digester Mixers - Multiple Vortex Ring Plungers
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	08
Estimate Revision Date:	2010-09-17
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

FOG Program Evaluation and Enhancement
Digester Mixers - Multiple Vortex Ring Plungers

Description		Total w/ Markups Allocated
100-ft MXING - 3 Vortex Ring Plungers		2,246,632
100-FT DIGESTER		
11000 - Equipment		2,246,632
	100-FT DIGESTER Total	2,246,632
110-ft MIXING - 5 Vortex Ring Plungers		3,851,443
110-FT DIGESTER		
11000 - Equipment		3,851,443
	110-FT DIGESTER Total	3,851,443

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED ESTIMATE REPORT

FOG Program Evaluation and Enhancement
Digester Mixers - Multiple Vortex Ring Plungers
Conceptual Level Estimate

Project Number:	132242-004-200
BC Project Manager:	Tim Banyai
BC Office:	Walnut Creek
Estimate Issue Number:	01
Estimate Original Issue Date:	2009-05-21
Estimate Revision Number:	08
Estimate Revision Date:	2010-09-17
Lead Estimator:	Des Orsinelli/Dan Goodburn
Estimate QA/QC Reviewer:	NA

PROCESS LOCATION/ALTERNATES INDEX

100-ft DIGESTERS
Mixers - Multiple Vortex Ring Plungers

110-ft DIGESTERS
Mixers - Multiple Vortex Ring Plungers

FOG Program Evaluation and Enhancement
Digester Mixers - Multiple Vortex Ring Plungers

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	100-ft MXING - 3 Vortex Ring Plungers									
	100-FT DIGESTER									**858,722**
	11000 - Equipment									
	11010 - Process Equipment									
1461[	Mixer - 12.5 hp LM16 Linear Motion Mixer	3.00	each	43,260.80	242,451.00		528.88		286,240.68	858,722
	Equipment Total									**858,722**

FOG Program Evaluation and Enhancement
Digester Mixers - Multiple Vortex Ring Plungers

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	110-ft MIXING - 5 Vortex Ring Plungers									
	110-FT DIGESTER									**1,472,123**
	11000 - Equipment									
	11010 - Process Equipment									
1461[	Mixer - 12.5 hp LM16 Linear Motion Mixer	5.00	each	43,260.80	250,635.00		528.88		294,424.68	1,472,123
	Equipment Total									**1,472,123**

FOG Program Evaluation and Enhancement
Digester Mixers - Multiple Vortex Ring Plungers

Category	Percent	Amount
100-ft MXING - 3 Vortex Ring Plungers Totals		
Labor	**5.57 %**	**129,782**
Material	**31.21 %**	**727,353**
Subcontractor		
Equipment	**0.07 %**	**1,587**
Other		
User		
Net Costs		**858,722**
Demolition	10.00 %	85,872
Support Structure/Mounting/Platform	5.00 %	42,936
Misc Piping	5.00 %	42,936
Electrical/Instrumentation	20.00 %	171,744
Construction Contingency	25.00 %	300,553
Subtotal		**1,502,764**
Estimating Contingency	15.00 %	225,415
Subtotal		**1,728,178**
Engineering, Legal, and Admin	30.00 %	518,453
Total 100-ft MXING - 3 Vortex Ring Plungers		**2,246,632**

FOG Program Evaluation and Enhancement
Digester Mixers - Multiple Vortex Ring Plungers

Category	Percent	Amount
110-ft MIXING - 5 Vortex Ring Plungers Totals		
Labor	**9.28 %**	**216,304**
Material	**53.76 %**	**1,253,175**
Subcontractor		
Equipment	**0.11 %**	**2,644**
Other		
User		
Net Costs		**1,472,123**
Demolition	10.00 %	147,212
Support Structure/Mounting/Platform	5.00 %	73,606
Misc Piping	5.00 %	73,606
Electrical/Instrumentation	20.00 %	294,425
Construction Contingency	25.00 %	515,243
Subtotal		**2,576,216**
Estimating Contingency	15.00 %	386,432
Subtotal		**2,962,648**
Engineering, Legal, and Admin	30.00 %	888,795
Total 110-ft MIXING - 5 Vortex Ring Plungers		**3,851,443**

From Summary Sheet:

Year of analysis	2010
Escalation rate	3.00%
Discount rate	5.00%

Risk adjustments (+/- percent):

Benefits	
Capital costs	
Running costs	

% increase of loads

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 1 - New Gas Mixing

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	1,529,204																													
Total capital outlays	**1,529,204**																													
Annual Running Costs:																														
Power Costs	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500
Total running costs		**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**
R&R Costs:																														
Compressor Maintenance	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Total refurbishments		**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**	**12,000**
Net Benefit/(cost)	**(1,529,204)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**	**(47,500)**

From Summary Sheet:

Year of analysis	2010
Escalation rate	3.00%
Discount rate	5.00%

Risk adjustments (+/- percent):

Benefits	
Capital costs	
Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 2a - Mechanical Draft Tube

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	972,598																													
Total capital outlays	**972,598**																													
Annual Running Costs:																														
Power Costs	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500
Total running costs		**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**
R&R Costs:																														
Bearing and seal replacement						2,600					2,600					2,600					2,600					2,600					
Crane to remove mech equip						1,000					1,000					1,000					1,000					1,000					
Mixer maintenance	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Total refurbishments		**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**
Net Benefit/(cost)	**(972,598)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**	**(39,900)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**	**(39,900)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**	**(39,900)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**	**(39,900)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**	**(39,900)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**

From Summary Sheet:

Year of analysis	2010
Escalation rate	3.00%
Discount rate	5.00%

Risk adjustments (+/- percent):

Benefits	
Capital costs	
Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 3 - External Pump Circulation

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
xpressed in 2010 dollars, unescalated																														
apital Outlays																														
Cost from Capital Cost Tab	1,187,515																													
Total capital outlays	**1,187,515**																													
nnual Running Costs:																														
Power	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269
Total running costs		**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**
&R Costs:																														
Bearing and seal replacement						1,300					1,300					1,300					1,300					1,300					
Pump maintenance	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Total refurbishments		**400**	**400**	**400**	**400**	**1,700**	**400**	**400**	**400**	**400**	**1,700**	**400**	**400**	**400**	**400**	**1,700**	**400**	**400**	**400**	**400**	**1,700**	**400**	**400**	**400**	**400**	**1,700**	**400**	**400**	**400**	**400**
et Benefit/(cost)	**(1,187,515)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**	**(68,969)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**	**(68,969)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**	**(68,969)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**	**(68,969)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**	**(68,969)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**

From Summary Sheet:

Year of analysis	2010
Escalation rate	3.00%
Discount rate	5.00%

Risk adjustments (+/- percent):

Benefits	
Capital costs	
Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 4a - Vortex Ring/Linear Motion

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	770,289																													
Total capital outlays	**770,289**																													
Annual Running Costs:																														
Power	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864
Total running costs		**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**
R&R Costs:																														
Bearing and seal replacement						650					650					650					650					650					
Mixer maintenance	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Total refurbishments		**200**	**200**	**200**	**200**	**850**	**200**	**200**	**200**	**200**	**850**	**200**	**200**	**200**	**200**	**850**	**200**	**200**	**200**	**200**	**850**	**200**	**200**	**200**	**200**	**850**	**200**	**200**	**200**	**200**
Net Benefit/(cost)	**(770,289)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,714)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,714)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,714)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,714)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,714)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 4b - Vortex Ring/Linear Motion 4W/m3

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	3,851,443																													
Total capital outlays	**3,851,443**																													
Annual Running Costs:																														
Power Costs	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500
Total running costs		**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**
R&R Costs:																														
Bearing and seal replacement							3,250						3,250								3,250				3,250					
Mixer maintenance	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total refurbishments		**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**4,250**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**4,250**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**4,250**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**4,250**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**
Net Benefit/(cost)	**(3,851,443)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(39,750)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(39,750)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(39,750)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(39,750)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 5a - Focused Flow

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	460,030																													
Total capital outlays	**460,030**																													
Annual Running Costs:																														
Power	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965
Total running costs		**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**
R&R Costs:																														
Bearing and seal replacement						2,600					2,600					2,600					2,600				2,600					
Crane to remove mech equip						1,000					1,000					1,000					1,000				1,000					
Mixer maintenance	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Total refurbishments		**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**800**
Net Benefit/(cost)	**(460,030)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 5b - Focused Flow 4W/m3

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	690,046																													
Total capital outlays	**690,046**																													
Annual Running Costs:																														
Power Costs	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500
Total running costs	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**
R&R Costs:																														
Bearing and seal replacement						3,900					3,900					3,900					3,900				3,900					
Crane to remove mech equip						1,000					1,000					1,000					1,000				1,000					
Mixer maintenance	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total refurbishments		**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**
Net Benefit/(cost)	**(725,546)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(41,400)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(41,400)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(41,400)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(41,400)**	**(36,500)**	**(36,500)**	**(36,500)**	**(41,400)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Existing - Gas Mixing (Existing)

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Annual Running Costs:																														
Power Costs	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593	20,593
Compressor Maintenance	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Digester Cleaning				21,700				21,700				21,700				21,700					21,700				21,700				21,700	
Total running costs	**26,593**	**26,593**	**26,593**	**48,293**	**26,593**	**26,593**	**26,593**	**48,293**	**26,593**	**26,593**	**26,593**	**48,293**	**26,593**	**26,593**	**26,593**	**48,293**	**26,593**	**26,593**	**26,593**	**26,593**	**48,293**	**26,593**	**26,593**	**26,593**	**48,293**	**26,593**	**26,593**	**26,593**	**48,293**	**26,593**
Net Benefit/(cost)	**(26,593)**	**(26,593)**	**(26,593)**	**(48,293)**	**(26,593)**	**(26,593)**	**(26,593)**	**(48,293)**	**(26,593)**	**(26,593)**	**(26,593)**	**(48,293)**	**(26,593)**	**(26,593)**	**(26,593)**	**(48,293)**	**(26,593)**	**(26,593)**	**(26,593)**	**(26,593)**	**(48,293)**	**(26,593)**	**(26,593)**	**(26,593)**	**(48,293)**	**(26,593)**	**(26,593)**	**(26,593)**	**(48,293)**	**(26,593)**	**(26,593)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 2a - Mechanical Draft Tube (Steel Fixed)

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	1,069,858																													
Total capital outlays	**1,069,858**																													
Annual Running Costs:																														
Power	38,439	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965
Total running costs		**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**
R&R Costs:																														
Bearing and seal replacement						2,600					2,600					2,600					2,600					2,600				
Crane to remove mech equip						1,000					1,000					1,000					1,000					1,000				
Mixer maintenance	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Total refurbishments		**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**
Net Benefit/(cost)	**(1,069,858)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 2b - Mechanical Draft Tube (Concrete Submerged)

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	1,215,748																													
Total capital outlays	**1,215,748**																													
Annual Running Costs:																														
Power Costs	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931
Total running costs		**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**
R&R Costs:																														
Bearing and seal replacement						2,600					2,600					2,600					2,600					2,600				
Crane to remove mech equip						1,000					1,000					1,000					1,000					1,000				
Mixer maintenance	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Total refurbishments		**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**
Net Benefit/(cost)	**(1,215,748)**	**(44,731)**	**(44,731)**	**(44,731)**	**(44,731)**	**(48,331)**	**(44,731)**	**(44,731)**	**(44,731)**	**(44,731)**	**(48,331)**	**(44,731)**	**(44,731)**	**(44,731)**	**(44,731)**	**(48,331)**	**(44,731)**	**(44,731)**	**(44,731)**	**(44,731)**	**(48,331)**	**(44,731)**	**(44,731)**	**(44,731)**	**(44,731)**	**(48,331)**	**(44,731)**	**(44,731)**	**(44,731)**	**(44,731)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 5a - Focused Flow (Steel Fixed)

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	759,051																													
Total capital outlays	**759,051**																													
Annual Running Costs:																														
Power	38,439	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965
Total running costs		**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**
R&R Costs:																														
Bearing and seal replacement						3,900					3,900					3,900					3,900					3,900				
Crane to remove mech equip						1,000					1,000					1,000					1,000					1,000				
Mixer maintenance	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total refurbishments		**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**
Net Benefit/(cost)	**(759,051)**	**(22,965)**	**(22,965)**	**(22,965)**	**(22,965)**	**(27,865)**	**(22,965)**	**(22,965)**	**(22,965)**	**(22,965)**	**(27,865)**	**(22,965)**	**(22,965)**	**(22,965)**	**(22,965)**	**(27,865)**	**(22,965)**	**(22,965)**	**(22,965)**	**(22,965)**	**(27,865)**	**(22,965)**	**(22,965)**	**(22,965)**	**(22,965)**	**(27,865)**	**(22,965)**	**(22,965)**	**(22,965)**	**(22,965)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 5b - Focused Flow (Concrete Submerged)

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	862,558																													
Total capital outlays	**862,558**																													
Annual Running Costs:																														
Power Costs	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931	43,931
Total running costs	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**	**43,931**
R&R Costs:																														
Bearing and seal replacement						3,900					3,900					3,900					3,900					3,900				
Crane to remove mech equip						1,000					1,000					1,000					1,000					1,000				
Mixer maintenance	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total refurbishments	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**
Net Benefit/(cost)	**(907,488)**	**(44,931)**	**(44,931)**	**(44,931)**	**(44,931)**	**(49,831)**	**(44,931)**	**(44,931)**	**(44,931)**	**(44,931)**	**(49,831)**	**(44,931)**	**(44,931)**	**(44,931)**	**(44,931)**	**(49,831)**	**(44,931)**	**(44,931)**	**(44,931)**	**(44,931)**	**(49,831)**	**(44,931)**	**(44,931)**	**(44,931)**	**(44,931)**	**(49,831)**	**(44,931)**	**(44,931)**	**(44,931)**	**(44,931)**

From Summary Sheet:

		Risk adjustments (+/- percent):		
Year of analysis	2010	Benefits		% increase of loads
Escalation rate	3.00%	Capital costs		
Discount rate	5.00%	Running costs		

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 1 - New Gas Mixing

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	1,285,214																													
Total capital outlays	**1,285,214**																													
Annual Running Costs:																														
Power Costs	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500
Total running costs		**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**
R&R Costs:																														
Compressor Maintenance	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850	1,850
Total refurbishments		**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**	**1,850**
Net Benefit/(cost)	**(1,285,214)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**	**(37,350)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 2a - Mechanical Draft Tube

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	972,598																													
Total capital outlays	**972,598**																													
Annual Running Costs:																														
Power Costs	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500
Total running costs		**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**
R&R Costs:																														
Bearing and seal replacement						2,600					2,600					2,600					2,600					2,600					
Crane to remove mech equip						1,000					1,000					1,000					1,000					1,000					
Mixer maintenance	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Total refurbishments		**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**
Net Benefit/(cost)	**(972,598)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**	**(39,900)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**	**(39,900)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**	**(39,900)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**	**(39,900)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**	**(39,900)**	**(36,300)**	**(36,300)**	**(36,300)**	**(36,300)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 3 - External Pump Circulation

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	1,187,515																													
Total capital outlays	**1,187,515**																													
Annual Running Costs:																														
Power	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269	67,269
Total running costs		**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**	**67,269**
R&R Costs:																														
Bearing and seal replacement						1,300					1,300					1,300					1,300					1,300					
Pump maintenance	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Total refurbishments		**400**	**400**	**400**	**400**	**1,700**	**400**	**400**	**400**	**400**	**1,700**	**400**	**400**	**400**	**400**	**1,700**	**400**	**400**	**400**	**400**	**1,700**	**400**	**400**	**400**	**400**	**1,700**	**400**	**400**	**400**	**400**
Net Benefit/(cost)	**(1,187,515)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**	**(68,969)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**	**(68,969)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**	**(68,969)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**	**(68,969)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**	**(68,969)**	**(67,669)**	**(67,669)**	**(67,669)**	**(67,669)**

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 4a - Vortex Ring/Linear Motion

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	770,289																													
Total capital outlays	**770,289**																													
Annual Running Costs:																														
Power	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864
Total running costs		**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**	**6,864**
R&R Costs:																														
Bearing and seal replacement						650					650					650					650					650					
Mixer maintenance	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Total refurbishments		**200**	**200**	**200**	**200**	**850**	**200**	**200**	**200**	**200**	**850**	**200**	**200**	**200**	**200**	**850**	**200**	**200**	**200**	**200**	**850**	**200**	**200**	**200**	**200**	**850**	**200**	**200**	**200**	**200**
Net Benefit/(cost)	**(770,289)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,714)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,714)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,714)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,714)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,714)**	**(7,064)**	**(7,064)**	**(7,064)**	**(7,064)**

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 4b - Vortex Ring/Linear Motion 4W/m3

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	3,851,443																													
Total capital outlays	**3,851,443**																													
Annual Running Costs:																														
Power Costs	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500
Total running costs		**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**
R&R Costs:																														
Bearing and seal replacement							3,250						3,250								3,250				3,250					
Mixer maintenance	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total refurbishments		**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**4,250**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**4,250**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**4,250**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**4,250**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**
Net Benefit/(cost)	**(3,851,443)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(39,750)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(39,750)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(39,750)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(39,750)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 5a - Focused Flow

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	460,030																													
Total capital outlays	**460,030**																													
Annual Running Costs:																														
Power	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965	21,965
Total running costs		**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**	**21,965**
R&R Costs:																														
Bearing and seal replacement						2,600					2,600					2,600					2,600				2,600					
Crane to remove mech equip						1,000					1,000					1,000					1,000				1,000					
Mixer maintenance	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Total refurbishments		**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**4,400**	**800**	**800**	**800**	**800**	**800**
Net Benefit/(cost)	**(460,030)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(26,365)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**	**(22,765)**

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2010	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	5.00%	Running costs	

San Jose/Santa Clara WPCP
Digester Mixer Upgrades (110 ft dia)
Life Cycle Alternative Cost Analysis ($000s)
Alternative 5b - Focused Flow 4W/m3

	Year																													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Expressed in 2010 dollars, unescalated																														
Capital Outlays																														
Cost from Capital Cost Tab	690,046																													
Total capital outlays	**690,046**																													
Annual Running Costs:																														
Power Costs	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500
Total running costs	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**	**35,500**
R&R Costs:																														
Bearing and seal replacement						3,900					3,900					3,900					3,900				3,900					
Crane to remove mech equip						1,000					1,000					1,000					1,000				1,000					
Mixer maintenance	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total refurbishments		**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**5,900**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**
Net Benefit/(cost)	**(725,546)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(41,400)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(41,400)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(41,400)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(41,400)**	**(36,500)**	**(36,500)**	**(36,500)**	**(41,400)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**	**(36,500)**