2017 Facilities Master Plan

FINAL REPORT – OCTOBER 2018

Central Marin Sanitation Agency

2017 FACILITIES MASTER PLAN

FINAL

October 2018

CENTRAL MARIN SANITATION AGENCY

2017 FACILITIES MASTER PLAN

INDEX

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

EXECUTIVE SUMMARY

FINAL
October 2018

CENTRAL MARIN SANITATION AGENCY

2017 FACILITIES MASTER PLAN

EXECUTIVE SUMMARY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DISCLOSURE STATEMENT

Funding for this document has been provided in full or in part through an agreement with the State Water Resources Control Board. California's Clean Water State Revolving Fund is capitalized through a variety of funding sources, including grants from the United States Environmental Protection Agency and state bond proceeds. The contents of this document do not necessarily reflect the views and policies of the foregoing, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

1.0 PURPOSE

This report is an executive summary of the 2017 Facilities Master Plan prepared for the Central Marin Sanitation Agency (Agency). The primary objectives of the Facilities Master Plan are to assess the ability of existing facilities to provide reliable wastewater treatment, plan for future regulations, and develop a prioritized and comprehensive Capital Improvement Program (CIP) that addresses the Agency's current and future needs.

Included in this report is a brief summary of the content and key findings and recommendations from ten (10) technical memoranda (TMs) prepared for the Facilities Master Plan. For more information in any subject area, the reader is directed to the individual TMs. The Facilities Master Plan is organized as follows:

- Executive Summary
- TM No. 1 - Equipment and Facility Condition Assessment
- TM No. 2 - Biogas Utilization
- TM No. 3 - Organic Waste Receiving Facility
- TM No. 4 - Nutrient Removal
- TM No. 5 - Biosolids Management Alternatives
- TM No. 6 - Biosolids Dewatering
- TM No. 7 - Blending Reduction Alternative Analysis
- TM No. 8 - Secondary Treatment
- TM No. 9 - Solar Power Generation
- TM No. 10 - Sea Level Rise

2.0 EQUIPMENT AND FACILITY CONDITION ASSESSMENT

TM No. 1 - Equipment and Facility Condition Assessment, the first major component of the Facilities Master Plan, summarized the results of a focused condition assessment. From a visual inspection of the Agency's assets and conversations with Agency staff, a risk based evaluation was conducted which identified 26 capital projects recommended over the next 15 years. A summary of these recommended projects is provided in Table ES.1. These projects were prioritized by completion timeframes. The total capital cost for the recommended projects is approximately $17.5 million.

Table ES.1 Prioritized 10-Year CIP
2017 Facilities Master Plan
Central Marin Sanitation Agency

CIP Years	Project Number and Title	Risk Rank	Cost
1-2	CCT Effluent Pipe Corrosion Repair (10-1)	1	$753,000
1-2	Secondary Clarifier Rehabilitation (08-1)	4	$944,000
1-2	Digester Mixing Pump Study (13-1)	4	$100,000
1-2	Influent Flow Meter Alternatives Study (99-4)	4	$75,000
1-2	Primary Clarifier Rehabilitation (05-1)	2	$1,739,000
1-2	Hydraulic Unit Replacement (04-1)	2	$737,000
Years 1-2	**Subtotal (6 projects)**		**$4,348,000**
3-5	RAS/WAS Pump Replacements (08-2)	7	$1,883,000
3-5	Biotower No. 1 Upgrade (06-2)	7	$1,996,000
3-5	Grit Blower and Diffuser Replacements (04-3)	7	$508,300
3-5	Gallery C Pump Replacements (10-2)	7	$108,000
3-5	Seismic Study (99-1)	7	$200,000
3-5	Roof Repairs (00-1)	7	$64,000
Years 3-5	**Subtotal (6 projects)**		**$4,759,000**
6-10	Grit Classifiers and Hoppers Replacement (04-2)	16	$1,235,000
6-10	CCT Gate Replacement (09-1)	16	$401,000
6-10	Gallery Pipe Reconfiguration (00-2)	16	$110,000
6-10	OWRF Pump Replacement (21-1)	16	$89,000
6-10	Digester Basement Floor Slab Repair (13-2)	24	$119,000
6-10	Grit Room Rehabilitation (04-4)	14	$1,936,000
6-10	Crack and Leak Repairs (00-4)	14	$132,000
6-10	CCT Valve Rehabilitation (09-2)	20	$324,000
6-10	Solids Handling Building Elevator Replacement (12-5)	20	$513,000
6-10	Biotower Pump Room Corrosion Repair (06-1)	20	$190,000
Years 6-10	**Subtotal (10 projects)**		**$5,049,000**
10+	Main Switchgear Replacement (14-1)	13	$1,017,000
10+	Biotower Scrubber and Air Handling Unit Replacement (06-3)	20	$2,200,000
10+	Ferric Room Floor Coating (04-5)	24	$110,000
10+	OWRF Crane Optimization Evaluation (99-3)	24	$0
Beyond 10 Years	**Subtotal (4 projects)**		$**3,327,000**

Notes:
(1) Projects with $0 cost would be included as part of a larger CIP project.

3.0 BIOGAS UTILIZATION

As part of the Facilities Master Plan three scenarios were developed to evaluate the impact of increasing the amount of imported high-strength waste (HSW), specifically fats, oils, and grease (FOG) and food waste (FW), processed in the Agency's two anaerobic digesters. The first scenario considered would achieve plant self-sufficiency, the second scenario would maximize existing cogeneration capacity, and the third scenario would maximize existing digestion capacity. The details of these scenarios are shown in Table ES.2.

Table ES.2 Projected Biogas Energy Production
2017 Facilities Master Plan
Central Marin Sanitation Agency

	FY 16/17[(1)]	Scenario 1[(2)]	Scenario 2[(3)]	Scenario 3[(4)]
Digester Feed				
PS+TWAS VS Load, klb VS/d (@8.03 mgd ADWF)	16.2	16.2	16.2	16.2
FOG VS Load, klb VS/d	3.32	4.80	6.66	21.5
FW VS Load, klb VS/d	3.84	4.22	4.22	4.22
Total VS Load, klb VS/d	23.4	25.2	27.1	41.9
Digester Performance				
Average Biogas Flowrate, scfm[(5)]	190	215	243	466
Peak Biogas Flowrate, scfm[(5,6)]	266	301	340	652
Electrical Power Generation				
Average Electrical Power, kW[(7)]	567	653	750	1,520

Notes:
(1) Calculated based on FY 16/17 average PS+TWAS, FOG, and FW VS loads; Q=8.03 mgd ADWF.
(2) FY 16/17 average PS+TWAS VS load, 10% increase in FW VS load, average electrical power goal = 653 kW (excludes NG and PG&E power purchases).
(3) FY 16/17 average PS+TWAS VS load, 10% increase in FW VS load, average electrical power goal = 750 kW (maximum cogen system power output).
(4) FY 16/17 average PS+TWAS VS load, digester feed VS load = 41.9 klb/d (VSLR = 0.160 lb/d-cf), 10% increase in FW VS load, FOG VS load by difference (maximum digester loading capacity).
(5) Standard conditions of 60 deg F, 1 atm.
(6) Peak average biogas flowrate = 1.4.
(7) Assumes cogeneration electrical efficiency of 30%.

With any of the three scenarios, the amount of biogas produced would increase. For the first two scenarios, this additional biogas could be utilized in the Agency's existing cogeneration engine. However, for the third scenario, the additional biogas produced would exceed the existing cogeneration capacity of the Agency. TM No. 2 - Biogas Utilization assessed ways the Agency could beneficially use this excess biogas.

Three alternative biogas uses were considered:

- Alternative 1: Producing electricity from an additional cogeneration system.

- Alternative 2: Producing RNG for trucking to an off-site vehicle refueling.
- Alternative 3: Producing RNG for trucking to an off-site pipeline injection.

The first alternative would involve providing an additional cogeneration engine adjacent to the Agency's existing cogeneration engine and expanding the Agency's existing biogas conditioning system. This alternative has the lowest capital cost at approximately $8.9 million as well as the simplest implementation. Additionally, the price obtained for electricity sold back to the grid from this new cogeneration engine would be fixed for the term of the agreement, providing certainty for the revenue generating potential.

The second alternative would involve providing a facility to turn biogas into renewable natural gas (RNG), a RNG storage facility, and a tail gas thermal oxidizer. The RNG produced would be trucked to an existing PG&E fueling station and would thus require close coordination and future discussions with PG&E. This alternative has the lowest net present value, but also has a capital cost of approximately $13.3 million and takes advantage of the RNG's relatively higher value as a vehicle fuel and the currently available low carbon fuel standard (LCFS) credits and renewable identification number (RIN) value. However, there is uncertainty regarding the future value of LCFS credits and RINs and there is no guarantee of a long-term fixed RNG price, so this alternative is inherently more risky to implement.

The third alternative would be similar to the second alternative, but would require additional biogas treatment to produce RNG of pipeline quality. The RNG produced would be trucked to a new PG&E pipeline injection station, and would also require close coordination and future discussions with PG&E. This alternative has the highest capital cost of approximately $22.6 million. Furthermore, no credits were assumed for pipeline injection. Thus, this alternative has a high implementation risk and high capital cost, as well as limited revenue generating capability.

Prior to implementing any of these alternatives, the Agency should conduct a study to confirm that the digesters can handle the proposed increase in FOG and FW loading above FY 16/17 levels.

4.0 ORGANIC WASTE RECEIVING FACILITY

While TM No. 2 - Biogas Utilization looked at alternatives to beneficially use the additional biogas produced with an increased influx of HSW to the digesters, TM No. 3 - Organic Waste Receiving Facility evaluates four alternatives for expanding the Organic Waste Receiving Facility (OWRF) to accommodate this increased influx of HSW to the Agency.

The four alternatives considered were:

- Alternative 1: New Below-Grade Storage to Double Capacity

- Alternative 2: New Aboveground Storage to Double Capacity
- Alternative 3: New Below-Grade Storage for 1 day HRT
- Alternative 4: New Aboveground Storage for 1 day HRT

These four alternatives were evaluated based on their total project cost, their net present value, and their non-economic evaluation score. Non-economic considerations included: consistent digester feed, ease of maintenance, ease of construction, staff familiarity, and onsite footprint.

Alternative 3 was estimated to have the lowest capital cost and net present value of approximately $1,440,000 and $8,037,000, respectively. Alternative 3 also had the best non-economic evaluation score. However, as mentioned above, the Agency should conduct a study to confirm that an increase in FOG and FW loading can be accommodated in the digesters without negatively impacting the digestion process.

5.0 NUTRIENT REMOVAL

The Agency's wastewater treatment plant (WWTP) and other publically owned treatment works (POTWs) discharging into San Francisco Bay are operating under a 2014 supplemental basin-wide discharge permit, which requires final effluent nitrogen and phosphorus monitoring by POTWs as well as ecological studies to determine appropriate nitrogen and/or phosphorus discharge limits to prevent impairment of the Bay.

At this time, the ecological studies have been inconclusive with respect to establishing specific nitrogen and/or phosphorus discharge limits, and it is anticipated that specific numeric limits would not be issued until the 2024 permit renewal at the earliest. It is anticipated that these specific limits would range from a no-net loading increase to a combined ammonia limit of 2.0 mgN/L, total nitrogen (TN) limit of 15 mgN/L, and total phosphorus (TP) limit of 1.0 mgP/L. This combined limit corresponds to "Level 2" as defined by the Bay Area Clean Water Agencies (BACWA) for ongoing planning studies, which is the less restrictive of two tiers of potential numeric discharge limits as shown in Table ES.3.

Table ES.3 Seasonal Nutrient Removal Targets in BACWA Scoping Plan
2017 Facilities Master Plan
Central Marin Sanitation Agency

Level	Ammonia	Total Nitrogen	Total Phosphorus	Comments
1 - Optimization	Variable	Variable	Variable	Plant specific
2 - Upgrade	2 mg N/L	15 mg N/L	1 mg P/L	No effluent filters or supplemental carbon required
3 - Upgrade	2 mg N/L	6 mg N/L	0.3 mg P/L	Typically requires effluent filters and supplemental carbon

TM No. 4 - Nutrient Removal evaluated a range of options to meet these potential final effluent nitrogen and phosphorus discharge limits. There are a number of feasible sidestream treatment options, mainstream treatment options (based on the existing secondary treatment facilities), and parallel mainstream treatment options that could meet potential Level 2 nutrient discharge limits as defined by BACWA. The mainstream treatment options include the modified Ludzak-Ettinger (MLE) process, ballasted sedimentation process (BioMag™), and integrated fixed film/activated sludge (IFAS) process. The parallel mainstream treatment options include the membrane bioreactor (MBR) process and the aerobic granular sludge (AGS) process.

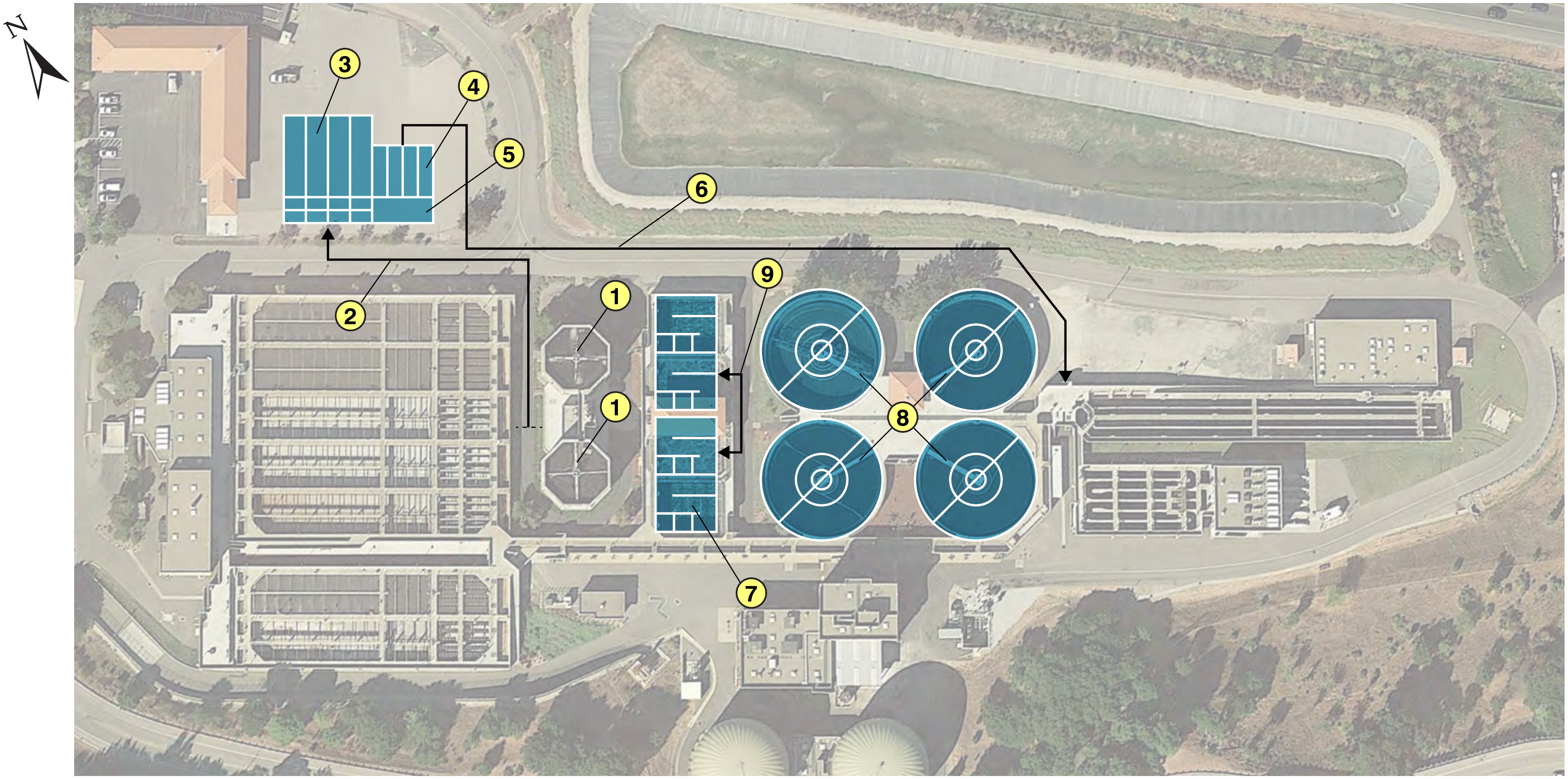
These options were arranged into various combinations of alternatives to meet the proposed Level 2 nitrogen and phosphorus limits and compared on a cost basis. One possible treatment alternative included abandoning the existing biotowers, modifying the existing secondary treatment system into a MLE process, and adding parallel MBR treatment. The estimated project cost for this alternative was approximately $34 million. Figure ES.1 shows a potential layout for these facilities.

It is recommended that additional monitoring be conducted to validate the assumptions made in this study about plant influent and solids handling recycle characteristics. Plant influent soluble biochemical oxygen demand (BOD) analyses are recommended to determine the readily biodegradable soluble organics load, as this is the BOD fraction necessary for effective biological nitrogen and/or phosphorus removal. In addition, pilot testing of the AGS process should be considered in the future to demonstrate compliance with the existing final effluent suspended solids discharge limit and with anticipated Level 2 nitrogen and phosphorus discharge limits.

6.0 BIOSOLIDS MANAGEMENT ALTERNATIVES

TM No. 5 - Biosolids Management Alternatives summarized the Agency's existing biosolids management practices, outlined the new regulatory requirements for organic diversion from landfills, and discussed how these requirements may alter how biosolids are currently managed at the Agency. Recommended summer and winter strategies for biosolids management were also provided.

The Agency currently produces a Class B biosolid and sends the majority of these biosolids to Redwood landfill in the winter months for use as alternative daily cover, and to land application through Synagro in the summer months. The Agency also sends about 25 percent of its biosolids to the Lystek facility in Fairfield-Suisun for production of a liquid fertilizer.



LEGEND

1. Existing Biotower (Abandoned in Place)
2. New Primary Effluent Pipe
3. New MBR Aeration Tanks with Preanoxic Zones
4. New Membrane Tanks
5. New Deoxygenation Tanks
6. New Secondary Effluent Pipe
7. Retrofit Existing Aeration Tanks to Modified Ludzak-Ettinger Configuration
8. Retrofit Existing Secondary Clarifiers with New Energy Dissipating Inlets, Flocculation Baffles, and Mechanisms
9. New Returned Activated Sludge Pipes for Sludge Reaeration Configuration during Peak Flow Periods

NUTRIENT REMOVAL ALTERNATIVE 1

FIGURE ES.1

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With recently enacted regulations, including Senate Bill 1383, Assembly Bill 1594, and Assembly Bill 341, landfilling biosolids may become more challenging over the next 5 to 10 years. Additionally, there are a number of local county ordinances restricting land application of biosolids. All of these regulations place price and capacity pressures on existing biosolids markets, increasing competition among utilities for available biosolids outlets.

Given these pressures, this TM provided a recommended path forward for biosolids management at the Agency. It was recommended that the Agency continue summer land application, as available, and pursue winter biosolids end use options with Synagro in the near term (3 to 5 years). As the cost of land application increases to over $60 per wet ton, it was recommended that the Agency consider increasing the portion of biosolids sent to compost. As the cost of composting and land application increase to over $65 to $70 per wet ton, the Agency should consider joining a future regional Bay Area Biosolids Coalition facility.

7.0 BIOSOLIDS DEWATERING

Currently the Agency dewaters its biosolids in three centrifuges (two duty, one standby) prior to hauling biosolids offsite. These centrifuges were installed in 2002, and in the spring of 2016, the Agency hired a centrifuge service company to conduct a condition assessment. The results of this condition assessment were used in TM No. 6 - Biosolids Dewatering to assist the Agency in determining whether the Agency should continue maintaining the existing centrifuges, replace them with new centrifuges, or install a different dewatering technology. The analysis of the existing centrifuges included review of the performance history, maintenance records, and the manufacturer’s condition assessment report.

Four alternatives were considered in this analysis:

- Alternative 1: Rehabilitate Centrifuges
- Alternative 2: New Centrifuges
- Alternative 3: New Screw Presses
- Alternative 4: New Rotary Fan Presses

These alternatives were compared based on their capital and lifecycle costs, their power and polymer usages, their dewatering performance, and the space limitations in the existing building.

Based on this analysis, Alternative 1 was found to have the lowest lifecycle cost. However, it was noted that rehabilitating the existing centrifuges would not enable the Agency to capitalize on recent innovations or advancements in dewatering technology or energy efficiency. In addition, as the Agency increases system loads by importing more organic material, the existing centrifuges would require longer operation per day than currently practiced. The total project cost for this alternative was estimated to be approximately $331,000, with a present worth of about $20,952,000. Given that the Agency has proactively maintained the existing centrifuges such that they have at least another 5 to 10 years of useful service life, Alternative 1 was selected for implementation.

8.0 BLENDING REDUCTION ALTERNATIVE ANALYSIS

The Agency's 2012 National Pollutant Discharge Elimination System (NPDES) permit required an analysis of blending alternatives with the permit renewal application. TM No. 7 - Blending Reduction Alternative Analysis provided this needed analysis.

Two primary effluent storage alternatives and six treatment alternatives to reduce the frequency, duration, and volume of wet weather blending events were analyzed. The two storage alternatives included:

- Alternative S-1: Convert Existing Effluent Storage Pond
- Alternative S-2: Install New Below-Grade Storage Tank

The six treatment alternatives include:

- Alternative T-1: Maintain Existing Secondary Treatment
- Alternative T-2: Optimize Existing Secondary Treatment
- Alternative T-3: Expand Existing Secondary Treatment
- Alternative T-4: Convert Biotowers and Activated Sludge to Run in Parallel
- Alternative T-5: Install New High-Rate Biological Treatment with Ballasted Flocculation
- Alternative T-6: Install Conventional Treatment for Blending Elimination

These alternatives were compared on a cost basis, and an estimated annual blending volume reduction was calculated for each alternative. Costs for these alternatives ranged from $0 for Alternative T-1 (0% reduction in blending) to $303 million dollars for Alternative T-6 (100% reduction in blending). Advantages and disadvantages for each alternative were also documented. Based on the results of this TM, the Agency's Board selected Alternative T-1: Maintain Existing Secondary Treatment as its preferred alternative for submission to the Regional Water Quality Control Board (RWQCB) in the NPDES permit renewal application process. Subsequently the RWQCB accepted the Board’s selection and Alternative T-1 was adopted in the Agency's 2018 NPDES permit.

9.0 SECONDARY TREATMENT

The main purpose of TM No. 8 - Secondary Treatment was to identify efficient secondary treatment operating strategies for dry and wet weather conditions. The evaluation summarized in this TM considers the number of biotowers, aeration tanks, and secondary clarifiers that are in service as well as pumping strategies and their impacts on plant performance, effluent quality, and power usage. This evaluation was based on compliance with the current final effluent discharge permit, which includes limits for total suspended solids (TSS) and carbonaceous biochemical oxygen demand (cBOD). It does not consider secondary treatment modifications and/or new facilities that may be required to comply with potential future nutrient limits, which were addressed in TM No. 4 - Nutrient Removal.

It was recommended that the Agency continue the current operating strategies as the Agency's WWTP has consistently performed well and produced excellent effluent quality with cBOD and TSS concentrations averaging between 5 and 6 mg/L during the eight year review period from 2009 through 2016. The Agency's current strategy includes operating one biotower, two aeration tanks in parallel, and three secondary clarifiers during dry weather. During wet weather the Agency's current strategy includes operating one biotower, four aeration tanks in parallel mode, and four secondary clarifiers during wet weather. In both wet and dry weather the biotowers are fed at a constant rate and return activated sludge pumping is flow paced. A summary of this, and other acceptable operating strategies for both dry and wet weather is shown in Figure ES.2.

10.0 SOLAR POWER GENERATION

TM No. 9 - Solar Power Generation summarized the technical and financial feasibility for providing solar power generation at the Agency's WWTP. This TM considered three locations for the addition of solar panels, as shown in Figure ES.3. These locations were identified because they would have minimal or no impact on Agency operations, sufficient space to achieve economies of scale, unshaded and unobstructed areas, and no future planned use. The three areas identified could accommodate up to 500 kilowatts of solar photovoltaic (PV) generation.

While solar PV generation is possible, it was determined that Agency owned solar PV is uneconomical due to long payback periods. The Agency has existing on-site electricity generation which limits the economic value of solar generation. Additionally, the Agency would not be eligible to receive tax credits for a solar project.

Dry Weather (May through October)

Increasing SRT
Increasing Power

Number of Aeration Tanks in Service	Number of Biotowers in Service		
	0	1	2
0	NO	NO	NO
1	NO	NO	NO
2	NO	RECOMMENDED	ACCEPTABLE
3	NO	ACCEPTABLE	ACCEPTABLE
4	NO	NO	NO

Decreasing SVI
Decreasing Power

Wet Weather (November through April)

Increasing SRT
Increasing Power

Number of Aeration Tanks in Service	Number of Biotowers in Service		
	0	1	2
0	NO	NO	NO
1	NO	NO	NO
2	NO	NO	NO
3	NO	ACCEPTABLE	ACCEPTABLE
4	NO	RECOMMENDED	ACCEPTABLE

Decreasing SVI
Decreasing Power

LEGEND / TABLE KEY	
NO	Not recommended, anticipate poor effluent quality or not meeting NPDES permit.
RECOMMENDED	Recommended as continued strategy. Has historically provided excellent effluent quality.
ACCEPTABLE	Acceptable operating mode and anticipate meeting NPDES permit. May result in slight reduction in effluent quality or increase (or decrease) in power usage.

OPERATIONAL EVALUATION SUMMARY

FIGURE ES.2

SOLAR PV LOCATIONS

FIGURE ES.3

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11.0 SEA LEVEL RISE

TM No. 10 - Sea Level Rise summarized the review of the Marin Bay Waterfront Adaption and Vulnerability Evaluation (BayWAVE) project. The goal of the BayWAVE project is to increase awareness and help the shoreline residents plan and prepare for potential future sea level rise impacts due to climate change. The BayWAVE project selected the U.S. Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS) to model sea level rise scenarios countywide. The CoSMoS combines wave models with projected sea level rise to identify areas at risk of flooding. Table ES.4 summarizes the use of CoSMoS to evaluate different scenarios for near-term (2030), mid-term (2050), and long-term (2100) sea level rise projections with and without consideration of the 100-year flood event.

Table ES.4 BayWAVE Scenarios Based on USGS CoSMoS
2017 Facilities Master Plan
Central Marin Sanitation Agency

Scenario	Sea Level Rise(1) (Inches)	100-Year Flood Event (Inches)	Sea Level Rise + 100-Year Flood Event (Inches)
1. Near-term: 2030	9.6	36	46
2. Mid-term: 2050	19.2	56	76
3. Long-term: 2100	60	96	156

Note:
(1) The BayWAVE model uses the projected median sea level rise. Projected ranges for the near, mid, and long-term scenarios, which do not include the increased loss of the Antarctic Ice Sheet, which may underestimate sea level rise (Kopp et al., 2014).

Based on the aerial maps generated from the CoSMos output when both sea level rise and the 100-year flood event are considered, potential flooding in the 2030 near-term scenario is anticipated to impact only access to the WWTP via Andersen Drive and not the WWTP or its assets. In the 2050 mid-term scenario and the 2100 long-term scenario, potential flooding is also anticipated to impact the eastern portion of the WWTP along Interstate 580. For all scenarios where the projected flooding would affect Andersen Drive, the Agency should meet with the City of San Rafael to discuss the level of mitigation the city will be evaluating to address the potential flooding risk to this and other city roadways.

This TM also summarized the hydraulic assessments of the gravity and pumped outfall discharge capacities with respect to the projected rise in sea level and 100-year flood events. A sensitivity analysis was conducted on the gravity and pumped outfall capacities with respect to assuming some of the diffuser ports on the outfall would be potentially buried in mud and unable to discharge flow. For both cases, the estimated reduction on gravity and pumped outfall discharge capacities was found to be minimal.

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM NO. 1
EQUIPMENT AND FACILITY CONDITION ASSESSMENT

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2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM
NO. 1
EQUIPMENT AND FACILITY CONDITION ASSESSMENT

TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF FIGURES

EQUIPMENT AND FACILITY CONDITION ASSESSMENT

1.0 INTRODUCTION

This technical memorandum summarizes the condition assessment of the Wastewater Treatment Plant (WWTP) at the Central Marin Sanitation Agency (Agency). The condition assessment included a visual assessment of WWTP assets. Capital projects are recommended for assets or facilities that are in need of rehabilitation or replacement. Recommended projects are prioritized in a 10-year capital improvement plan (CIP) based on the probability and risk of failure.

2.0 SUMMARY OF KEY FINDINGS

The key findings are:

- 26 capital projects are recommended over the next 15 years to replace WWTP assets and facilities in need of rehabilitation or replacement. The total capital cost for the projects is $17.5 million (in today's dollars).
- A 10-year CIP was developed and projects were prioritized using a risk-based approach. The 10-year CIP includes 22 projects at a capital cost of $14.2 million (in today's dollars). Project timing and cost is as follows:
  - 6 projects in years 1-2 with a total capital cost of $4.3 million.
  - 6 projects in years 3-5 with a total capital cost of $4.8 million.
  - 10 projects in years 6-10 with a total capital cost of $5.1 million.

3.0 BACKGROUND

3.1 Wastewater Treatment Plant Facilities

The Agency's WWTP was designed in 1981 with an average dry weather flow (ADWF) capacity of 10.0 million gallons per day (mgd) and a corresponding sustained peak secondary treatment capacity of 30.0 mgd. Construction of the WWTP was completed around 1985 and operation began shortly thereafter. The facility treats wastewater from the City of Larkspur, the Towns of Corte Madera, Fairfax, Ross, San Anselmo, portions of San Rafael, the unincorporated areas of Ross Valley, San Quentin Village, and San Quentin State Prison and discharges into the San Francisco Bay (Bay).

The WWTP consists of preliminary treatment (headworks with screening and grit removal), primary treatment, secondary treatment (biotowers, activated sludge, and secondary clarification), disinfection, and dechlorination. Solids handling includes waste activated sludge thickening, anaerobic digestion, biosolids dewatering, and cogeneration fueled with biogas. During wet weather events, primary treated effluent flows greater than the peak secondary treatment capacity (30 mgd) are diverted around the secondary process and blended with secondary effluent prior to disinfection, dechlorination, and discharge to the bay via a gravity outfall and/or effluent pump station.

The original design approach included effluent disposal by gravity through an offshore outfall and diffusers. Since wet weather flows could exceed the hydraulic capacity of the outfall during high tides, a 4.0 million gallons (MG) effluent storage pond was included for storing final effluent until the tide elevation dropped. To provide additional capacity, the effluent storage pond volume was increased to 7.0 MG by increasing the height and side slope of the pond berm.

The Wet Weather Improvements Project (WWIP) was completed in May 2010 to handle increasing wet weather flows from the satellite collection agencies. Treatment plant expansions and modifications included new mechanical equipment for the Aerated Grit Chamber 3, two new primary clarifiers to increase the primary treatment capacity to 125 mgd, polymer storage and feed facilities to increase primary clarifier performance, two new chlorine contact tanks, and a new 155-mgd effluent pumping station to increase disposal capacity during concurrent peak flow and high tide events. Motorized operators were installed on existing aeration tank gates so that changing the aeration tanks to a sludge reaeration configuration could be made through the SCADA system if necessary during wet weather events. With the construction of an effluent pump station, the WWTP is no longer reliant on the storage pond for effluent flow shaving, but it is still available for emergencies and to facilitate shutdowns and maintenance activities.

A summary of the upgrade and expansion projects since the WWTP became operational in 1984 is summarized below:

- 1995 Odor Control Improvements
- 1995 Hypochlorite and Bisulfite Facilities
- 1999 Process Control System Replacement
- 2003 Cogeneration Engine Replacement
- 2006 Vactor Receiving Station
- 2007 Effluent Storage Pond Improvements
- 2008 Outfall Improvements
- 2010 Headworks Barscreen Replacement
- 2012/13 Digester Improvements and Organic Waste Receiving Facility (OWRF)

- 2010 Wet Weather Improvements Project (WWIP)
- 2011 Aeration Blower Replacement
- 2013 Reclaimed Water System Improvements
- 2014 Sludge Thickening System Replacement
- 2015 Solids Handling Building Odor Control

3.2 Previous Studies and Additional Sources of Information

In addition to implementing various upgrades and improvements, the Agency has prepared several studies and reports to evaluate their facilities. This information was reviewed and combined with field observations and staff input to prepare this TM. Information reviewed for this study includes the references noted below.

- WWTP Condition Assessment (2016)
- FOG Tank Coating Inspection (2015)
- Odor Control Study and Design (2015)
- Ferric Tanks Inspection at Headworks (2011)
- Capital Master Plan (2011)
- Outfall Inspection (2010)
- Adopted Operating and Capital Budgets (2012-2017)
- Asset Management Annual Status Reports (2011-2016)
- CMMS Asset List

4.0 CONDITION ASSESSMENT METHODOLOGY

This section presents the approach and methodology used to perform the WWTP assessment and identify the recommended improvements. Figure 1.1 summarizes the process used to develop a prioritized list of capital projects. A description of each step is provided in this section. Sections 5 through 8 and the appendices summarize the findings of the assessment.

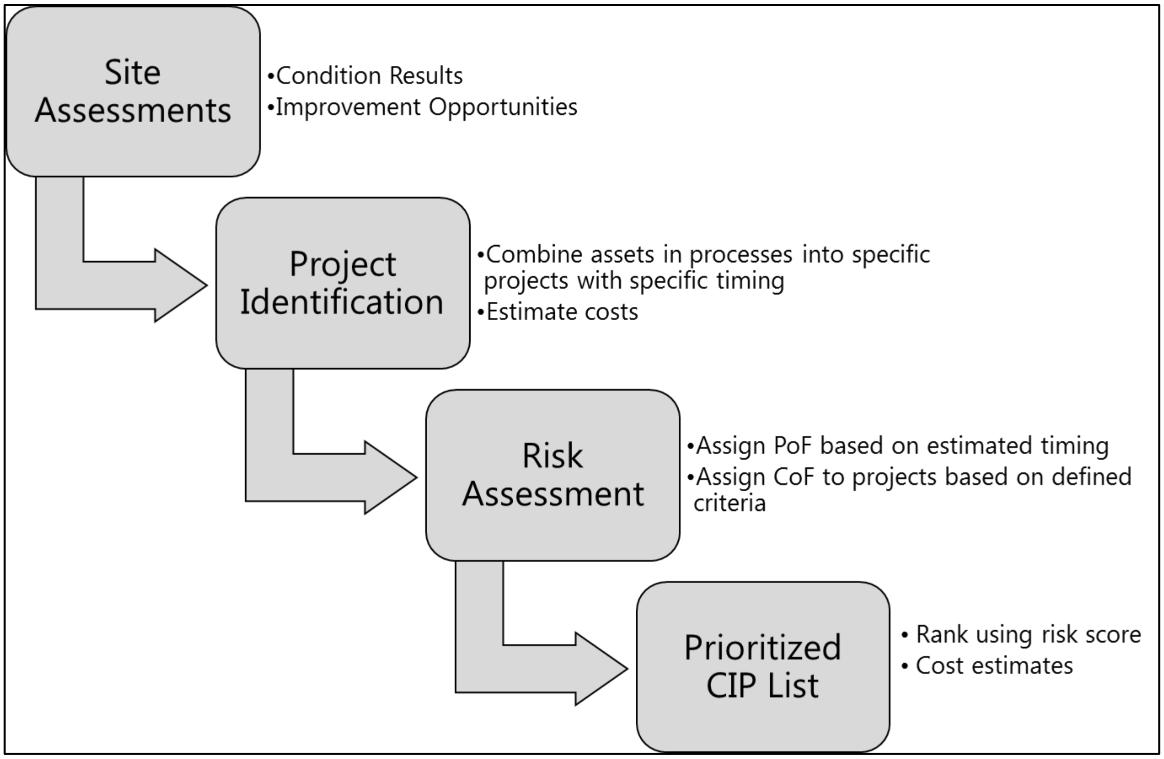

Figure 1.1 Condition Assessment Process

4.1 Site Assessment

The site assessment documents the observations and findings for key areas of the WWTP. A multi-disciplined engineering team performed the visual assessments on November 29-30, 2016. Plant staff accompanied the team during the assessments. A workshop was conducted to prepare for the assessments.

4.1.1 <u>Pre-Assessment Workshop</u>

A pre-assessment workshop was held on October 27, 2016 to discuss the approach for the 2-day visual assessment. The workshop covered the following topics:

- The multi-disciplined team and their roles in the visual assessment.
- Available information (listed in section 3.2).
- Manner for collecting information, templates of forms to be used in the field, and the scoring criteria to be used to rate plant assets.
- Input from Agency staff regarding the WWTP history, known problem areas, history of replacements and major rehabilitations, and recommended areas where the assessment should focus.

4.1.2 Area Inventories

An inventory was compiled of the major above-ground assets with the appropriate level of detail for a visual condition assessment and facility-wide capital project planning. Table 1.1 lists the twelve process areas of the plant that were visually assessed during the project.

Table 1.1 Observed WWTP Areas
2017 Facilities Master Plan
Central Marin Sanitation Agency

Area Number	Area Title or Description
04	Headworks, Influent Box, Screening, and Grit
05	Primary Clarifiers and Pumping Gallery
06	Bio-towers and Pumping Building
07	Aeration Tanks and Blower Building
08	Secondary Clarifiers and Pumping Gallery
09	Chlorine Contact Tanks
10	Chlorination and Dechlorination Building and Gallery
12	Solids Handling Building and Generator Room
13	Digester Area
14	Switchgear Building
20	Effluent Pump Station
21	Organic Waste Receiving Facility (OWRF)

Notes:
(1) Underground galleries between most process areas were also observed.

Asset inventories for each of these areas was prepared based on information from the Agency's computerized maintenance management system (CMMS). The major equipment, structures, and process components were included in the inventories. Items such as instrumentation and small valves were removed from the inventory because they would not impact the identification of capital projects. Copies of these inventories are included in Appendix A of this TM.

Figure 1.2 is a site plan of the WWTP and the area inventories included in the assessment.

4.1.3 Field Assessment Forms

Customized sets of field forms were developed for each of the twelve process areas. The forms included a process-level form used to document observation about the entire process or area, asset-type forms used to document the condition of individual pieces of equipment (such as pumps, blowers, or clarifiers), and a copy of the asset inventory. Figures 1.3 and 1.4 show samples of the field forms used.

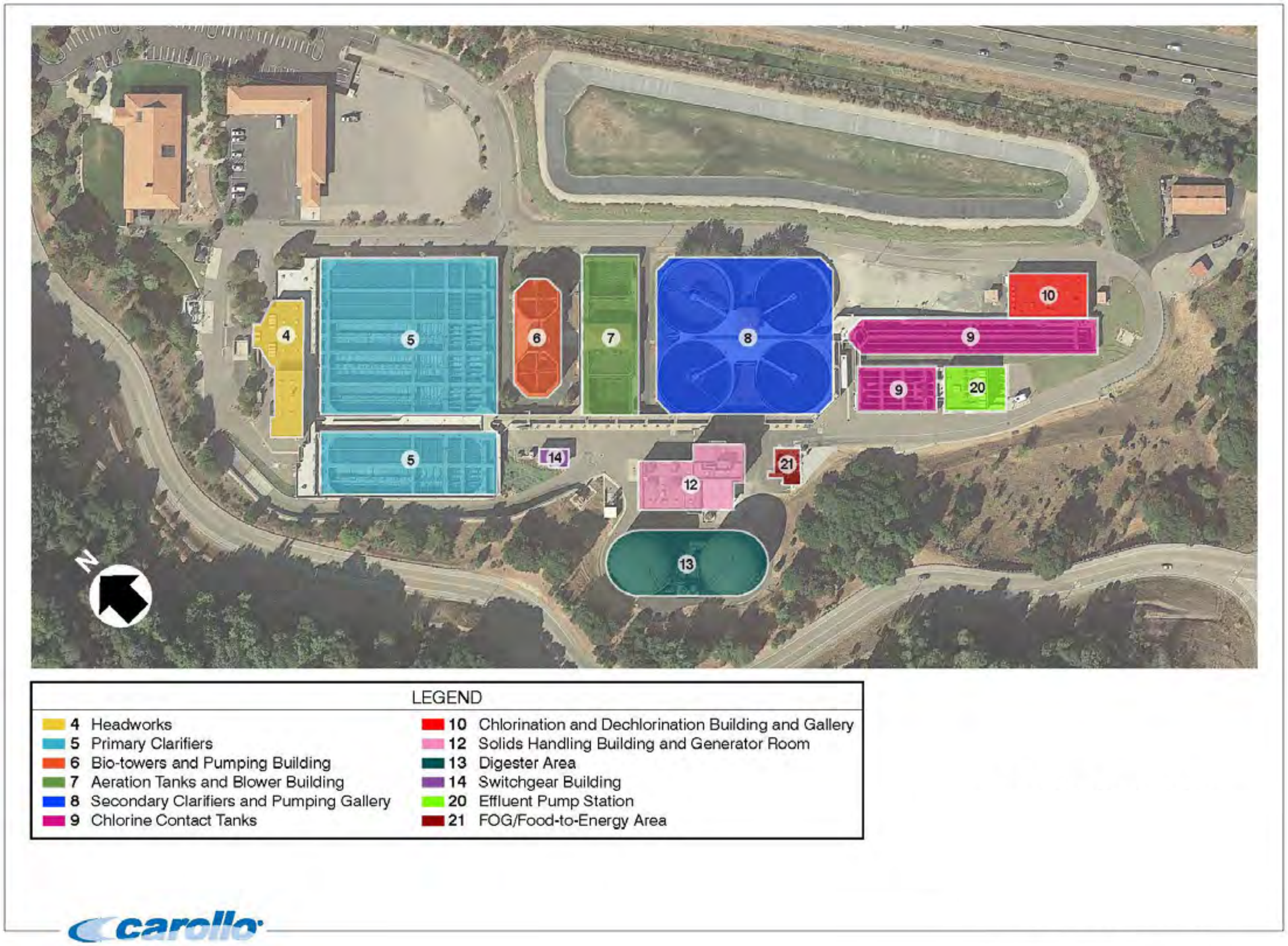

Figure 1.2 WWTP Site Plan and Area Inventories

Assessed By: Date:

Process/Area Aeration (Area 07)

Site / Civil / Structural Features

Potential components in this area:

Surrounding area	Pavement / Grading
Gallery	Walls, ceiling, hangers
Misc. components	Self-supporting mechanical systems

Deficiencies, Needs, or Potential Improvements:

Process Upgrades / Major Rehabilitations / Upcoming Projects:

Improvement Opportunities:

Performance

Energy Efficiency

Greenhouse Gas Reduction

General Notes / Noted Problems / Areas of Concern:

Figure 1.3 Sample Field Form 1

Assessed By: Date:

Asset Type PRIMARY SLUDGE PUMP UNITS (1-7)

Question/Criteria	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	Notes
Pump ID	P05.01	P05.02	P05.03	P05.04	P05.05	P05.06	P05.07	
Installation Year	'09	'06	'07	'08	'09	'09	'09	
Pump Casing / Body								
No observed defects								
Minor corrosion or chipped paint								
Lubricant leaks or stains								
Excessive corrosion or flaking paint								
Evidence of leaks / leaking								
Support / Base								
No observed defects								
Minor corrosion								
Anchor bolt damage / evidence of vibration								
Cracks in base / concrete pad								
Valves / Piping / Supports								
No observed defects								
Minor corrosion or chipped paint								
Evidence of leaks								
Excessive corrosion or flaking paint								
Noted / observed operational issues								
Motor								
Not operating during inspection								
No observed defects								
Lubricant leaks or stains								
Moderate or significant corrosion								
Excessive heat or noise								
Electrical & Instrumentation								
No observed defects								
Upgraded since pump installation								
Cracked coatings								
Obsolete technology								
Operation								
Not operating during inspection								
No observed issues								
Leaks observed								
Excessive heat or noise								
Estimated Timing to Renewal								
Immediate Need (0-2 years)								
2-5 years								
5-10 years								
10-20 years								
Long-term (20+ years)								

Renewal Activities:

Figure 1.4 Sample Field Form 2

4.2 Project Identification

Projects are identified for each process area using the results of the visual condition assessment. The observations from the site visits are combined with the available data to assign a rehabilitation or replacement timeframe for major systems or groups of assets within each process area. Where applicable, components of the same discipline or with similar timing, function, and/or location are grouped into a single project. The identified projects are focused at the capital level for use in a Master Plan and do not include small repairs or work that can be done by CMSA staff. Each project includes a basic description, estimated cost, and estimated timing.

The cost estimates are planning-level type estimates with an anticipated accuracy of +40 percent to -30 percent. Cost estimates are developed using Carollo's cost database, quotes from suppliers, and experience on similar projects. The cost estimates are developed using some detailed information about specific assets and applying factors to account for allowances, contingencies, and sales tax. Detailed cost estimate for each project are included in Appendix B.

A preliminary list of projects was presented to CMSA staff for review and comment. Input from staff was incorporated into the final project list.

4.3 Risk Assessment

Once the projects are identified, they are prioritized through a risk-based process that considers each project’s probability and consequence of failure. This section defines the set of criteria to assign a probability of failure and consequence of failure for each improvement project and how risk is assigned and classified for use in this project.

4.3.1 Risk Overview

Risk is the product of two elements: probability of failure and consequence of failure. Each element, consequence and probability, are independent of one another. The probability is a measure of the likelihood that an event will occur and the consequence is a measure of the impact if that event were to occur. The risk of an event occurring is defined as the product of these two elements, probability and consequence. Using this methodology, something considered to be high risk is both likely to occur and has a significant impact. Conversely, something that is low risk is unlikely to occur and has little impact. The various combinations of low and high probabilities and consequences make up the risk spectrum.

Figure 1.5 illustrates the concept of the risk as the combination of probability and consequence of failure.

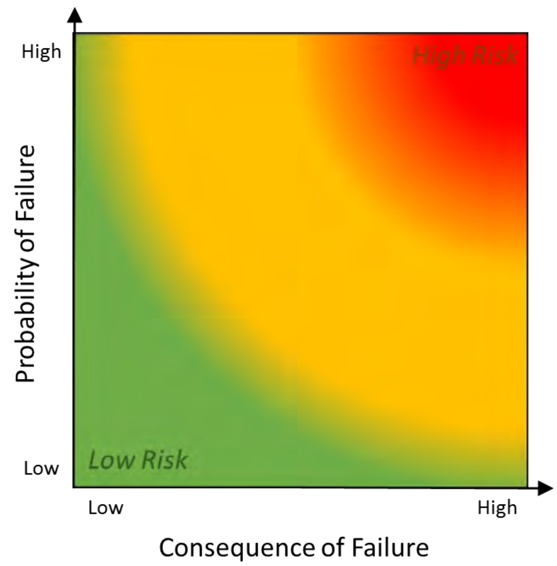

Figure 1.5 Risk Matrix

Risk will be evaluated for the projects identified for the 10-year CIP. Note that this risk assessment methodology is intended for prioritizing projects, and not for prioritizing replacement of each asset in the inventory.

4.3.2 Consequence of Failure

The CoF is a measure of the criticality or impact of a specific asset or group of assets. The CoF is assigned to the individual projects identified for each process area within the WWTP. CoF scores are dependent on the elements included in the scope of each project and is designed to represent the potential impact if the project is not completed.

The CoF is assessed for each project in four different categories designed to capture the major elements that contribute to a project being critical. The four categories and a brief description of why they are included are listed below.

- Regulatory Compliance & Environmental Disruptions - meeting all discharge permits, spills or contamination, pollution,
- Safety & Community Disturbances - health and safety of the community and staff and disruptions to the local community and how long they last. For example, odor complaints are short term impacts to the community, but a spill onto the freeways takes much longer to remedy.
- Financial Effects - not implementing the project could result in taking on more financial burdens. For example, cost of emergency response, buying replacement parts or equipment, or unplanned repairs of major assets. This is not intended to incorporate the estimated cost of the project.

- Operational Impacts - impact to the main processes and the ability of the plant to move and treat the flow of wastewater. This includes shutting down a process and the downtime of major equipment. This is intended to represent typical flow scenarios, not extreme peaks.

Definitions for the scores for each category are included in Table 1.2. Note that this scoring is subjective and is intended to rate the potential impact should a given project not be completed.

Table 1.2 Consequence of Failure Criteria and Definitions
2017 Facilities Master Plan
Central Marin Sanitation Agency

Category	Low (1)	Low-Medium (2)	Medium (3)	Medium-High (4)	High (5)
Regulatory & Environment	No impact on meeting regulations	Minor spill contained to plant site	Major spill contained on plant site	Spill off site or minor permit violation	Major or serious permit violation or serious environmental impact
Safety & Community	No impact to the community, health, or safety	Minor community disturbance remedied quickly (e.g., one odor complaint)	Short-term impacts (i.e. less than one week) on community or potential for injury	Moderate community disturbance that cannot be remedied within one month (e.g., multiple odor complaints)	Potential for loss of life or long-term impact on community
Financial(1)	No foreseen financial impact	Financial impact greater than $10,000	Financial impact greater than $100,000	Financial impact greater than $500,000	Financial impact greater than $1,000,000
Operational	No impact on plant flows and no downtime of major equipment	Minor process disruption, requires operational changes	Major process disruption requiring use of effluent pond for less than 4 hours	Major process disruption requiring use of effluent pond for less than 8 hours	Major process disruption resulting in plant shutdown or significant downtime of major equipment that could result in discharge of untreated wastewater

Notes:
(1) Non-project costs resulting from an unplanned event, not the cost of the planned capital project. Example of costs include emergency response, bypass operations, and repair costs.

The maximum score in any category is used to calculate the overall CoF score for each project. This method is preferred over an average of the scores in all categories, which diminishes the results of any one category.

4.3.3 Probability of Failure

The PoF is a measure of the likelihood that a specific asset or system could fail to perform their intended function. The PoF is assigned to the individual projects identified for each process area within the WWTP.

PoF scores are assigned using a "1 to 5" scoring system designed to represent the timeframe until a project is needed. A score of 1 corresponds to new assets or projects with no rehabilitation or replacement expected within the next 15 years and a score of 5 corresponds to action being needed within the next 2 years (See Table 1.3).

Table 1.3 Probability of Failure Criteria
2017 Facilities Master Plan
Central Marin Sanitation Agency

Score	Estimated Project Timeframe	Condition Description
1	Not expected within next 15 years	Recently installed or constructed
2	10-15 years	No observed issues
3	5-10 years	Minor repairs or maintenance needed
4	3-5 years	Moderate repairs or major maintenance needed
5	Within the next 2 years	Significant repairs or replacement needed

Notes:
(1) Estimated Project Timeframe based on engineering judgment of the discipline engineers involved in the visual assessment.

The score is representative of the current state of the assets included in the scope of each identified project. The age of equipment and the findings from the visual assessment for each process area are combined into projects. These projects are assigned a PoF score to represent the recommended timing to complete the project. The timing is based on the entire scope of the project and is based on a review of the results from the visual condition assessment and engineering judgment.

4.3.4 Risk Score

The risk score is calculated as the product of the PoF and CoF scores. The risk score is used as a means to rank and compare projects. The risk score is not a direct indicator of the order projects need to occur, but rather to assist in the prioritizing of potential projects that cover different areas of the WWTP. It is important to note that the risk score is intended to differentiate the need for projects using a defined scoring system, however, professional judgment still needs to be applied to make sure that the results make practical sense within the scope of the Agency's 10-year CIP.

4.4 Prioritized 10-Year CIP

The risk analysis is performed for each project identified through the visual condition assessment process. The risk score will be used to rank the projects from high to low priority. During the development of the 10-year CIP for the Facilities Master Plan, the recommended scheduling of projects will focus on the higher priority projects first and, if necessary, lower priority projects will have their timing adjusted to fit within the Agency's resource limits.

5.0 SITE ASSESSMENT SUMMARY

The observations and findings presented in this section summarize the results of the data review, visual assessments, and subsequent analysis performed by the Carollo assessment team. Select photos are included in Appendix C.

5.1 Headworks (Area 04)

The observed area includes the influent pipes and vaults, the grit chamber room, and the rooms for the grit classifiers and air blowers. Grit chambers 1, 2, 4, and 5 were in service during the inspection, chamber 3 was empty. Recent upgrades to this area include replacement of the traveling filter screens in 2010.

The 2016 condition assessment of the grit tanks by V&A indicated that the concrete tanks are in good overall condition. Minor resurfacing and crack sealant were all that was noted, including under the walkways. The recommended timeframe for these actions are 2-5 years and more than 5 years respectively.

The key observations and findings from this area are as follows:

- The roof of the headworks building is from the original construction (1982). Cracks and spalling were observed on the ceiling of the main room, including around the skylights. Replacement of the roof is recommended in the next 3-5 years.
- Corrosion was observed on much of the metallic components in the grit chamber room, including the channel slide gate rails and air piping. Much of the metallic equipment in the room is in need of repair or replacement within the next 5-10 years. The following observations were made about specific items in this room.
  - A 2015 design report for the odor control units recommends replacing the air scrubber.
  - The Perforated Plate Filter Screen (barscreen) motors are extremely corroded.
  - Conduit seals are missing from conduits entering/exiting the area. There are non-explosion proof control panels inside the explosion-proof area. (All electrical panels located within the classified area containing arcing or sparking contacts should be explosion-proof rated, but the code does not require existing facilities to be upgraded to comply with current standards if they were in compliance with the standard at the time of construction.)

- Three air quality gas monitor instruments installed on the wall appear extremely old and recent calibration tags were not found.

- The headworks hydraulic unit is original to the facility, making the unit more than 30 years old. This unit controls the non-electric slide gates, grit hoppers, and other equipment in the headworks area. It was noted that a hydraulic line broke last year. The unit and lines are in need of replacement in the next 3-5 years, but alternatives to hydraulic actuation should be considered first. Replacing with another hydraulic unit may be cost prohibitive for the number of components it controls. Many of the new slide gates are controlled by electric actuators instead of the hydraulic unit.

- The floor in the ferric tank room is corroding in areas from chemical leaks. Coating or lining of the floor with a chemical resistant material is recommended in the next 10-15 years.

- Two channel air blowers and one grit blower are more than 30 years old and one other grit blower is more than 20 years old (photo included in Appendix C). At this age, the blowers are likely inefficient and may be able to be replaced with few blowers. The channel diffusers in tanks 1, 2, 4, and 5 are original. Replacement the four old blowers and the old diffusers is recommended in the next 5-10 years. According to staff, there is money in the FY18 CIP to replace the diffusers with new a generation of diffuser for this application.

- All but one of the grit classifiers are more than 20 years old (photo included in Appendix C). One classifier was replaced in 2008. Classifiers 4 and 5 share a single hopper. The older classifiers are corroded and leak during operation. The associated hoppers are corroded, with heavy corrosion and some leakage on the bottom sliders observed from the grit disposal area (photo included in Appendix C). Replacement of all grit classifiers and hoppers, except the newer one, is recommended within the next 5-10 years. Consider alternative technologies to the existing classifiers.

- The influent flow meters may be oversized for typical plant flows. The influent pipes are at least 45-inches in diameter to accommodate the extreme peak flow scenarios. However, the existing flow meters may not be as accurate under more average flow conditions. A flow of 3 mgd would produce a flow velocity of 0.42 feet per second in a 45-inch pipe and 0.29 feet per second in a 54-inch pipe. A minimum velocity of 1 foot per second is typically recommended for most flow meters. Finding a flow meter that can measure high and low flows may not be feasible in the current configuration. Alternative means of measuring the flows should be evaluated. According to staff, these meters are 30 years old and become less reliable at low flows.

5.2 Primary Clarifiers and Pumping (Area 05)

The observed areas include the seven primary clarifier tanks, including sluice gates and scum troughs, and the below grade gallery, including the primary sludge pumps and air handling units. Clarifiers 1 through 5 were in service at the time of the inspection, clarifiers 6 and 7 were empty. Recent upgrades to this area include the addition of clarifiers 6 and 7 and associated equipment (2007), replacement of many influent slides gates (2014), recoating of the concrete area around the gates (ongoing), and replacement of the metal flights and chains with plastic versions (2015).

The 2016 condition assessment of the primary clarifiers by V&A indicated that the concrete tanks are in good condition, but noted some repair needs: repair spalls and exposed rebar, epoxy injection of observed cracks, resurface the concrete on the lower portion of the tanks, recoat the concrete in the upper portion of the tanks, replace expansion joint sealant backing material.

The key observations and findings from this area are as follows:

- Clarifier tank structures:
  - Movement cracks were found in the blending channel for clarifiers 6 and 7 built during the 2010 WWIP project. Injection is recommended to repair these cracks.
  - Portions of the concrete facade on the exterior of Clarifier No. 1 has broken off near the stairs leading to the switchgear building (photo included in Appendix C). Repair of the facade is recommended in the next 5-10 years.
  - Evidence of cracks, weeping, and leaks in the exterior walls of the clarifiers were observed from galleries A, A extension, and B. Repair the leaks in the clarifier/gallery walls via injection within the next 5-10 years.
  - The influent channel was not observed during the visual assessment, but talks with staff suggest that the concrete has never been resurfaced. The concrete is probably in similar or worse condition than the grit chambers. It is recommended that the condition of this area be evaluated in the next 5 years.
  - V&A's report recommends repairing spalls with exposed rebar and repairing a diagonal crack on a column within the next 2 years. The report also recommends resurfacing the lower concrete and recoating the upper concrete in clarifiers 1-5 in 2-5 years. Our visual assessment would agree that a rehabilitation of the tank interiors is recommended within the next 3-5 years.
- Clarifier components:
  - The flights and chains were recently upgrade to plastic (mechanism was not replaced), but some of the other clarifier components are still metal, including the scum troughs and weir launders.

- According to the equipment data, the sludge collector drives and motors are original to the facility (1985). Visually, they appeared worn, but lacked any other issues. This is beyond the typical service life we expect for this equipment, but they don't appear to be in danger of failing. It may be worthwhile to replace them during the next rehabilitation or upgrade of the clarifiers.
  - The influent channel was not observed during the visual assessment, but discussions with staff suggest that the area is all original. Based on age, the channel air diffusers should be considered for replacement, especially if the channel air blowers are replaced (see notes from Headworks area).
  - Metal piping located in the clarifiers was observed to have coating failure and areas of corrosion (photo included in Appendix C). The V&A report states that the mechanical components are stainless steel or fiberglass, but a review of the drawings could not confirm the material of these pipes. Removal and replacement with Sch. 80 PVC piping is recommended within the next 3-5 years.

- Various equipment in this area does not meet current NFPA 820 Standards. These items met the standard at the time of installation, but the standard has since changed. No immediate action is needed, but these items should be considered during the next major rehabilitation or upgrade of the clarifier area.
  - Nameplates for sludge collector motors and scum collector motors for primary clarifiers 1 through 5 are illegible, but the motors do not appear to be explosion-proof. Motors should be explosion proof.
  - Conduit seals on conduits routed on primary clarifiers could not be found. Conduit seals should be provided.
  - Disconnect switches and hand switches for primary clarifiers 1 through 5 are not explosion-proof. Replace with rated equipment.

- The bases of most of the pumps in the gallery are corroded and in need of repair (photo included in Appendix C). In some cases, the corrosion was painted over instead of being removed and repaired prior to painting (photo included in Appendix C). Corrosion was noted on the bases of the ten pumps (P05.01, .02, .03, .04, .06, .07, .08, .09, .12, and .20). Repair or replacement of the corroded pump bases is recommended in the next 3-5 years. Cracks in the concrete pads should be repaired at the same time.

- Equipment nameplates were frequently observed to be painted over, making them illegible. Adding a precaution into the painting procedure to avoid the nameplate is recommended.

- A groove in the gallery floor for drainage is located in the landing area of the entry stairs on the north end of the gallery. For safety reasons, a covering or grating is recommended to prevent staff injury.

- According to staff, the grit piping is being worn out from the process fluid. The material of the piping is not known, but glass-lined piping is recommended for all grit lines. The timing of this activity could coincide with the replacement of the headworks grit classifiers.

- Air handlers units AH05.01 and AH04.01 located in at the north end of the gallery appear to be original. AH05.01 was noisy and rattled when operating. Both units should be further evaluated to determine if replacement is warranted.

5.3 Biotowers (Area 06)

The observed area includes the two biotowers, including their rotating mechanisms and top layer of media, the control room, and the below-grade pump room. Recent upgrades to this area include the replacement of the rotating mechanism and top two layers of media in Biotower No. 2 (2010) and rehabilitation of the biotower feed and scrubber pumps (2007/08).

The key observations and findings from this area are as follows:

- The rotating mechanism of Biotower No. 1 has multiple areas of corrosion and loss of galvanizing. The mechanism is original to the structure and the mechanism for the other biotower was replaced more than 5 years ago. Repair of the corroded areas may be possible for extending the life of the mechanism. However, based on age and appearance, replacement of the mechanism is recommended in the next 3-5 years.

- The top two layers of media in Biotower No. 2 were replaced in 2008. The media in Biotower No. 1 is original and has areas of deformation, likely due to its age or from being walked on. It is recommended that the media be replaced when the mechanism is replaced for Biotower No. 1. At the time of the project, it is recommended that compression testing be performed to evaluate the media's integrity and whether replacement of all the media is necessary, or whether only the top two layers need replacement.

- Control Room:
  - The electrical room roof was observed to be leaking. Replacement of the roof is recommended in the next 5-10 years.
  - Strong smell of chlorine was detected upon entering the control room. The origin of the smell was not discovered. Further investigation of the cause of the smell is recommended.
  - The air handling unit located in the control room is original to the facility (1985). The unit was running without noticeable noise or vibration, but performance and efficiency were not evaluated. Considering the age of the unit and the potential upgrades to the scrubber system, replacement is recommended within the next 10-15 years.

- Pump Room:
  - Staff noted that a spill of a chlorine solution occurred in this room from the odor scrubber unit. Many components on or near the floor have moderate or worse corrosion, including pump bases and pipe/duct supports. Corrosion was observed where the 36-inch diameter scrubber effluent pipes penetrate the floor. Additionally, the floor coating is flaking in some areas. Repair of all corrosion is recommended in the next 2 years.
  - The edge of the floor grating in the center of the room is corroded. For safety reasons, replacement of the grating with a non-corrosive material is recommended. The Agency already has plans to address this in FY18.
  - The odor control scrubber is original to the facility. A 2015 Brown and Caldwell design report recommends replacing the scrubber with two activated carbon units located adjacent to the building. Based on the age and appearance of the scrubber (the coating on the unit is flaking off in multiple areas), and considering the results of the design study, it is recommended to replace the unit within the next 10-15 years.

- The ground around and under the biotower building is eroding. This settlement could eventually impact the structure. This observation is discussed further in Section 5.13 (Additional Observations and Areas).

5.4 Aeration (Area 07)

The observed area includes the aeration tanks, sluice gates, blower building, blower units, and Gallery L. All four aeration tanks were in service during the inspection. Recent upgrades to this area include the replacement of two blower units with new Neuros blower units and rebuilds of two centrifugal blowers (2012) and replacement of various slide gates.

The key observations and findings from this area are as follows:

- The ceiling is leaking in Gallery L (below the effluent box). The leaks are located above the RAS piping. At the time of the inspection, the gallery walls were being painted and the piping was covered in plastic (photo included in Appendix C). Injection is recommended to repair these cracks and to stop the leaking within the next 5-10 years.
  - During a previous site visit, evidence of scale or minor corrosion was observed on the top of the pipes. The pipe was coated as part of Gallery L improvements. Should this eventually becomes a problem in the future, the incoming 20-inch line cannot be isolated from the RAS line running back to the bio-towers.

- Moderate corrosion is observed on the Tank No. 3 influent slide gate (photo included in Appendix C). Monitor corrosion on the rails and guides to make sure the gates operates. Replacement of the gate is not needed for the foreseeable future. Many of the cast iron gates have been replaced with stainless steel gates recently.

- Settling has occurred between the aeration and secondary clarifier areas. This settlement could eventually impact the process piping located between the process areas. This observation is discussed further in Section 5.13 (Additional Observations and Areas).

5.5 Secondary Clarifiers and Pumping (Area 08)

The observed area includes the four secondary clarifiers, control room, below-grade pump room, and Gallery E. All four secondary clarifiers were in service during the inspection. Recent upgrades to this area include replacement of effluent gates (2005), replacement of multiple pump motors and conversion of the WAS pump motors to VFDs (2013/15), and the replacement of the whole secondary drive unit of Clarifier No. 2 (2016).

The 2016 condition assessment of the secondary clarifiers by V&A indicated that rotating mechanism and catwalk has corrosion and coating failures and corrosion on approximately 10% of the superstructure, moderate to severe corrosion of the scum piping, and the concrete was found to be in good condition with no major defects. Application of touch-up coating, filler compounds, and weld repairs of metal components are recommended within 2 years.

The key observations and findings from this area are as follows:

- Clarifier Structures and Mechanisms:
  - Collector drives for three of the clarifiers are corroded and appear to be original. As noted in the V&A report, the mechanisms and components are in need of repairs within the next 2 years. The V&A findings rate these defects as Level 2 (not needing immediate action), however, actions are recommended by V&A to prevent further degradation. When action is taken to repair the mechanisms, rehabilitation (refurbish and recoat) of these drives is recommended.
  - Also noted in the V&A report, resurfacing of the concrete on the effluent trough wall and application of a coating is recommended beyond 5 years. This should be performed at the same time as the repairs or replacement of the mechanisms. Additionally, the catwalks should be torn down to girders, coated, and walkways replaced with FRP grating.
  - As noted in TM No 8 of this Facilities Master Plan, the replacement of all four mechanisms is recommended to optimize clarifier performance. This need may drive the timing of a project more than the condition of the equipment. Based solely on the condition of the assets, timing of the recommended actions would be 10-15 years. After the initial repairs, the mechanisms should be placed on a coating schedule to protect against corrosion.

- Control Room:
  - VFDs for the 6 RAS pumps (P08.01, 8.02, 8.03, 8.04, 8.05, and 8.06) are old Robicon models. Finding spare parts for these VFDs can be very difficult (now or in the near future). Replacement of these VFDs is recommended over the next 3-5 years, as budget permits.
  - Clarifier drive VFDs appear old, corroded, and worn out. Finding spare parts for these VFDs can be very difficult (now or in the near future). Replacement of these VFDs is recommended over the next 3-5 years, as budget permits.
- Pump Room and Gallery E:
  - A ceiling joint in Gallery E is leaking (see photos) and leaks were observed in the gallery walls. Repair of the leaks is recommended within the next 5-10 years.
  - Separation was noted in the expansion joint between the pump room wall and the clarifier at the sump. This may be the result of settlement of the ground in this area. Monitor this separation annually to see if it is expanding.
  - The original design and construction of the secondary clarifiers included RAS, WAS, and drain lines for each clarifier entering the pump room through a corner sump (photo included in Appendix C). Since these pipes are located in a sump, they are frequently exposed to water. Corrosion was observed on some of these pipes in the sump and at the wall penetration. No isolation valves were installed during construction and a break in any of these lines could flood the pump room and galleries. The pipe sections were replaced for clarifier no. 3 after the date of this inspection and a corrosion inspection was performed (by V&A) that verified the piping for the other clarifier sumps were in good condition.
  - The RAS, WAS, scum, and drain pumps were installed in 1985 or 1996/7, with the exception of WAS pump 1 (2007) and WAS pump 4 (2011). These pumps have been in service for 20 or 30 years. Many of the pumps have moderate corrosion and leak from the packing. No major operational issues were observed or noted from staff and performance data was analyzed. Considering the age and appearance of the older pump, replacement is recommended in 3-5 years. A process evaluation of these pumps is included in TM No. 8 of this Facilities Master Plan.

5.6 Chlorine Contact Tanks (Area 09)

The observed area includes the above-ground chlorine contact tanks and components. The gallery is included in the next section. Tanks 1 through 4 were in service during the inspection, tanks 5 and 6 were not in service. Recent upgrades to this area include addition of tanks 5 and 6 (2010), installed 84-inch and 72-inch sluice gate at the outfall (2010), and replacement of the 72-inch effluent gate (2011).

The 2016 condition assessment by V&A indicated that the concrete coating differed for the different tanks and at different heights, but the concrete was in generally good condition at and above the water line. However, the areas below the water line had slightly worse condition (VANDA Level 2 advancing to Level 3) and several indications of rebar corrosion. Off-gassing of sodium hypochlorite residual has worn away the coating and caused damage to the outer mortar layer of the concrete at and slightly above the waterline. Concrete testing found pH level ranged from 6 to 11, ranging from severe to mildly corrosive. Submerged metallic appurtenances, such as the sluice gate guide frame, had significantly corroded at areas of failed coating. V&A recommended recoating the upper portion of the tanks in the next 2-5 years and depending on the results of future concrete tests, recoat the lower portion. They also recommend repairing corroded rebar in the next 2 years with a corrosion inhibitor and sealing cracks in the walls and catwalk in 2-5 years. They also recommend repairing and recoating the steel frame of the corroded influent sluice gate within the next 2 years.

The key observations and findings from this area are as follows:

- Moderate corrosion was observed on the influent gates for tanks 1 through 4. Corrosion was observed inside the framing (photo included in Appendix C). Repair of the gates is recommended in the next 2 years. Consider using stainless steel if the gates are replaced.

- Moderate corrosion was observed on the recycled water screen unit. Operational issues were noted in a wet weather improvement project memo. Replacement of the unit is recommended within the next 3-5 years. The replacement should be a different style or technology to alleviate the operational issues. Options include a plate press filter, basket strainer, or a finer screen.

- Minor corrosion was observed on the telescoping valves of tanks 1 through 4. Repair of these valves is recommended in the next 3-5 years.

- Minor corrosion was observed on the effluent gates and other metal components of tanks 5 and 6. Considering the area was built in 2010, it appears the environment is corrosive, possibly due to a high chlorine residual.

- The influent gate of tank 5 had moderate corrosion on the guides and was not properly sealed when observed (photo included in Appendix C). This was assumed to have been a one-time issue based on feedback from Agency staff.

- Minor cracking was observed along the interior walls of the tanks, above the water line.

5.7 Chlorination and Dechlorination Building and Gallery (Area 10)

The observed area includes the chlorination/dechlorination building and Gallery C (adjacent to chlorine contact tank 4). Recent upgrades to this area include the rehabilitation of the chemical storage rooms (2015), replaced three plant water pumps (2013), and the replacement of the 3W tank with new hypo pneumatic bladder tanks (2013).

The key observations and findings from this area are as follows:

- Corrosion was observed on the 54-inch effluent pipe in Gallery C. Repair the corrosion in the next 2 years. Investigate the cause of the corrosion.
- Scum pump P10.1 and P10.2 have moderate corrosion on the pump and heavy corrosion on the bases. The pumps are from 1990 and 1996, respectively. A FY18 project is planned to replace scum pumps and troughs.
- The injection point for the sodium hypochlorite is located in an overhead pipe, connected with a pipe saddle (no injection quill), and with no static mixer downstream. Additionally, the injection point is about 5 feet upstream of a flow meter. Consider relocating the injections point and using an injection quill and installing a static mixer downstream of the injection point.
- Minor corrosion and scaling was observed on the carrier water pumps (P10.8 through P10.10). Asset data indicates these pumps were installed in 1996. Replacement of these pumps is recommended in 3-5 years.
- Coating loss was observed on the floor of the sodium bisulfite room under the elevated walkway. Flaking coating was also observed in multiple areas of the room. Recoating is planned to be addressed in-house this fiscal year when the SBS metering pumps are refurbished.
- Multiple small pumps in the gallery were observed to be from 1996 and in fair to poor condition. This includes the effluent sample pump (P10.11) and the two adjacent pumps for bioassay and Remillard Pond. These pumps should be planned for replacement in the next 3-5 years.
- A leak was observed at a pipe penetration into the chlorine contact tank.
- Moderate to severe corrosion was observed on the access hatches in the gallery floor. Replace the covers and hinges in 3-5 years.

5.8 Solids Handling Building (Area 12)

The observed area includes the rotary drum thickener area, engine and generator room, siloxane filter area, and the various floors of the solids handling building. Recent upgrades to this area include installation of the rotary drum thickeners (2015), upgrades to the polymer system (2016), and upgrades to the odor control system (2016).

The key observations and findings from this area are as follows:

- Rotary Drum Thickener Area:
  - Cracks and staining were observed in the secondary containment area for the ferric chloride tanks (photo included in Appendix C). Staff noted that a FY18 maintenance project will address this issue.
  - Staff noted that the reclaimed water flow is low in this area. They don't know what is causing the problem, but suspect that it could be the result of undersized pipes or too high of water velocity.

- Solids Handling Building:
  - The roof of the building was upgraded in 2007.
  - Roof hatches on the roof were observed to be corroded. Repair these hatches in the next 3-5 years.
  - Distribution panel DP 12.1 (near MCC 12.2) does not have arc flash label. Add arc flash label similar to other panels and MCCs.
  - Staff noted past issues with the building elevator. No issues were observed during the inspection. Based on the age of the facility, it would be estimated that replacement of the elevator would be needed in the next 5-10 years.

- Gas Compressor Room (ground floor):
  - The gas compressors are almost 15 years old. Based on the appearance of the equipment and input from staff, the units will need to be replaced in 10-15 years. According to staff, this should be considered for replacing as part of a larger project, such as a biofuel production skid.
  - The conduits in the gas compressor room did not appear to be sealed. This is recommended next time there is a project in this area.

- Boiler Room (ground floor):
  - Conduits entering/exiting this room do not have conduit seals. This is recommended next time there is a project in this area.
  - The two boilers appear to be original to the facility. Staff indicated that most of the heat is now supplied by the generator unit and the boilers are used as standby units.
  - The heat exchangers were replaced in 2016 and a new oil exchanger has been ordered.

  - The 2016 condition assessment by V&A included an assessment of hot water piping located throughout the plant. It found metal loss of the piping and recommended reevaluating the piping system in 5-10 years.

- Engine / Generator Room (ground floor):
  - The Cummins engine is more than 25 years old and is kept as a standby diesel generator. No issues were observed. The Cummins was last assessed in November 2013.

- Polymer Room (ground floor):
  - Polymer pump starter panels (480V, 3 phase, 1 HP) do not have arc flash labels. Add arc flash label similar to other panels and MCCs.

- Centrifuge Room and Sludge Hopper Area:
  - The centrifuges were observed to be in fair condition and were not operating during the inspection. A separate evaluation of the centrifuge units is covered under a separate master plan TM. Based on the visual condition assessment, no action is needed.
  - Each centrifuge is associated with one hopper and the units are unable to switch between hoppers. Minor corrosion was observed on components of the biosolids hoppers (photo included in Appendix C) and staff noted that this is partially caused by overflows of a single hopper when only one centrifuge is in service. It is recommended to evaluate alternatives such as moving the centrifuges to the third floor, installing an automated conveyance systems, or different truck loading options.

5.9 Digesters (Area 13)

The observed area includes the exterior of the digester tanks, the pump mixing room, the basement, the digester gas scrubbers, and the waste gas burners. Recent upgrades to this area include construction of the digester gas scrubber system located between the digesters (2010), replacement of the sludge conditioning pumps (2015), and the replacement of the heat exchangers (2016).

The 2016 condition assessment by V&A looked at the basement slab of the digester building. The assessment focused on an area that had been saw cut. The assessment found that leveling grout needed to be replaced in the next 2-5 years along with replacing the sealant and backer rod on the west expansion joint.

The key observations and findings from this area are as follows:

- Sludge Pumping Room (Basement Level):
  - Basement area has Class 1, Division 1 red boundary lines around digesters in accordance with NFPA 820 requirements. However, the motors, valve

actuators, disconnect switches, and other electrical components inside the classified boundary are not explosion proof rated. In addition, conduits entering/exiting the classified boundary do not have conduit seals. Electrical equipment within the classified area may be considered exempt or grandfathered since they may have been installed before NFPA 820 requirements became a standard in 1995. Before any project improvements take place in this area, these components should be reviewed to determine whether replacement is needed to meet NFPA requirements.

  – Delamination on the floor was observed during the inspection. Per the V&A study, this has been noted and is in need of repair within the next 3-5 years.
  – Corrosion was observed on the drain near the ferric pumps. Repair the corrosion damage of the drain.

- Mixing Pump Room (Main Level):
  – Significant vibration of the two digester mixing pumps was observed during the assessment. Staff noted that the vibration has caused hangers and supports to come loose and were replaced with more robust versions. The cause of the vibration could not be figured out from the visual assessment, but the issue is in need for further investigation. Within the next 2 years it is recommended to perform vibration testing on the pumps to first determine if the vibration is within the manufacturer's guidelines and to assess the impact of the vibration on the building. If the pump vibration cannot be reduced, structural modifications may be necessary to isolate the pump vibration from the building.
  – Additionally, it was noted that the discharge isolation valves on the mixing pumps need additional support to reduce any load being placed onto the pump. The pipe supports for the elevated discharge header do not appear to provide enough support of the valves and piping to eliminate the load placed on the pumps. It is unclear if this is contributing to the vibration, but it should also be analyzed in the assessment of the pump to determine if additional pipe supports on the header are necessary.
  – Cracks were observed in the walls of the digester, which are also the walls of the mixing room (photo included in Appendix C). A more detailed investigation of the cracks is recommended as part of the investigation of the mixing pumps. These cracks may be attributed to the pump vibration or not. The investigation should focus on what is necessary to repair the cracks.
  – Two 480V, 3 phase distribution panelboards (DP13.1 and 13.2) in the digester pump mixing room do not have arc flash labels. Provide arc flash labels for these panels similar to other panels and MCCs.
  – A makeshift piping system was installed to handle the bleed off from the pumps and convey it to the trench drain in the room. The makeshift system overflows and sludge had overflowed onto the floor (photo included in Appendix C). A

more permanent installation is recommended, preferably one connected to a drain pipe.

- Exterior Areas:
  - There are several motors and instruments installed within the classified boundary around the digesters (including the scrubber system) that are not explosion proof rated and do not have conduit seals. These items were most likely installed per the standards at the time and are not required to be upgraded to meet current standards. However, upgrading these items and conduit installation is recommended to meet current standards the next time this equipment is replaced.

5.10 Switchgear Facility (Area 14)

The observed area includes the switchgear building, including the internal and external electrical equipment. Recent upgrades to this area include the addition of a power monitoring unit on the main switchgear.

The key observations and findings from this area are as follows:

- The switchgear shows little visual sign of degradation due to aging. However, the inspection performed was limited to visual appearance of the exterior. The switchgear is serviced about every 2 years. It is recommended the switchgear be inspected by a representative from the manufacturer during the next scheduled service.

- The switchgear is approximately 30 years old. Like most electrical equipment of this age, the manufacturer has discontinued the model. While spare parts are still available, they come at a premium cost. At some point, the parts will be unavailable from the manufacturer and the Agency would have to turn to the secondary parts market. The Agency should begin to look at replacement of the switchgear. Based on the age of the units, it is estimated that the units will need to be replaced within 10-15 years.

- The roof of the building has not been upgraded since the original construction. The roof is recommended for replacement within the next 5-10 years.

- The building climate is controlled by a single ventilator in the roof and louvers in the building walls. Summer temperatures in the area can get high enough that there is potential for overheating of the equipment. It is recommended to monitor the temperature of the room during summer months to determine if an air conditioning unit is necessary to keep the equipment within the manufacturer's recommended operating range. If an air conditioning unit is installed, replace the windows to reduce losses through the single pane windows.

- The electrical equipment and bus duct located outside of the switchgear building was corroded and showed signs of wear. It wasn't immediately clear what equipment may belong to the Authority and what may belong to PG&E. Some of the equipment appears to be in need of replacement in the coming years. If this equipment belongs to PG&E, the Authority should contact them to assess the equipment.

5.11 Effluent Pump Station (Area 20)

The observed area includes the interior of the effluent pump station, including the pumps, engines, and other equipment inside the building. This facility was constructed as part of the wet weather improvements project (2010).

The key observations and findings from this area are as follows:

- The facility is only a few years old. No issues were observed during the inspection. The pump units are only run during conditions when effluent cannot flow by gravity through the outfall.

- Staff noted that the pumps components were rusting from sitting idle and being exposed to the high chlorine environment of the clearwell. The staff have implemented a program to exercise the pumps more frequently to prevent rust from causing the pumps to stick.

5.12 Organic Waste Recycling Facility (Area 21)

The observed area includes the below-grade pump vault and the equipment surrounding the vault. The facility was constructed as part of the Digester Improvements and FOG/Food to Energy Facility project (2010). Recent improvements include replacement of two mixing pumps within the last 6 months and recoating of the tank interior (2015).

The key observations and findings from this area are as follows:

- Corrosion was observed on the rails and bolts of the crane inside the vault. These components of the crane did not appear to be suited for outdoor installation. Repair jib crane corrosion.

- Lifting of equipment in and out of the vault requires the use of two cranes: one located on the vault floor and one outside the vault, at grade. The two crane system is cumbersome to use, according to staff. The pick points align in a very small area and both cranes rely on human power to rotate their booms. If possible, replace the existing crane system with a single crane.

- The food waste is delivered by a third party by the truckload. Pumps have been damaged by utensils and other metal objects that are contained in the food waste deliveries. CMSA should work with the food waste provider to ensure these items do not make it into the system. Additional screening systems can be provided at a high cost and probably isn't economical. Using hardened stainless steel pump internals and casings (such as one produced by Vaughn) may reduce the wear on the pumps. Alternatively, specialty food waste pumps are available from companies such as Doda, but come at a higher cost and lead time.

- A strong odor surrounds the facility. The odor differs from the typical wastewater process odors of the rest of the plant. The odor scrubber unit is not treating the air enough or the odors are escaping from the food waste tank. This could be an indication that the carbon media needs to be replaced or the result of an undersized suction fan, undersized scrubber vessel, or the incorrect odor removal technology. Staff is testing a hot water cleaning procedure to see if this is the result of aerosolized grease coating the carbon media. Since the odors are confined to the plant, no immediate action is necessary, but further investigation of the odors is recommended.

5.13 Additional Observations and Areas

The key observations and findings from areas outside the ones listed above are as follows:

- Evaluation of seismic impacts due to settlement. Subsidence of the ground was observed in multiple areas of the plant, including the bio-tower building and between the aeration and secondary clarifier areas. Because the plant was constructed on piles, the settlement has produced gaps under the bottom of buildings. There is potential that the loading and seismic calculations were dependent on the tops of the piles being at grade. If the tops of the piles are exposed, the piles may have lost some structural integrity and may not be seismically appropriate. Additionally, the settlement may have an effect on buried piping between the major processes. An assessment is recommended for the next 3-5 years to determine any structural or seismic issues related to the settlement.

- Cracks were observed on many of the gallery walls, floors, and ceilings. Leaking or weeping was observed from some of the cracks. The cracks are not structural issues at this point, but should still be fixed. Injection is recommended to repair these cracks in the next 3-5 years. It is recommended to hire a contractor to identify all areas for injection repairs and have them take care of the work over the period of a few days.

- The pipe hangers in many areas and galleries were observed to be long, slender overhead pipe braces. Areas include the boiler room, cogeneration room, and gallery C. Retrofit these hangers with newer hangers that are sized for seismic loads.

- Corrosion was observed on the top of fire water pipes in two separate areas of the galleries. The cause of the corrosion is from leaks in chemical lines located above the fire water pipes in the pipe banks that run along the gallery walls. If possible, the

Agency should consider reconfiguring the piping in the next 3-5 years so that chemicals are not located above other pipes.

6.0 PROJECT IDENTIFICATION

A total of 26 projects were identified for inclusion in the Master Plan based on the need to repair or replace items based on condition or age. The projects were identified for each of the twelve process areas assessed. Each project includes a basic description, estimated cost, projected timing, and the consequence of failure criteria and definition from Table 1.2. Detailed cost estimates are included in Appendix B. The timing and consequence of each project is included in section 7.0. Detailed findings and observations from the visual condition assessment are included in section 5.0.

6.1 Headworks (Area 04)

6.1.1 Hydraulic Unit Replacement (04-1)

- Project Description: Remove the hydraulic unit located in the headworks building and associated fluid lines. Convert all existing pneumatic units to electric operation and decommissioning hydraulic unit.
  - Project elements include:
    - Decommission and remove the existing hydraulic unit and components.
    - Convert approximately 20 hydraulically controlled gates with electric actuators for the headworks influent gates, grit tanks, primary clarifiers, and grit hoppers.
    - Addition of electrical components and wiring compatible with existing MCCs for power of the new actuators. No additional MCCs are anticipated.
- Project Timing: 3-5 years.
- Consequence of Failure: 4 - Operational Impacts (Major process disruption requiring use of effluent pond for less than 8 hours).
- Estimated Cost: $737,000.

6.1.2 Grit Classifiers and Hoppers Replacement (04-2)

- Project Description: Replace four of the five grit classifiers, associated grit pumps and grit piping, and repair or replace the associated grit hoppers. The fifth classifier was installed around 2008 and does not need replacement.
  - Project elements include:
    - Replace grit classifiers units 1 thru 4.
    - Replace associated grit pumps.

        - Remove and replace grit piping. Consider glass-lined pipe.
        - Replace associated grit hoppers (conversion of gates to electric actuator from hydraulic included in project 04-1).

- <u>Project Timing</u>: 3-5 years.

- <u>Consequence of Failure</u>: 2 - Regulatory & Environment Disruptions (Minor spill contained to plant site).

- <u>Estimated Cost</u>: $1,235,000.

6.1.3 <u>Grit Blower and Diffuser Replacements (04-3)</u>

- <u>Project Description</u>: Replace the original blowers and associated diffusers for the aerated grit tanks. The budget estimates replacing two blower units only because there is money in the FY18 CIP to replace the diffusers with new a generation of diffuser for this application.
    - Project elements include:
        - Replace Grit Blower Nos. 1 and 2.

- <u>Project Timing</u>: 3-5 years

- <u>Consequence of Failure</u>: 3 - Operational Impacts (Major process disruption requiring use of effluent pond for less than 4 hours)

- <u>Estimated Cost</u>: $508,000.

6.1.4 <u>Grit Room Rehabilitation (04-4)</u>

- <u>Project Description</u>: Rehabilitation of most metal components within the grit room, including repair corrosion on slide gates, and upgrade the air handling system with an activated carbon system per the recommendations in the 2015 Brown and Caldwell Odor Control study.
    - Project elements include:
        - Repair corrosion on slide gate rails and frame.
        - Replace the air handling units and scrubber with an activated carbon units per the recommendations in the 2015 Brown and Caldwell Odor Control study.

- <u>Project Timing</u>: 5-10 years

- <u>Consequence of Failure</u>: 3 - Operational Impacts (Major process disruption requiring use of effluent pond for less than 4 hours)

- <u>Estimated Cost</u>: $1,936,000.

6.1.5 Ferric Room Floor Coating (04-5)

- Project Description: Recoat the floor in the ferric room and repair cracked concrete.
  - Project elements include:
    - Repair cracked concrete.
    - Recoat approximately 1,500 square foot area.
- Project Timing: 10-15 years.
- Consequence of Failure: 2 - Financial Effects (Financial impact greater than $10,000).
- Estimated Cost: $110,000.

6.2 Primary Clarifiers and Pumping (Area 05)

6.2.1 Primary Clarifier Rehabilitation (05-1)

- Project Description: Recoat clarifier interior concrete, repair cracks in columns and under walkways, replace scum skimmer drives and motors, replace metal piping and appurtenances in Clarifier Nos. 1 thru No. 5, including weir launders.
  - Project elements include:
    - Take each clarifier out of service and clean.
    - Recoat clarifier interior concrete above and below water line.
    - Repair cracks in columns and under walkways as needed.
    - Replace scum skimmer drives and motors.
    - Replace mechanisms for flights and chains.
    - Remove and replace weir launders. Replace with FRP.
    - Replace metal piping and appurtenances. Use Sch. 80 PVC.
- Project Timing: 3-5 years.
- Consequence of Failure: 4 - Operational Impacts (Major process disruption requiring use of effluent pond for less than 8 hours).
- Estimated Cost: $1,739,000.

6.3 Biotowers (Area 06)

6.3.1 Biotower Pump Room Corrosion Repair (06-1)

- Project Description: Repair corrosion in biotower pump room. The floor coating and grating was damaged from a chlorine spill in this room. Recoat concrete floor, repair and recoat corroded pump bases and pipe supports.
  - Project elements include:

    - Strip, prep, and recoat approximately 1,900 square feet of concrete floor with vinyl ester coating system.
    - Repair corrosion on bases of all four pumps.
    - Repair corrosion and coat the bases of four or more pipe supports.

- Project Timing: 5-10 years.

- Consequence of Failure: 2 - Financial Effects (Financial impact greater than $10,000).

- Estimated Cost: $190,000.

6.3.2 Biotower No. 1 Upgrade (06-2)

- Project Description: Replace rotating mechanism and media of Biotower 1. (Budgetary number includes replacement of all media. Alternative option to replace only the top two layers of media upon detailed inspection of lower layers.):
  - Project elements include:
    - Remove existing hydraulic rotating mechanism.
    - Install new motor-operated mechanism. Assumes available bucket in MCC.
    - Remove and replace all media layers.

- Project Timing: 3-5 years.

- Consequence of Failure: 3 - Operational Impacts (Major process disruption requiring use of effluent pond for less than 4 hours).

- Estimated Cost: $1,996,000.

6.3.3 Biotower Scrubber and Air Handling Unit Replacement (06-3)

- Project Description: Replace the odor scrubber and air handling unit. Per detailed recommendations in 2015 Brown and Caldwell design report for plant odor control systems, recommended alternative is to replace existing scrubber with two activated carbon units located adjacent to the building.
  - Project elements include:
    - See 2015 Brown and Caldwell design report for specific project elements.
    - Replace Biotower Air Handler unit (AH06.01) located in control room.

- Project Timing: 10-15 years.

- Consequence of Failure: 3 - Safety and Community Disturbances (Short-term impacts (i.e. less than one week) on community or potential for injury).

- Estimated Cost: $2,200,000.

6.4 Aeration (Area 07)

No projects identified for this area.

6.5 Secondary Clarifiers and Pumping (Area 08)

6.5.1 Secondary Clarifier Rehabilitation (08-1)

- Project Description: Repair the corrosion on the drain, RAS, and WAS pipes entering the pump room through the corner sumps. Repair corrosion on the mechanisms and metal components inside the clarifiers, resurface the effluent trough concrete, and retrofit the catwalk with FRP. (Per detailed recommendations from 2016 condition assessment of the secondary clarifiers by V&A.):
  - Project elements include:
    - Take each clarifier out of service and clean.
    - Resurface concrete on effluent trough wall 2 feet under V-notch weirs and apply a coating.
    - Perform touch-up coating on the approx. 10% of surface area of clarifier mechanism and appurtenances including the cat-walk.
    - During clarifier mechanism touch-up coating, apply filler compound to fill in corrosion pits with less than 25% wall thickness loss as necessary.
    - During clarifier mechanism touch-up coating, perform weld repairs where wall thickness loss is greater than 25% as necessary.
    - Remove the top steel walkways, blast and coat walkway girders, and replace walking surface with FRP grating.
- Project Timing: 0-2 years.
- Consequence of Failure: 3 - Operational Impacts (Major process disruption requiring use of effluent pond for less than 4 hours)
- Estimated Cost: $944,000.

6.5.2 RAS/WAS Pump Replacements (08-2)

- Project Description: Replace RAS and WAS pumps and VFDs for the RAS pumps.
  - Project elements include:
    - Replace RAS pumps 1 thru 6 (P08.01 thru P08.06).
    - Replace VFDs for all six RAS pumps.
    - Replace WAS pumps 2 and 3 (P08.08 and P08.09).
    - Replace and reconfigure inlet and outlet piping as needed.
- Project Timing: 3-5 years

- Consequence of Failure: 3 - Operational Impacts (Major process disruption requiring use of effluent pond for less than 4 hours).

- Estimated Cost: $1,883,000.

6.6 Chlorine Contact Tanks (Area 09)

6.6.1 CCT Gate Replacement (09-1)

- Project Description: Replace the influent gates of tanks No. 1 thru 4 with stainless steel gates.
  - Project elements include:
    - Replace three 42-inch by 42-inch inlet gates to CCTs (SG09.01, SG09.02, SG09.03).

- Project Timing: 3-5 years.

- Consequence of Failure: 2 - Operational Impacts (Minor process disruption, requires operational changes).

- Estimated Cost: $401,000.

6.6.2 CCT Valve Rehabilitation (09-2)

- Project Description: Refurbish the telescoping valves on chlorine contact tanks 1 to 4. Replace recycled water (3W) bar screen (consider replacing with better technology with finer screens). Alternative option is to replace telescoping valves with rotating pipe skimmers with motorized actuators.
  - Project elements include:
    - Refurbish four (4) telescoping valves.
    - Replace recycled water (3W) bar screen.

- Project Timing: 5-10 years.

- Consequence of Failure: 2 - Operational Impacts (Minor process disruption, requires operational changes).

- Estimated Cost: $324,000.

6.7 Chlorination and Dechlorination Building and Gallery (Area 10)

6.7.1 CCT Effluent Pipe Corrosion Repair (10-1)

- Project Description: Repair corrosion on the 54-inch effluent pipe in Gallery L. Repair the leaks in the concrete overhead.
  - Project elements include:

    - Install temporary bypass of 54-inch effluent pipe.
    - Repair corrosion on the 54-inch effluent pipe.
    - Repair the leaks in the concrete overhead.

- Project Timing: 0-2 years.

- Consequence of Failure: 4 - Operational Impacts (Major process disruption requiring use of effluent pond for less than 8 hours).

- Estimated Cost: $753,000.

6.7.2 Gallery C Pump Replacements (10-2)

- Project Description: Replace carrier water pumps.
  - Project elements include:
    - Replace three (3) carrier water pumps (P10.08 thru P10.10).

- Project Timing: 3-5 years.

- Consequence of Failure: 3 - Operational Impacts (Major process disruption requiring use of effluent pond for less than 4 hours).

- Estimated Cost: $108,000.

6.8 Solids Handling Building (Area 12)

6.8.1 Solids Handling Building Elevator Replacement (12-5)

- Project Description: Replace the elevator of the solids handling building.
  - Project elements include:
    - Remove existing elevator and associated equipment.
    - Install new elevator and associated equipment in same location.

- Project Timing: 5-10 years.

- Consequence of Failure: 2 - Safety & Community Disturbance (Minor community disturbance remedied quickly).

- Estimated Cost: $513,000.

6.9 Digesters (Area 13)

6.9.1 Digester Mixing Pump Study (13-1)

- Project Description: Conduct a study to investigate the cause of the pump vibration, possible remedies, its relationship to the cracks on the wall of the pump mix room, and the need for additional supports for the discharge header.

- Project elements include:
  - Conduct a study to determine the cause of the vibration and potential remedies.

- Project Timing: 0-2 years.

- Consequence of Failure: 3 - Operational Impacts (Major process disruption requiring use of effluent pond for less than 4 hours).

- Estimated Cost: $100,000.

6.9.2 Digester Basement Floor Slab Repair (13-2)

- Project Description: Repair the saw cut area in the digester basement. (Per detailed recommendations from 2016 condition assessment of the secondary clarifiers by V&A.).
  - Project elements include:
    - Remove and replace existing leveling grout within saw-cut area. Abrasive blast floor and install anti-skid epoxy flooring system if flooding occurs.
    - Replace sealant and backer rod on expansion on west side of basement slab.

- Project Timing: 3-5 years

- Consequence of Failure: 1 - No impacts.

- Estimated Cost: $119,000.

6.10 Switchgear Facility (Area 14)

6.10.1 Main Switchgear Replacement (14-1)

- Project Description: Replace the main switchgear in the existing building. Based on our experience, the 30-year old main switchgear will need to be replaced by the time it is 45 years old.
  - Project elements include:
    - Remove existing switchgear and associated electrical items.
    - Install new switchgear in existing building.
    - Install new HVAC unit on existing building based on needs of new switchgear.

- Project Timing: 10-15 years.

- Consequence of Failure: 5 - Operational Impacts (Major process disruption resulting in plant shutdown or significant downtime of major equipment that could result in discharge of untreated wastewater)

- Estimated Cost: $1,017,000.

6.11 Effluent Pump Station (Area 20)

No projects identified for this area.

6.12 Organic Waste Recycling Facility (Area 21)

6.12.1 OWRF Pump Replacement (21-1)

- Project Description: Replace the two OWRF Mix Pumps with pump more suited for this type of process. Replace the pumps with hardened stainless steel pump internals and casings.
  - Project elements include:
    - Replace two (2) OWRF Mix Pumps (P21.01 and P21.02). Consider hardened stainless steel internals and casings for new pumps.
- Project Timing: 3-5 years
- Consequence of Failure: 2 - Operational Impacts (Minor process disruption, requires operational changes)
- Estimated Cost: $89,000.

6.13 Multi-Area Projects

6.13.1 Roof Repairs (00-1)

- Project Description: Repair the roofs for the following areas: headworks, bio-tower control room, and switchgear facility.
  - Project elements include:
    - Find and fix leak in biotower control building roof. Replace membrane and media.
    - Repair cracks in headworks grit room roof. Replace membrane and media.
    - Replace membrane and media on switchgear facility roof.
- Project Timing: 3-5 years
- Consequence of Failure: 3 - Financial Effects (Financial impact greater than $100,000)
- Estimated Cost: $64,000.

6.13.2 Gallery Pipe Repairs (00-2)

- Project Description: Replace leaking chemical lines located along the gallery walls with double contained PVC pipe. If necessary, reconfigure the piping to relocate chemical lines to the bottom row.
  - Project elements include:
    - Replace leaking chemical lines.
    - Repair pipes where chemical lines have dripped.
    - Relocate chemical lines to bottom of pipe rack, where possible.
- Project Timing: 3-5 years
- Consequence of Failure: 2 - Regulatory and Environmental Disruptions (Minor spill contained to plant site)
- Estimated Cost: $110,000.

6.13.3 Crack and Leak Repairs (00-4)

- Project Description: Repair cracks in concrete walls, floors, and ceilings using injection in the following areas: Galley E ceiling, Gallery L ceiling above RAS piping, multiple locations along Gallery B walls, primary clarifier wall in Gallery A.
  - Project elements include:
    - Injection crack repair for the listed locations.
    - Assumes 10' x 5' work area required in each location.
- Project Timing: 5-10 years
- Consequence of Failure: 3 - Regulatory and Environmental Disruptions (Major spill contained on plant site)
- Estimated Cost: $132,000.

6.14 Studies and Other Enhancements

6.14.1 Site Seismic Study (99-1)

- Project Description: Conduct a study to evaluate seismic impacts due to site settlement. Subsidence of the ground was observed in multiple areas of the plant, including the bio-tower building and between the aeration and secondary clarifier areas. Because the plant was constructed on piles, the settlement has produced gaps under the bottom of buildings. There is potential that the seismic design was dependent on the tops of the piles being at grade and fully supported. With the tops of the piles exposed, the unsupported pile length may be over stressed during an earthquake resulting in pile failure. The settlement may have affected buried piping between the major processes. An assessment is recommended to evaluate the risk posed by structural changes resulting from settlement.

  – Project elements include:
    ▪ Conduct a seismic study.

- Project Timing: 3-5 years

- Consequence of Failure: 3 - Financial Effect (Financial impact greater than $100,000)

- Estimated Cost: $200,000.

6.14.2 OWRF Crane Optimization Evaluation (99-3)

- Project Description: Evaluate alternatives for replacing the existing two-crane system in the Organic Waste Recycling Facility area with a single crane system. This system may be best implemented during a future expansion of the facility.

- Project Timing: 10-15 years

- Consequence of Failure: 2 - Operational Impacts (Minor process disruption, requires operational changes)

- Estimated Cost: $0 (to be incorporated into the cost of future facility expansion).

6.14.3 Influent Flow Meter Alternatives Study (99-4)

- Project Description: The influent flow meters may be oversized for typical plant flows. Evaluate potential alternatives or options that can improve accuracy at low flows. Efforts should be coordinated with the Effluent Flow Meter Study.

- Project Timing: 0-2 years

- Consequence of Failure: 3 - Financial Effects, Financial impact greater than $100,000.

- Estimated Cost: $75,000.

7.0 RISK ASSESSMENT

The risk analysis is performed at the project-level in order to compare the potential impact that each project would have on the WWTP. The risk assessment was performed using the methodology explained in section 4 and using the definitions in Tables 1.3 and 1.2 for probability (PoF) and consequence of failure (CoF), respectively. The detailed consequence of failure scoring for each project is included in Appendix D.

Table 1.4 lists the projects based on the risk score, from highest to lowest. The risk score is not a direct indicator of the order projects need to occur, but rather to assist in the prioritizing of potential projects that cover different areas of the WWTP.

Table 1.4 Risk Assessment Summary
2017 Facilities Master Plan
Central Marin Sanitation Agency

No.	Project Number and Title	Timing (POF)	COF	Risk Score
1	CCT Effluent Pipe Corrosion Repair (10-1)	0-2 years (5)	4	20
2	Hydraulic Unit Replacement (04-1)	3-5 years (4)	4	16
3	Primary Clarifier Rehabilitation (05-1)	3-5 years (4)	4	16
4	Secondary Clarifier Rehabilitation (08-1)	0-2 years (5)	3	15
5	Digester Mixing Pump Study (13-1)	0-2 years (5)	3	15
6	Influent Flow Meter Alternatives Study (99-4)	0-2 years (5)	3	15
7	Grit Blower and Diffuser Replacements (04-3)	3-5 years (4)	3	12
8	Biotower No. 1 Upgrade (06-2)	3-5 years (4)	3	12
9	RAS/WAS Pump Replacements (08-2)	3-5 years (4)	3	12
10	Gallery C Pump Replacements (10-2)	3-5 years (4)	3	12
11	Roof Repairs (00-1)	3-5 years (4)	3	12
12	Seismic Study (99-1)	3-5 years (4)	3	12
13	Main Switchgear Replacement (14-1)	10-15 years (2)	5	10
14	Grit Room Rehabilitation (04-4)	5-10 years (3)	3	9
15	Crack and Leak Repairs (00-4)	5-10 years (3)	3	9
16	Grit Classifiers and Hoppers Replacement (04-2)	3-5 years (4)	2	8
17	CCT Gate Replacement (09-1)	3-5 years (4)	2	8
18	OWRF Pump Replacement (21-1)	3-5 years (4)	2	8
19	Gallery Pipe Reconfiguration (00-2)	3-5 years (4)	2	8
20	Biotower Pump Room Corrosion Repair (06-1)	5-10 years (3)	2	6
21	Biotower Scrubber and Air Handling Unit Replacement (06-3)	10-15 years (2)	3	6
22	CCT Valve Rehabilitation (09-2)	5-10 years (3)	2	6
23	Solids Handling Building Elevator Replacement (12-5)	5-10 years (3)	2	6
24	Ferric Room Floor Coating (04-5)	10-15 years (2)	2	4
25	Digester Basement Floor Slab Repair (13-2)	3-5 years (4)	1	4
26	OWRF Crane Optimization Evaluation (99-3)	10-15 years (2)	2	4

Notes:
(1) POF = Probability of Failure. Definitions of scores are included in Table 1.3.
(2) COF = Consequence of Failure. Definitions of scores are included in Table 1.2.

8.0 PRIORITIZED 10-YEAR CIP

Table 1.5 summarizes the recommended capital projects in a prioritized 10-year CIP. The projects are organized based on the recommended timing. Within each timing group, projects are prioritized based on their risk score and cost. It is important to note that the risk score is intended to differentiate the need for projects using a defined scoring system, however, professional judgment still needs to be applied to make sure that the results make practical sense within the scope of the Agency's prioritized 10-year CIP. In total, $14.2 million over 22 projects is recommended over the next 10 years.

To aid in the implementation of the 10-year CIP, the Agency has prepared an action plan to track and complete selected capital projects. This action plan is included in Appendix E for reference.

Table 1.5 Prioritized 10-Year CIP
2017 Facilities Master Plan
Central Marin Sanitation Agency

CIP Years	Project Number and Title	Risk Rank	Cost
1-2	CCT Effluent Pipe Corrosion Repair (10-1)	1	$753,000
1-2	Secondary Clarifier Rehabilitation (08-1)	4	$944,000
1-2	Digester Mixing Pump Study (13-1)	4	$100,000
1-2	Influent Flow Meter Alternatives Study (99-4)	4	$75,000
1-2	Primary Clarifier Rehabilitation (05-1)	2	$1,739,000
1-2	Hydraulic Unit Replacement (04-1)	2	$737,000
Years 1-2	**Subtotal (6 projects)**		**$4,348,000**
3-5	RAS/WAS Pump Replacements (08-2)	7	$1,883,000
3-5	Biotower No. 1 Upgrade (06-2)	7	$1,996,000
3-5	Grit Blower and Diffuser Replacements (04-3)	7	$508,000
3-5	Gallery C Pump Replacements (10-2)	7	$108,000
3-5	Seismic Study (99-1)	7	$200,000
3-5	Roof Repairs (00-1)	7	$64,000
Years 3-5	**Subtotal (6 projects)**		**$4,759,000**
6-10	Grit Classifiers and Hoppers Replacement (04-2)	16	$1,235,000
6-10	CCT Gate Replacement (09-1)	16	$401,000
6-10	Gallery Pipe Reconfiguration (00-2)	16	$110,000
6-10	OWRF Pump Replacement (21-1)	16	$89,000
6-10	Digester Basement Floor Slab Repair (13-2)	24	$119,000
6-10	Grit Room Rehabilitation (04-4)	14	$1,936,000
6-10	Crack and Leak Repairs (00-4)	14	$132,000
6-10	CCT Valve Rehabilitation (09-2)	20	$324,000
6-10	Solids Handling Building Elevator Replacement (12-5)	20	$513,000
6-10	Biotower Pump Room Corrosion Repair (06-1)	20	$190,000
Years 6-10	**Subtotal (10 projects)**		**$5,049,000**
10+	Main Switchgear Replacement (14-1)	13	$1,017,000
10+	Biotower Scrubber and Air Handling Unit Replacement (06-3)	20	$2,200,000
10+	Ferric Room Floor Coating (04-5)	24	$110,000
10+	OWRF Crane Optimization Evaluation (99-3)	24	$0
Beyond 10 Years	**Subtotal (4 projects)**		**$3,327,000**

Notes:
(1) Projects with $0 cost would be included as part of a larger project.

APPENDIX A – AREA INVENTORIES

Inventories were prepared for the following areas.

- 04 Headworks, Influent Box, Screening, and Grit
- 05 Primary Clarifiers and Pumping Gallery
- 06 Bio-towers and Pumping Building
- 07 Aeration Tanks and Blower Building
- 08 Secondary Clarifiers and Pumping Gallery
- 09 Chlorine Contact Tanks
- 10 Chlorination and Dechlorination Building and Gallery
- 12 Solids Handling Building and Generator Room
- 13 Digester Area
- 14 Switchgear Building
- 20 Effluent Pump Station
- 21 FOG / Food to Energy Area

Process/Area	Headworks (Area 04)	
Major Assets / Systems	**Install**	**Attributes**
Influent		
Influent Box Structure	1/1/1982	
Pressure manhole lids (Ross Valley / San Rafel)	1/1/1982	
SGH04.01 RV FM Influent Gate (Hydraulic)	2/1/2010	Hydraulic Sluice Gate -
SGH04.02 SR FM Influent Gate (Hydraulic)	1/1/2010	Hydraulic Sluice Gate -
FIT4.01 San Rafael Flow	2/11/1985	Flowmeter - Manning
FIT4.02 Ross Valley Flow	2/11/1985	Flowmeter - Manning
FIT4.03 San Rafael Flow ISCO	8/23/2010	Flowmeter - ISCO
FIT4.04 Ross Valley Flow ISCO	8/23/2010	Flowmeter - ISCO
Grit Tanks and Screening		
Headworks buildling		
BS04.01 INFLUENT BARSCREEN #1	2/1/2010	Bar Screen - Waste Tech
BS04.02 INFLUENT BARSCREEN #2	2/1/2010	Bar Screen - Waste Tech
TA04.01 Grit Tank #1		Concrete Tank -
TA04.02 Grit Tank #2		Concrete Tank -
TA04.03 Grit Tank #3		Concrete Tank -
TA04.04 Grit Tank #4		Concrete Tank -
TA04.05 Grit Tank #5		Concrete Tank -
SGH04.03 Grit Tank #1 Influent Gate (Hydraul	1/1/2010	Hydraulic Sluice Gate -
SGH04.04 Grit Tank #2 Influent Gate (Hydrau	1/1/2010	Hydraulic Sluice Gate -
SGH04.05 Grit Tank #3 Influent Gate (Hydraul	4/1/2010	Hydraulic Sluice Gate - 60"x60" - Rodney Hunt Co.
SGH04.06 Grit Tank #4 Influent Gate (Hydraul	1/1/2010	Hydraulic Sluice Gate -
SGH04.07 Grit Tank #5 Influent Gate (Hydraul	1/1/2010	Hydraulic Sluice Gate -
Grit Tank #1 Channel Diffusers		
Grit Tank #2 Channel Diffusers		
Grit Tank #3 Channel Diffusers		
Grit Tank #4 Channel Diffusers		
Grit Tank #5 Channel Diffusers		
Blower Room		
AH04.01 Ferric Storage Room Air Handler	1/1/1996	Air Handling Unit - 200 PSI / .75HP Motor - Trane
B04.01 Channel Air Blower #1	1/15/1985	Air Blower - Roots
B04.02 Channel Air Blower #2	1/15/1985	Air Blower - Roots
B04.03 Channel Air Blower #3	8/15/2008	Air Blower - 6" - Roots
B04.04 Channel Air Blower #4	4/19/2007	Air Blower - 4653SM - Roots
B04.05 Grit Air Blower #1	1/15/1985	Air Blower - 6" - Roots
B04.06 Grit Air Blower #2	1/15/1995	Air Blower - 6" - Roots
B04.07 Grit Air Blower #3 (WWIP)	4/23/2008	Air Blower - 6" - Roots
Air Scrubber		
OS04.01 HW'sODOR SCRUBBER		ODOR SCRUBBER - no info found
FA04.04 HW's Odor Scrubber Fan		Fan - NO INFO FOUND
P04.15 HW's Scrubber Pump #1	4/1/2009	Pump - 3HP - Penguin
P04.16 HW's Scrubber Pump #2	4/1/2009	Pump - 3hp - Penguin
MP04.15L Motor, Left	1/1/1985	Motor, Pump - 3hp - Penguin
MP04.15R Motor, Right	1/1/1985	Motor, Pump - 3HP - Penguin
MP04.16L Motor, Left	1/1/1985	Motor, Pump - 3HP - Penguin

Process/Area | Headworks (Area 04)

Major Assets / Systems	Install	Attributes
MP04.16R Motor, Right	1/1/1985	Motor, Pump - 3hp - Penguin
FIT04.01 HW's Scrubber 1st Stage Flowmeter	2/11/1985	Flowmeter -
FIT04.02 HW's Scrubber 3 Flowmeter	2/11/1985	Flowmeter -
FIT04.03 HW's Scrubber 2nd Stage Flowmeter	2/11/1985	Flowmeter -
FIT04.06 Ferric Chemical Pump #1		Flowmeter - 0.25 / -0.83 offset - Sparling/Tigermag
FIT04.07 Ferric Chemical Pump #2		Flowmeter - 0.25 / -1.38 offset - Sparling/Tigermag
Grit Room		
P04.01 Grit Pump #1	2/1/2006	Pump - 4 x4 200gpm @ 51tdh - Clow-Yeoman
P04.02 Grit Pump #2	7/1/2014	Pump - 4 x4 200gpm @ 51tdh - Clow-Yeoman
P04.03 Grit Pump #3	2/1/2010	Pump - 4x4 200gpm - Morris
P04.04 Grit Pump #4	2/1/2003	Pump - 4 x4 200gpm @ 51tdh - Clow-Yeomans
P04.05 Grit Pump #5	7/1/2014	Pump - 4 x 4 200gpm - Clow-Yeomans
Washer/compactors #1	1/0/1900	
Washer/compactors #2	1/0/1900	
GC04.01 Grit Classifier #1	2/1/1996	Grit Classifier - 12" - WEMCO
GC04.02 Grit Classifier #2	2/1/1995	Grit Classifier - Krebs
GC04.03 Grit Classifier #3	2/1/1994	Grit Classifier - Krebs
GC04.04 Grit Classifier #4	2/1/1993	Grit Classifier - Krebs
GC04.05 Grit Classifier #5	4/23/2008	Grit Classifier - Wemco
HOP04.01 Grit Hopper #1	4/1/1995	Hopper, Grit / Sludge - no info
HOP04.02 Grit Hopper #2	4/1/1995	Hopper, Grit / Sludge - no info
HOP04.03 Grit Hopper #3	4/1/1995	Hopper, Grit / Sludge - no info
HP04.01 HWs Hydraulic Pump #1	2/1/2008	Grit Hopper, Hydraulic Pumps, Hopper Gate - 5 GPM - Parker
HP04.02 HWs Hydraulic Pump #2	2/1/2008	Grit Hopper, Hydraulic Pumps, Hopper Gate - 5 GPM - Parker
HP04.04 Grit Hopper #4	2/28/1985	Grit Hopper, Hydraulic Pumps, Hopper Gate - no info
Electrical Room		
MCC 04.01	1/1/1984	MCC -
MCC 04.02	1/1/1984	MCC -
XF04.01 Headworks Transformer 1	6/2/2015	Transformer - 30KVA - Eaton
XF04.02 Headworks Transformer 2	9/1/2010	Transformer - 30KVA - MGM
XF04.02 Headworks Transformer 2	9/1/2010	Transformer - 30KVA - MGM
VFD04.06 Variable Frequency Drive		VFD - 2.9A - Teco
VFD04.07 Variable Frequency Drive		VFD - 2.9A - Teco
Chemical Systems (exterior)		
Containment area	1/0/1900	
P04.17 Peroxide Metering Pump #1	4/1/1996	Pump - Milton Roy
P04.18 Peroxide Metering Pump #2	4/1/1997	Pump - Milton Roy
P04.19 Peroxide Metering Pump #3	4/1/1996	Pump - Milton Roy
TA04.06 HW's Ferric Storage Tank #1	2/28/1985	Concrete Tank - 13900 gallon - Ace Buehler
TA04.07 HW's Ferric Storage Tank #2	2/28/1985	Concrete Tank - 13900 gallon - Ace Buehler
P04.06 HWs Ferric Pump #1	3/5/2013	Pump - Tuthill
P04.07 HWs Ferric Pump #2	1/1/1995	Pump - Tuthill

Missing Assets

Process/Area	Primary Clarifiers (Area 05)	
Major Assets / Systems	**Install**	**Attributes**
General		
Bypass Channel		
Clarifier Influent and Isolation Gates		
SG05.01 South Channel Isolation Gate (Manual)	1/1/2008	Sluice Gate -
SG05.02 North Channel Isolation Gate (Manual)	1/1/2008	Sluice Gate -
SG05.03A Mid Channel Isolation Gate (Manual)	1/1/2008	Sluice Gate -
SG05.03B Mid Channel Isolation Gate (Manual)	1/1/2008	Sluice Gate -
SG05.04A Channel 1 and 2 Influent Isolation Ga	5/17/2016	Sluice Gate - 30 x 42 - Waterman
SG05.04B Channel 1 and 2 Influent Isolation Ga	5/17/2016	Sluice Gate - 30 x 42 - Waterman
SG05.05A Channel 2 and 3 Influent Isolation Ga	5/17/2016	Sluice Gate - 30 x 42 - Waterman
SG05.05B Channel 2 and 3 Influent Isolation G	5/17/2016	Sluice Gate - 30 x 42 - Waterman
SG05.06A Channel 3 and 4 Influent Isolation Ga	5/17/2016	Sluice Gate - 30 X 42 - Waterman
SG05.06B Channel 3 and 4 Influent Isolation Ga	5/17/2016	Sluice Gate - 30 x 42 - Waterman
SG05.07A Channel 4 and 5 Influent Isolation Ga	7/17/2014	Sluice Gate - Waterman
SG05.07B Channel 4 and 5 Influent Isolation Ga	7/17/2014	Sluice Gate - 30 x 42 - Waterman
CG05.08 Channel Gate (Manual)	4/1/2010	Channel Gate (Manual) - 74"x38" - Rodney Hunt
CG05.09 Channel Gate (Manual)	4/1/2010	Channel Gate (Manual) - 63.5"x38" - Rodney Hunt
Primary #1		
TA05.01 Primary Clarifier #1	1/15/1985	Concrete Tank -
SGH05.01 Primary Influent Gate #1A (Hydrauli	1/1/2008	Hydraulic Sluice Gate -
SGH05.02 Primary Influent Gate #1B (Hydrauli	1/1/2008	Hydraulic Sluice Gate -
C05.01 Primary Sludge Collector #1	1/1/1985	Sludge Collector Drive - FMC Corporation Motor: 1 HP/1150 RPM - Inst. 1985
MC05.01 Motor	1/15/1985	Motor, Collector - 1 HP/1150 RPM - Reliance Electric
C05.11 Primary Scum Collector #1	6/2/2008	Sludge Collector Drive - FMC Corporation
MC05.11	10/21/2008	Motor, Collector - 1HP/1750 RPM - Emerson
Plastic Flights and Chains, Clarifier 1	1/1/2015	
Primary #2		
TA05.02 Primary Clarifier #2	1/15/1985	Concrete Tank -
SGH05.03 Primary Influent Gate #2A (Hydrauli	1/1/2008	Hydraulic Sluice Gate -
SGH05.04 Primary Influent Gate #2B (Hydrauli	1/1/2008	Hydraulic Sluice Gate -
C05.12 Primary Scum Collector #2	6/2/2008	Sludge Collector Drive - FMC Corporation Motor: ***Tag Unreadable*** - Inst. 2008
C05.02 Primary Sludge Collector #2	1/1/1985	Sludge Collector Drive - FMC Corporation Motor: 1HP/1150 RPM - Inst. 1985
MC05.02 Motor	1/15/1985	Motor, Collector - 1HP/1150 RPM - Reliance Electric
MC05.12	10/21/2008	Motor, Collector - ***Tag Unreadable*** - Reliance Electric
Plastic Flights and Chains, Clarifier 2	1/0/1900	
Primary #3		
TA05.03 Primary Clarifier #3	1/15/1985	Concrete Tank -
C05.03 Primary Sludge Collector #3	1/1/1985	Sludge Collector Drive - FMC Corporation Motor: 1HP/1150RPM - Inst. 1985
SGH05.05 Primary Influent Gate #3A (Hydrauli	1/1/2008	Hydraulic Sluice Gate -
SGH05.06 Primary Influent Gate #3B (Hydrauli	1/1/2008	Hydraulic Sluice Gate -
C05.13 Primary Scum Collector #3	6/2/2008	Sludge Collector Drive - FMC Corporation Motor: ***Tag Unreadable*** - Inst. 2008
MC05.03 Motor	1/15/1985	Motor, Collector - 1HP/1150RPM - Reliance Electric
MC05.13	10/21/2008	Motor, Collector - ***Tag Unreadable*** - Reliance Electric
Plastic Flights and Chains, Clarifier 3	1/1/2015	

Process/Area	Primary Clarifiers (Area 05)		
Major Assets / Systems	**Install**	**Attributes**	
Primary #4			
TA05.04 Primary Clarifier #4	1/15/1985	Concrete Tank -	
C05.04 Primary Sludge Collector #4	1/1/1985	Sludge Collector Drive -	Motor: - Inst. 1985
SGH05.07 Primary Influent Gate #4A (Hydrauli	1/1/2008	Hydraulic Sluice Gate -	
SGH05.08 Primary Influent Gate #4B (Hydrauli	1/1/2008	Hydraulic Sluice Gate -	
C05.14 Primary Scum Collector #4	1/1/2008	Sludge Collector Drive - FMC Corporation	Motor: ***Tag Unreadable*** - Inst. 2008
MC05.04 Motor	1/15/1985	Motor, Collector - *Plate Unreadable*	
MC05.14 Motor	10/21/2008	Motor, Collector - ***Tag Unreadable*** - Reliance Electric	
Plastic Flights and Chains, Clarifier 4	1/1/2015		
Primary #5			
TA05.05 Primary Clarifier #5	1/15/1985	Concrete Tank -	
C05.05 Primary Sludge Collector #5	1/1/1985	Sludge Collector Drive - FMC Corporation	Motor: 1 HP/1150 RPM - Inst. 1985
SGH05.09 Primary Influent Gate #5A (Hydrauli	1/1/2008	Hydraulic Sluice Gate -	
SGH05.10 Primary Influent Gate #5B (Hydrauli	1/1/2008	Hydraulic Sluice Gate -	
C05.15 Primary Scum Collector #5	1/1/2008	Sludge Collector Drive - FMC Corporation	
MC05.05 Motor	1/15/1985	Motor, Collector - 1 HP/1150 RPM - Reliance Electric	
MC05.15 Motor	10/21/2008	Motor, Collector - ***Tag Unreadable*** - Reliance Electric	
Plastic Flights and Chains, Clarifier 5	1/1/2015		
Primary #6			
TA05.06 Primary Clarifier #6	4/23/2008	Concrete Tank -	
C05.06 Primary Sludge Collector #6	4/23/2008	Sludge Collector Drive - New-Eurodrive, Inc USA	Motor: 1HP/1140 RPM - Inst. 1900
SG05.11 Primary Clarifier Inlet Gate 6A (Motoriz	4/1/2010	Sluice Gate - 72"x36" - Rodney Hunt	
SG05.12 Primary Clarifier Inlet Gate 6B (Motoriz	4/1/2010	Sluice Gate - 72"X36" - Rodney Hunt	
C05.16 Primary Scum Collector #6	4/1/2010	Sludge Collector Drive - 18"x234"x2" - Polytec Systems, Inc	
MC05.06 Motor	1/0/1900	Motor, Collector - 1HP/1140 RPM - Baldor	
MC05.16 Motor		Motor, Collector - ***Plate Unreadable*** - Baldor	
GB05.16 Primary Scum Collector #6 Gearbox	6/15/2016	Gearbox - SEW-Eurodrive	
Plastic Flights and Chains, Clarifier 6	1/1/2015		
Primary #7			
TA05.07 Primary Clarifier #7	4/1/2010	Concrete Tank -	
C05.07 Primary Sludge Collector #7	4/23/2008	Sludge Collector Drive - New-Eurodrive, Inc USA	
SG05.13 Primary Clarifier Inlet Gate 7A (Motoriz	4/1/2010	Sluice Gate - 72"x36" - Rodney Hunt	
SG05.14 Primary Clarifier Inlet Gate 7B (Motoriz	4/1/2010	Sluice Gate - 72"x36" - Rodney Hunt	
C05.17 Primary Scum Collector #7	4/1/2010	Sludge Collector Drive - 18"x234"x2" - Polytec Systems, Inc	
MC05.07 Motor		Motor, Collector - 1HP/1140RPM - Baldor	
MC05.17 Motor		Motor, Collector - 1HP/1750 RPM - Baldor	
Plastic Flights and Chains, Clarifier 7	1/1/2015		
Primary Gallery			
P05.23 Primary Clarifier Drain Pump	4/1/2010	Pump - 6" - Gorman Rupp	Motor: 15HP / 1180 RPM / 460vac - Inst. 2010
MP05.23 Pri Clarifier Drain Pump Motor	4/1/2010	Motor, Pump - 15HP / 1180 RPM / 460vac - Emerson	
P05.01 Primary Sludge Pump #1	6/1/2009	Pump - Moyno Pump Company	Motor: 7.5HP / 1170 RPM / 460VAC - Inst. 198
MP05.01 Motor	1/1/1985	Motor, Pump - 7.5HP / 1170 RPM / 460VAC - U.S. Electrical Motors	
V05.20 6 Prim Sludge #1 P5.1 (Discharge), Plu	4/1/1992	Valve -	
V05.21 6 Prim Sludge #1 (Suction), Plug, Home	4/1/1992	Valve -	
P05.02 Primary Sludge Pump #2	6/21/2006	Pump - Moyno Pump Company	Motor: 7.5HP / 1170 RPM / 460vac - Inst. 198

Process/Area	Primary Clarifiers (Area 05)	
Major Assets / Systems	**Install**	**Attributes**
MP05.02 Motor	1/1/1985	Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
V05.18 6 Prim Sludge #2 P5.2 (Discharge), Plu	4/1/1992	Valve -
V05.19 6 Prim Sludge #2 (Suction), Plug, Home	4/1/1992	Valve -
P05.03 Primary Sludge Pump #3	1/0/1900	Pump - Moyno Pump Company
MP05.03 Motor	1/0/1900	Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
V05.16 6 Prim Sludge #3 P5.3 (Discharge), Plu	4/1/1992	Valve -
V05.17 6 Prim Sludge #3 (Suction), Plug, Home	4/1/1992	Valve -
P05.04 Primary Sludge Pump #4	6/16/2008	Pump - Moyno Pump Company Motor: 7.5HP / 1170 RPM / 460vac - Inst. 198
MP05.04 Motor	1/1/1985	Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
V05.14 6 Prim Sludge #4 P5.4 (Discharge), Plu	4/1/1992	Valve -
V05.15 6 Prim Sludge #4 (Suction), Plug, Dezu	4/1/1992	Valve -
P05.05 Primary Sludge Pump #5	6/8/2009	Pump - Moyno Pump Company
MP05.05 Motor	1/1/1985	Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
V05.12 6 Prim Sludge #5 P5.5 (Discharge), Plu	4/1/1992	Valve -
V05.13 6 Prim Sludge #5 (Suction), Plug, Home	4/1/1992	Valve -
P05.06 Primary Sludge Pump #6	6/1/2009	Pump - Moyno Pump Company
MP05.06 Motor	1/1/1985	Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
V05.10 6 Prim Sludge #6 P5.6 (Discharge), Plu	4/1/1992	Valve -
V05.11 6 Prim Sludge #6 (Suction), Plug, Dezu	4/1/1992	Valve -
P05.07 Primary Sludge Pump #7	5/1/2009	Pump - Moyno Pump Company
MP05.07 Motor	1/1/1985	Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
V05.08 6 Prim Sludge #7 P5.7 (Discharge), Plu	4/1/1992	Valve -
V05.09 6 Prim Sludge #7 (Suction), Plug, Home	4/1/1992	Valve -
P05.08 Primary Sludge Pump #8	4/1/2009	Pump - Moyno Pump Company
MP05.08 Motor	1/1/1985	Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
V05.06 6 Prim Sludge #8 P5.8 (Discharge), Plu	4/1/1992	Valve -
V05.07 6 Prim Sludge #8 (Suction), Plug, Dezu	4/1/1992	Valve -
P05.09 Primary Sludge Pump #9	10/1/2009	Pump - Moyno Pump Company
MP05.09 Motor	1/1/1985	Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
V05.03 6 Prim Sludge #9 P5.9 (Discharge), Plu	4/1/1992	Valve -
V05.04 6 Prim Sludge #9 (Suction), Plug, Home	4/1/1992	Valve -
P05.10 Primary Sludge Pump #10	3/19/2007	Pump - Moyno Pump Company
MP05.10 Motor	1/1/1985	Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
V05.01 6 Prim Sludge #10 P5.10 (Discharge), F	4/1/1992	Valve -
V05.02 6 Prim Sludge #10 (Suction), Plug, Hom	4/1/1992	Valve -
AH05.01 Gallery A Air Handler	1/1/2001	Air Handling Unit - 200PSI / 2HP Motor - Trane
AH05.02 Gallery A Extension Air Handler	4/28/2008	Air Handling Unit - Carrier
P05.11 Primary Scum Pump #1	6/16/2008	Pump - Moyno Pump Company
MP05.11 Motor	1/1/1985	Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
P05.12 Primary Scum Pump #2	1/0/1900	Pump - Moyno Pump Company
MP05.12 Motor		Motor, Pump - 7.5HP / 1170 RPM / 460vac - US Electrical Motors
P05.15 Primary Tank Drain Pump	1/0/1900	Pump - 6" - Gorman Rupp
MP05.15 Motor	10/21/2008	Motor, Pump - 10HP / 1735 RPM / 460vac - US Electrical Motors
FIT5.91 Primary Sludge Flow 1	6/4/2007	Flowmeter - Sparling
FIT5.92 Primary Sludge Flow 2	6/4/2007	Flowmeter - Sparling

Process/Area	Primary Clarifiers (Area 05)		
Major Assets / Systems	**Install**	**Attributes**	
P05.16 Primary Sludge Pump #11	4/1/2010	Pump - 6" - Moyno	Motor: 7.5 HP 1170 RPM - Inst. 2010
MP05.16 Motor	4/1/2010	Motor, Pump - 7.5 HP 1170 RPM - Reliance Electric	
P05.17 Primary Sludge Pump #12	4/1/2010	Pump - 6x6 - Moyno	Motor: 7.5 HP 1170 RPM - Inst. 2010
MP05.17 Motor	4/1/2010	Motor, Pump - 7.5 HP 1170 RPM - Reliance Electric	
P05.18 Primary Sludge Pump #13	4/1/2010	Pump - 6x6 - Moyno	Motor: 7.5 HP 1170 RPM - Inst. 2010
MP05.18 Motor	4/1/2010	Motor, Pump - 7.5 HP 1170 RPM - Reliance Electric	
P05.19 Primary Sludge Pump #14	4/1/2010	Pump - 6x6 - Moyno	Motor: 7.5 HP 1170 RPM - Inst. 2010
MP05.19 Motor	4/1/2010	Motor, Pump - 7.5 HP 1170 RPM - Reliance Electric	
P05.20 Primary Scum Pump #3	4/1/2010	Pump - Moyno	Motor: 7.5 HP / 1170 RPM - Inst. 2010
MP05.20 Motor	4/1/2010	Motor, Pump - 7.5 HP / 1170 RPM - Reliance Electric	

Missing Assets

Process/Area	Biotowers (Area 06)		
Major Assets / Systems	**Install**	**Attributes**	
General Area			
Stacks and Structure			
Walkway			
Control Buildling and Pump Room	1/0/1900		
Control Room / Electrical			
MCC 06.01	1/0/1900	MCC -	
MCC 06.02	1/1/1984	MCC -	
FA06.01 MCC 6.1 / 6.2 Exhaust Fan		Fan - HP. 3\4 - greenheck	
FA06.02 MCC 6.1 / 6.2 Exhaust Fan		Fan - HP.1\4 - GREENHECK	
#1 Biotower AFDs	1/15/2008	Adjustable Frequency Drive - 125A - Yaskawa	
#2 Biotower AFD	1/0/1900	Adjustable Frequency Drive - 125A - Yaskawa	
#3 Biotower AFD	1/15/2008	Adjustable Frequency Drive - 125A - Yaskawa	
#4 Biotower AFD	1/15/2008	Adjustable Frequency Drive - 125A - Yaskawa	
XF06.01 Biotower Transformer 1	7/13/1985	Transformer - 15KVA - Westinghouse	
Pump Room			
P06.01 Biotower Feed Pump #1	5/1/2007	Pump - 12" - Fairbanks Morse	Motor: 75Hp - Inst. 2008
P06.02 Biotower Feed Pump #2	2/1/2007	Pump - 12" - Fairbanks Morse	Motor: 75Hp - Inst. 2008
P06.03 Biotower Feed Pump #3	2/1/2008	Pump - 12" - Fairbanks Morse	Motor: 75Hp - Inst. 2008
P06.04 Biotower Feed Pump #4	2/1/2008	Pump - 12" - Fairbanks Morse	Motor: 75Hp - Inst. 1900
FIT06.05 Biotower Scrubber 1st Stage CL2 Flow	2/11/1985	Flowmeter -	
FIT06.06 Biotower Scrubber 1st Stage Dilution	2/11/1985	Flowmeter -	
FIT06.07 Biotower Scrubber 2nd Stage CL2 Flo	2/11/1985	Flowmeter -	
FIT06.08 Biotower Scrubber 2nd Stage Dilution	2/11/1985	Flowmeter -	
FA06.03 Odor Scrubber #1 Fan		Fan - HP. 10 - HARRINGTON IND.	
FA06.04 Odor Scrubber #2 Fan		Fan - HP. 1O - HARRINGTON IND.	
FA06.05 Odor Scrubber #3 Fan		Fan - HP. 10 - HARRINGTON IND.	
Biotowers			
OS06.01 #1 ODOR SCRUBBER		ODOR SCRUBBER -	
DT06.01 Biotower #1 Distributer	4/1/2010	Distributer - Case Cotter	
MD06.01 Biotower 1 Media	8/27/2008	Media (biotower) -	
P06.07 Biotower #1 Scrubber Pump	4/1/2007	Pump -	Motor: - Inst. 1985
P06.09 Biotower #1 Scrubber Drain Pump	1/0/1900	Pump -	
OS06.02 #2 ODOR SCRUBBER		ODOR SCRUBBER -	
DT06.02 Biotower #2 Distributer	1/15/1985	Distributer - Case Cotter	
MD06.02 Biotower 2 Media	8/27/2008	Media (biotower) -	
P06.08 Biotower #2 Scrubber Pump	4/1/2007	Pump -	Motor: - Inst. 1985
P06.10 Biotower #2 Scrubber Drain Pump	4/1/1996	Pump -	Motor: - Inst. 2006

Process/Area	Biotowers (Area 06)	
Major Assets / Systems	**Install**	**Attributes**
Misc. and Large Valves		
AH06.01 Biotower Air Handler	1/15/1985	Air Handling Unit - train torrivent
FIT06.03 Chlorine Solution Flowmeter 4	2/11/1985	Flowmeter -
V06.01 Biotower #1 30 Influent Valve	4/1/1992	Valve -
V06.02 Biotower #2 30 Influent Valve	4/1/1992	Valve -
V06.03 Biotower Pump #1 24 Suction Valve	4/1/1992	Valve -
V06.04 Biotower Pump #2 24 Suction Valve	4/1/1992	Valve -
V06.05 Biotower Pump #3 24 Suction Valve	4/1/1992	Valve -
V06.06 Biotower Pump #4 24 Suction Valve	4/1/1992	Valve -
V06.07 Biotower Pump #1 20 Discharge Valve	4/1/1992	Valve -
V06.08 Biotower Pump #2 20 Discharge Valve	4/1/1992	Valve -
V06.09 Biotower Pump #3 20 Discharge Valve	4/1/1992	Valve -
V06.10 Biotower Pump #4 20 Discharge Valve	4/1/1992	Valve -
V06.11 Biotower #1 36 Effluent Valve	4/1/1992	Valve -
V06.12 Biotower #2 36 Effluent Valve	4/1/1992	Valve -
V06.13 Biotower #1 Effluent 30 Flowmeter Isol	4/1/1992	Valve -
V06.14 Biotower #2 Effluent 30 Flowmeter Iso	4/1/1992	Valve -
MOV06.15 Secondary Q Control Valve #1 30 (I	8/15/2005	Motorized Valve - Limitorque
MOV06.16 Secondary Q Control Valve #2 30 (I	8/15/2005	Motorized Valve - McJunkin
V06.17 Ras Isolation Valve 24 (To: BT/Prim. Eff	4/1/1992	Valve -
V06.18 Ras Isolation Valve 24 (To: BT/Prim. Eff	1/0/1900	Valve -
V06.19 Ras Isolation Valve 24 (Gallery H)	4/1/1992	Valve -
V06.20 Ras Isolation Valve 24 (at BT Pumps)	4/1/1992	Valve -

Missing Assets

Process/Area	Aeration (Area 07)	
Major Assets / Systems	**Install**	**Attributes**
Aeration Influent Channels		
SG07.01 Aeration Tank #1 Influent Gate (Moto	2/1/1990	Sluice Gate - 36"x60" - Rodney Hunt
EM07.01 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG07.02 Aeration Tank #2 Influent Gate (Moto	2/1/1990	Sluice Gate - 36"x60" - Rodney Hunt
EM07.02 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG07.03 Aeration Tank #3 Influent Gate (Moto	2/1/1991	Sluice Gate - 36"x60" - Rodney Hunt
EM07.03 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG07.04 Aeration Tank #4 Influent Gate (Mot	2/1/1991	Sluice Gate - 36"x60" - Rodney Hunt
EM07.04 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SGM07.05 Aeration Bypass Gate (Motorized)(In	2/1/1996	Motorized Sluice Gate -
Aeration Tanks 1-4		
TA07.01 Aeration Tank #1	1/15/1985	Concrete Tank -
Aeration Tank #1 Diffusers	1/0/1900	
SG07.07 Aeration Tank #1 Influent Gate B (Mo	2/1/1992	Sluice Gate - 36"x60" - Rodney Hunt
EM07.07 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG07.06 Aeration Tank #1 Influent Gate A (Mo	2/1/1992	Sluice Gate - 36"x60" - Rodney Hunt
EM07.06 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG07.25 Aeration Tank Isolation Gate (Motorize	2/1/1996	Sluice Gate - 36"x60" - Rodney Hunt
EM07.25 Electric Gate Operator	1/0/1900	Electric Gate Operator - Rotork
SG07.26 Aeration Tank Isolation Gate (Motorize	2/1/1997	Sluice Gate - 36"X60" - Rodney Hunt
EM07.26 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
TA07.02 Aeration Tank #2	1/0/1900	Concrete Tank -
Aeration Tank #2 Diffusers	1/0/1900	
SG07.09 Aeration Tank #2 Influent Gate B (Mo	2/1/1993	Sluice Gate - 36"x60" - Rodney Hunt
EM07.09 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG07.08 Aeration Tank #2 Influent Gate A (Mo	2/1/1993	Sluice Gate - 36"x60" - Rodney Hunt
EM07.08 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
TA07.03 Aeration Tank #3	1/0/1900	Concrete Tank -
Aeration Tank #3 Diffusers	1/0/1900	
SG07.11 Aeration Tank #3 Influent Gate B (Mo	2/1/1994	Sluice Gate - 36"x60" - Rodney Hunt
EM07.11 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG07.10 Aeration Tank #3 Influent Gate A (Mo	2/1/1994	Sluice Gate - 36"x60" - Rodney Hunt
EM07.10 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG07.27 Aeration Tank Isolation Gate (Motorize	2/1/1997	Sluice Gate - 36"x60" - Rodney Hunt
EM07.27 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG07.28 Aeration Tank Isolation Gate (Motorize	2/1/1997	Sluice Gate - 36"x60" - Rodney Hunt
EM07.28 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
TA07.04 Aeration Tank #4	1/15/1985	Concrete Tank -
Aeration Tank #4 Diffusers	1/0/1900	
SG07.13 Aeration Tank #4 Influent Gate B (Mo	7/25/2012	Sluice Gate - 36"x60" - Waterman
EM07.13 Electric Gate Opener	4/1/2010	Electric Gate Operator - Rotork
SG07.12 Aeration Tank #4 Influent Gate A (Mo	7/25/2012	Sluice Gate - 36"x60" - Waterman
EM07.12 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG07.14 Aeration Tank #1 Effluent Channel Is	2/1/1996	Sluice Gate - 36"x60" - Rodney Hunt
EM07.14 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork

Process/Area	Aeration (Area 07)		
Major Assets / Systems	**Install**	**Attributes**	
Aeration Effluent Box			
SG07.15 Aeration Tank #1 Effluent Channel Is	1/0/1900	Sluice Gate -	
SG07.17 Aeration Tank #2 Effluent Gate (At Ef	2/1/1999	Sluice Gate -	
SGM07.19 Aeration Bypass Gate (Motorized)(Ef	2/1/1998	Motorized Sluice Gate -	
SG07.21 Aeration Tank #3 Effluent Gate (At Ef	2/1/2000	Sluice Gate -	
SG07.23 Aeration Tank #4 Effluent Channel Is	2/1/2001	Sluice Gate -	
SG07.24 Aeration Tank #4 Effluent Channel Is	1/0/1900	Sluice Gate - 36"x60" - Rodney Hunt	
EM07.24 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork	
SG07.22 Aeration Effl. Box isolation Gate (Betw	2/1/2000	Sluice Gate -	
SG07.20 Aeration Effl. Box isolation Gate (Betw	2/1/2000	Sluice Gate -	
SG07.18 Aeration Effl. Box isolation Gate (Betw	2/1/1999	Sluice Gate -	
SG07.16 Aeration Effl. Box isolation Gate (Betw	2/1/1998	Sluice Gate -	
Equipment Room			
Buildling - Equipment / Control Room	1/0/1900		
B07.01 Aeration Blower #1	1/15/1995	Air Blower - Hoffman	Motor: 100 HP - Inst. 2010
B07.02 Aeration Blower #2	11/1/2012	Air Blower - Nueros Turbo Blower	Motor: 150HP - Inst. 1990
B07.03 Aeration Blower #3	1/15/1995	Air Blower - Hoffman	Motor: 100 HP - Inst. 2010
B07.04 Aeration Blower #4	11/1/2012	Air Blower - Neuros Turbo Blower	Motor: 150 HP - Inst. 1990
FT07.01 Aeration Blower Filters		Filter -	
FIT7.31 Aera Tank 1 Airflow	2/11/1985	Flowmeter - Rosemont	
FIT7.32 Aera Tank 2 Airflow	10/19/2005	Flowmeter - Rosemont	
FIT7.33 Aera Tank 3 Airflow	2/11/1985	Flowmeter - Rosemont	
FIT7.34 Aera Tank 4 Airflow	2/11/1985	Flowmeter - Rosemont	
Control / Electrical Room			
MCC 07.01	1/1/1984	MCC -	
MCC 07.02	1/0/1900	MCC -	
FA07.05 MCC 7 Exhaust Fan		Fan - CANT ACCESS FAN	
VFDP07.01 Aeration Tank Drain Pump #1 VFD	4/4/2016	VFD for pump - 15Hp - TECO	
XF07.01 Aeration Transformer 1	9/1/2016	Transformer - 45KVA - Eaton	
Gallery L			
V07.01 Secondary Clarifier #1 Influent Valve 2	4/1/1992	Valve -	
V07.02 Secondary Clarifier #2 Influent Valve 2	4/1/1992	Valve -	
V07.03 Secondary Clarifier #3 Influent Valve 2	4/1/1992	Valve -	
V07.04 Secondary Clarifier #4 Influent Valve 2	4/1/1992	Valve -	
P07.03 Gallery L Sump Pump	4/1/1996	Pump -	
V07.31 RAS Isolation Valve (Gallery L to AT #	4/1/1992	Valve -	
V07.32 RAS Isolation Valve (Gallery L to AT #	4/1/1992	Valve -	
V07.33 RAS Isolation Valve (Gallery L to AT #	4/1/1992	Valve -	
V07.34 RAS Isolation Valve (Gallery L to AT #	4/1/1992	Valve -	
UH07.01 Gallery L Heater		Heater (room) -	
P07.01 Aeration Tank Drain Pump #1	4/7/2016	Pump - IMP.DIA. 14.125 - GORMAN-RUPP	Motor: 15HP 60 HZ 460V - Inst. 2016

Missing Assets

Process/Area	Secondary Clarifiers (Area 08)		
Major Assets / Systems	**Install**	**Attributes**	
Secondary Clarifiers 1-4			
TA08.01 Secondary Clarifier #1	1/1/1985	Concrete Tank - Kennedy + Jenks	Motor: - Inst. 2008
MTA08.01 Motor	10/21/2008	Motor, tank (clarifier) -	
C08.01 Secondary Clarifier #1 Collector	1/1/1985	Sludge Collector Drive - Flender Corporation	Motor: 3/4 Hp - Inst. 1985
SG08.01 Secondary Clarifier #1 Effluent Gate	1/8/2005	Sluice Gate -	
GB8.01 Secondary Clarifier Drive #1 Gearbox	6/24/2016	Gearbox - 56SM3A - Dodge APG	
TA08.02 Secondary Clarifier #2	1/1/1985	Concrete Tank - Kennedy + Jenks	Motor: - Inst. 2008
MTA08.02 Motor	10/21/2008	Motor, tank (clarifier) -	
C08.02 Secondary Clarifier #2 Collector	8/26/2010	Sludge Collector Drive - 1/2 Hp. - DBS Manufacturing Inc.	Motor: 1/2 Hp - Inst. 2010
SG08.02 Secondary Clarifier #2 Effluent Gate	1/8/2005	Sluice Gate -	
TA08.03 Secondary Clarifier #3	1/1/1985	Concrete Tank - Kennedy + Jenks main drive	Motor: - Inst. 2008
MTA08.03 Motor	10/21/2008	Motor, tank (clarifier) -	
C08.03 Secondary Clarifier #3 Collector	1/1/1985	Sludge Collector Drive - Flender Corporation	Motor: 3/4 Hp - Inst. 1985
SG08.03 Secondary Clarifier #3 Effluent Gate	1/15/1985	Sluice Gate -	
TA08.04 Secondary Clarifier #4	1/1/1985	Concrete Tank - cant read - Kennedy + Jenks	Motor: - Inst. 2008
MTA08.04 Motor	10/21/2008	Motor, tank (clarifier) -	
C08.04 Secondary Clarifier #4 Collector	1/1/1985	Sludge Collector Drive - Flender Corporation	Motor: 3/4 HP - Inst. 1985
SG08.04 Secondary Clarifier #4 Effluent Gate	1/8/2005	Sluice Gate -	
Equipment Room			
P08.01 RAS Pump #1	4/1/1997	Pump - 6x6 - Fairbanks Morse	Motor: 20 HP - Inst. 1900
P08.02 RAS Pump #2	4/1/1996	Pump - 6x6 - Fairbanks Morse	Motor: 20 HP - Inst. 1985
P08.03 RAS Pump #3	4/1/1997	Pump - 6x6 - Fairbanks Morse	Motor: 20 HP - Inst. 1985
P08.04 RAS Pump #4	4/1/1985	Pump - 6x6 - Fairbanks Morse	Motor: 20 hp - Inst. 1985
P08.05 RAS Pump #5	4/1/1985	Pump - 6x6 - Fairbanks Morse	
P08.06 RAS Pump #6	4/1/1996	Pump - 6x6 inch - Fairbanks Morse	
P08.07 WAS Pump #1	7/27/2007	Pump - Moyno Pump Company	Motor: 7.5 HP - Inst. 1985
P08.08 WAS Pump #2	1/1/1985	Pump - Moyno Pump Company	Motor: 7.5HP - Inst. 1985
P08.09 WAS Pump #3	1/1/1985	Pump - Moyno Pump Company	Motor: 7.5 HP - Inst. 1985
P08.10 WAS Pump #4	6/25/2011	Pump - Moyno Pump Company	Motor: - Inst. 1985
P08.11 Secondary Scum Pump #1	4/1/1997	Pump - MOYNO	Motor: 7.5 HP - Inst. 1985
P08.12 Secondary Scum Pump #2	4/1/1996	Pump - MOYNO	Motor: 7.5 HP - Inst. 1985
P08.13 Secondary Tank Drain Pump #1	4/1/1997	Pump - 6x6 - Fairbanks morse	Motor: 15 HP - Inst. 1985
P08.14 Secondary Tank Drain Pump #2	4/1/1996	Pump - 6x6 - Fairbanks morse	
Control Room			
Control Room Building	1/0/1900		
XF08.01 Secondary Transformer 1	9/1/1985	Transformer - 30KVA - Westinghouse	
MCC 08.01	1/1/1984	MCC -	
MCC 08.02	1/1/1984	MCC -	
#1 RAS AFD	4/1/2000	Adjustable Frequency Drive - Yaskawa	
#2 RAS AFD	12/17/2007	Adjustable Frequency Drive - 20HP - Yaskawa	
#3 RAS AFD	4/1/2000	Adjustable Frequency Drive - 20HP - yaskawa	
#4 RAS AFD	4/1/2000	Adjustable Frequency Drive - 20HP - yaskawa	
#5 RAS AFD	4/1/2008	Adjustable Frequency Drive - 20HP - Yaskawa	
#6 RAS AFD	4/1/2000	Adjustable Frequency Drive - 20HP - Yaskawa	
#1 WAS AFD	8/4/2014	Adjustable Frequency Drive - 7.5 HP - Teco- Westinghouse	

Process/Area **Secondary Clarifiers (Area 08)**

Major Assets / Systems	Install	Attributes
#2 WAS AFD	11/11/2014	Adjustable Frequency Drive - 7.5 HP - Teco- Westinghouse
#3 WAS AFD		Adjustable Frequency Drive - 7.5 HP - Teco- Westinghouse
#4 WAS AFD	11/11/2014	Adjustable Frequency Drive - 7.5 HP - Teco- Westinghouse
FA08.01 Area 8 Equipment Room Vent Fan #1	7/7/2016	Fan - 2 HP - GREENHECK
FA08.02 Area 8 Control Room Exhaust Fan #2		Fan - HP.1/6 - GREENHECK
Meter Room		
24" Mag meter		
V08.1 24 RAS Inflow To Flow Meter, TBD	4/1/1992	Valve -
V08.2 24 RAS Out From Flow Meter, TBD	4/1/1992	Valve -
P08.21 RAS Flow Meter Vault Sump Pump	4/1/1996	Pump -

Missing Assets

Process/Area	Chlorine Contact Tanks (Area 09)		
Major Assets / Systems	**Install**	**Attributes**	
Chlorine Contact Tanks 1-4			
SGM09.01 CCT #1 Influent Gate (Motorized)	1/15/1985	Motorized Sluice Gate - IQ25 - ROTORK	
SGM09.02 CCT #2 Influent Gate (Motorized)	1/15/1985	Motorized Sluice Gate - IQ25 - ROTORK	
SGM09.03 CCT #3 Influent Gate (Motorized)	1/15/1985	Motorized Sluice Gate - IQ25 - ROTORK	
SG09.04 Pond Fill Sluice Gate (Motorized)	1/15/1985	Sluice Gate - 42"x42" - Rodney Hunt	
EM09.04 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork	
SG09.05 Triangle Pit Fill Gate	1/15/1985	Sluice Gate -	
TA09.01 Chlorine Contact Tank #1 (Hillside)	1/15/1985	Concrete Tank -	
TA09.02 Chlorine Contact Tank #2 (Center)	1/15/1985	Concrete Tank -	
TA09.03 Chlorine Contact Tank #3 (Freeway S	1/15/1985	Concrete Tank -	
Chlorine Contact Tank #4	1/0/1900		
VT09.01 CCT #1 Telescoping Valve		Valve, Telescoping -	
VT09.02 CCT #2 A Telescoping Valve		Valve, Telescoping -	
VT09.03 CCT #2 B Telescoping Valve		Valve, Telescoping -	
VT09.04 CCT #3 Telescoping Valve		Valve, Telescoping -	
VT09.05 CCT Scum Sump Telescoping Valve		Valve, Telescoping -	
SG09.09 Chlorine Contact Tank 1 Influent Drain	4/1/2010	Sluice Gate - 24"x24" - Rodney Hunt	
SG09.10 Chlorine Contact Tank 2 Influent Drain	4/1/2010	Sluice Gate - 24"x24" - Rodney Hunt	
SG09.11 Chlorine Contact Tanks 1, 2, 3 & 4 Effl	4/1/2010	Sluice Gate - 72"x72" - Rodney Hunt	
EM09.11 Electric Gate Operator	9/9/2016	Electric Gate Operator - 115 RPM - Rotork	
SG09.12 Chlorine Contact Tanks 1, 2, 3 & 4 Effl	4/1/2010	Sluice Gate - 84"x84" - Rodney Hunt	
EM09.12 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork	
BS09.01 CCT Barscreen	1/1/1985	Bar Screen -	
SG09.06 CCT Barscreen Sump Drain Gate	1/15/1985	Sluice Gate -	
Chlorine Contact Tanks 5-6			
Chlorine Contact Tank #5	1/0/1900		
Chlorine Contact Tank #6	1/0/1900		
SG09.07 Chlorine Contact Tank 5 Inlet Gate (M	4/1/2010	Sluice Gate - 72"x60" - Rotork	
EM09.07 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork	
SG09.08 Chlorine Contact Tank 6 Inlet Gate (M	4/1/2010	Sluice Gate - 72"x60" - Rodney Hunt	
EM09.08 Electric Gate Operator	4/1/2010	Electric Gate Operator - JM-Squared - Rotork	
Chlorination and Pump Room			
M09.01 Chlorine Mixer #1	1/15/1985	Mixer (or Water Champ) -	
M09.02 Chlorine Mixer #2	1/15/1985	Mixer (or Water Champ) -	
M09.03 Water Champ	4/1/2010	Mixer (or Water Champ) - 10 HP - Seiman	
M09.04 Water Champ	5/1/2010	Mixer (or Water Champ) - 10 HP - Seiman	
M09.05 Water Champ	4/1/2010	Mixer (or Water Champ) - 10 HP - Seiman	
M09.06 Water Champ	4/1/2010	Mixer (or Water Champ) - 10 HP - Seiman	
M09.07 Water Champ	4/1/2010	Mixer (or Water Champ) - 10 HP - Seiman	
P09.01 Bypass Channel Drain Pump	1/15/1985	Pump - Fairbanks Morse	
P09.03 CCT / Pond Drain Pump	8/20/2007	Pump -	Motor: - Inst. 2008
P09.04 Gallery B / C Sump Pump	4/10/2014	Pump - Sulzer	
P09.05 CCT Sample Pump (Disinfection Dosing	9/2/1985	Pump -	Motor: - Inst. 1985
P09.06 CCT Sample Pump (Disinfection Dosing		Pump -	Motor: - Inst. 1985
P09.07 Booster Pump	4/1/2010	Pump - ITT Goulds Pump	Motor: 30 hp 18oo rpm 286T frame - Inst. 201

Process/Area Chlorine Contact Tanks (Area 09)

Major Assets / Systems	Install	Attributes
Electrical		
XF09.01 Chlorine Contact Transformer 1	7/13/1985	Transformer - 9KVA - Westinghouse
MCC 09.01	1/1/1984	MCC -
MCC 09.02	1/1/1984	MCC -
DIT9.75 Effluent Turbidity Meter		Transmitter - Hach Company
Misc.		
Area 09 Cuno Filter		Filter (F + "space") -

Missing Assets

Process/Area — Chlorination/Dechlorination (Area 10)

Major Assets / Systems	Install	Attributes	
Buildling 10			
Buildling	1/0/1900		
AH10.01 Building 10 Air Handler	1/15/1985	Air Handling Unit -	
Gallery C			
AH10.02 Gallery C Air Handler	1/15/1985	Air Handling Unit - Trane	
Hypo System			
TA10.01 HYPO Storage Tank #1	6/1/2004	Concrete Tank - 6000 Gal - Poly Processing Company	
TA10.02 HYPO Storage Tank #2	6/28/2010	Concrete Tank - 6000 Gal - SNEIDER	
TA10.03 HYPO Storage Tank #3	6/26/2003	Concrete Tank - Poly Processing Company	
TA10.04 HYPO Storage Tank #4	11/8/2012	Concrete Tank - 6000 Gal - Snyder Industries INC.	
TA10.05 HYPO Storage Tank #5	6/28/2010	Concrete Tank - 6000 Gal - SNEIDER	
P10.211 Hypo Disinfection Metering Pump #1	10/22/2001	Pump - 100 GPH - Milton Roy	Motor: 1 HP - Inst. 1985
P10.212 Hypo Disinfection Metering Pump #2	10/22/2001	Pump - 280 GPH - Milton Roy	Motor: 1 HP - Inst. 1985
P10.213 Hypo Metering Pump (Ross Valley)	4/1/1986	Pump - 280 GPH - Milton Roy	Motor: 1 HP - Inst. 1985
P10.214 Hypo Metering Pump (San Rafael)	4/1/1986	Pump - 280 GPH - Milton Roy	Motor: 1 HP - Inst. 1985
P10.215 Hypo Metering Pump (Odor Control)	4/1/1985	Pump - 100 GPH - Milton Roy	Motor: 1 HP - Inst. 1985
P10.216 Hypo Transfer Pump	4/1/2008	Pump - Imp. Dia. 6.81 - Ingersoll-Dresser	Motor: 3HP - Inst. 1985
P10.217 3W Hypo Disinfection Metering Pump	4/1/1985	Pump - 45 GPH - Milton Roy	Motor: - Inst. 1985
P10.218 Hypo Spill Vault Pump (Stick)	4/1/1985	Pump - Vanton Pump	Motor: ? - Inst. 1985
P10.219 Hypo Spill Vault Metering Pump	4/1/1985	Pump - Milton Roy	Motor: - Inst. 1985
UH10.01 Hypo Storage Room Heater #1		Heater (room) -	
UH10.02 Hypo Storage Room Heater #2		Heater (room) -	
BiSulfite System			
TA10.06 SBS Storage Tank #1	9/23/2014	Concrete Tank - 6100 - Poly Processing Company	
TA10.07 SBS Storage Tank #2	6/25/2013	Concrete Tank - 6600 Gallon - SNEIDER	
P10.311 SBS Dechlorination Metering Pump #	4/1/1985	Pump - Milton Roy	Motor: 1 HP - Inst. 1985
P10.312 SBS Dechlorination Metering Pump #	4/1/1985	Pump - 280 GPH - Milton Roy	Motor: 1 HP - Inst. 1985
P10.313 SBS Dechlorination Metering Pump #	4/1/1985	Pump - 280 GPH - Milton Roy	Motor: 1 HP - Inst. 1985
P10.314 SBS Transfer Pump	4/1/1985	Pump - Ingersoll-Dresser	Motor: 3 HP - Inst. 1985
P10.315 SBS Spill Vault Pump (Stick)	4/1/1985	Pump - Vanton Pump	Motor: 5 HP - Inst. 1985
P10.316 SBS Spill Vault Metering Pump	4/1/1985	Pump - Milton Roy	
P10.317 SBS Polishing Pump	4/1/1985	Pump - Milton Roy	Motor: - Inst. 1985
UH10.03 SBS Storage Room Heater		Heater (room) -	
Electrical			
MCC 10.01	1/1/1984	MCC -	
MCC 10.02	1/1/1984	MCC -	
FA10.08 MCC 10 Exhaust Fan		Fan -	
VFDP10.05 VFD pump 10.05 Plant Water Pum	2/1/2016	VFD for pump - 40 Hp - TECO	
VFDP10.06 VFD pump 10.06 Plant Water Pum	2/1/2016	VFD for pump - 40 Hp - TECO	
VFDP10.07 VFD pump 10.07 Plant Water Pum	2/1/2016	VFD for pump - 40 Hp - TECO	
VFDP10.08 VFD pump 10.08 Carrier Water Pu	2/1/2016	VFD for pump - 40 Hp - TECO	
VFDP10.09 VFD pump 10.09 Carrier Water Pu	2/1/2016	VFD for pump - 40 Hp - TECO	
VFDP10.10 VFD pump 10.10 Carrier Water Pu	2/1/2016	VFD for pump - 40 Hp - TECO	
XF10.01 Disinfection Transformer 1	6/2/2016	Transformer - 45KVA - Eaton	
XF10.02 Disinfection Transformer 2	7/13/1985	Transformer - 15KVA - Square D	
XFMR10.01 Area 10 Transformer 1	4/13/2016	Transformer - 45KVA - Eaton	

Process/Area	Chlorination/Dechlorination (Area 10)		
Major Assets / Systems	**Install**	**Attributes**	
Misc.			
CAT10.01 Hydro Tank Compressed Air Tank	4/1/1997	Compressed Air Tank - 26 gallon - Moroanton	
FIT10.410 R.V. 3 Water Flow		Flowmeter -	
FIT10.411 S.R. 3 Water Flow		Flowmeter -	
FIT10.412 Odor Control Water Flow		Flowmeter -	
FIT10.414 Bisulfite 3 Water Flow 1		Flowmeter -	
FIT10.415 Bisulfite 3 Water Flow 2		Flowmeter -	
FIT10.416 Plant Water Flow		Flowmeter -	
FIT10.501 Chlor Solution Flow 1		Flowmeter -	
FIT10.502 Chlor Solution Flow 2		Flowmeter -	
GB10.011 Strainer Gearbox		Gearbox - 26 - Cleaveland Gear	
P10.01 CCT Scum Pump #1	4/1/1990	Pump - Moyno	Motor: 5 HP - Inst. 1985
P10.02 CCT Scum Pump #2	4/1/1996	Pump - Moyno	Motor: 5 HP - Inst. 1985
P10.03 Gallery C Sump Pump	4/1/1996	Pump -	
P10.04 Gallery C Sump Pump	4/1/1996	Pump -	
P10.05 Plant Water Pump #1	4/1/1996	Pump - 4 X 3 - Fairbanks Morse	Motor: 40 HP - Inst. 1985
P10.06 Plant Water Pump #2	4/1/1996	Pump - 4 x 3 - Fairbanks Morse	Motor: 40 HP - Inst. 1985
P10.07 Plant Water Pump #3	4/1/1996	Pump - 4 x 3 - Fairbanks Morse	Motor: 40 HP - Inst. 1985
P10.08 Carrier Water Pump #1	4/1/1996	Pump - 4 x 3 - Crane Deming	Motor: 30 HP - Inst. 2010
P10.09 Carrier Water Pump #2	4/1/1996	Pump - 4 x 3 - Crane Deming	Motor: 30 HP - Inst. 1985
P10.10 Carrier Water Pump #3	4/1/1996	Pump - Crane Deming	Motor: 30 HP - Inst. 1985
P10.11 Chlorinated Effluent Sample Pump	4/1/1996	Pump - 11010705733201 - Paco	Motor: .75 HP - Inst. 1985
P10.12 Effluent Flow Meter Vault Sump Pump	4/1/1996	Pump - Gould Pump	
P10.13 Effluent De Chlorination Dosing Vault S	4/1/1996	Pump -	
P10.14A Dechlorinated Effluent Sample Pump	5/9/2008	Pump - Gorman Rupp	Motor: - Inst. 1985
P10.14B Dechlorinated Effluent Sample Pump	3/16/2012	Pump - 1 1/4" - AMT	Motor: - Inst. 1985
P10.15 Effluent Sampling Vault Sump Pump	4/1/1996	Pump -	
P10.16 3W Irrigation Pump	4/1/1996	Pump - 3 x 2 - Crane Deming	Motor: - Inst. 1985
P10.17 Bio Assay Sample Pump	4/1/1996	Pump - 9 Stages - Goulds	Motor: 1/2 HP - Inst. 1985
P10.18 Turtle Pond Pump	4/1/1996	Pump - 9 Stages - Goulds	Motor: 1/2 HP - Inst. 1985
P10.19 Effluent Sampling Vault Sump Pump	9/19/2007	Pump -	
ST10.01 Plant Water Strainer	1/15/1985	Strainer - 801 - Hellan fluid strainer	
ST10.02 Carrier Water Strainer	1/15/1985	Strainer - 801 - Hellan fluid strainer	
TNK10.01	8/14/2013	Tank (non-concrete) - 1950 Gallons - Young Engineering Manufac	
TNK10.02	8/14/2013	Tank (non-concrete) - 1950 Gallons - Young Engineering Manufac	
UH10.04 Analyzer Room Heater		Heater (room) -	

Missing Assets

Process/Area — Solids Handling Buildling (Area 12)

Major Assets / Systems	Install	Attributes
Solids Handling Buildling (SHB)		
Solids Handling Buildling (SHB)		
EL12.01 SOLIDS BUILDING ELEVATOR	2/11/1985	Elevator -
TA12.05 SHB Ferric Storage Tank	5/17/2011	Concrete Tank - 6000 Gal - Poly Processing Company
TA12.06 SHB Ferric Containment Tank	5/11/2011	Concrete Tank - 6,000 gallon -
RTDs / Thickeners		
THK001 Rotory Drum Thickener 1	4/13/2016	Thickener - FKC Co.
THK002 Rotory Drum Thickener 2	4/13/2016	Thickener - FKC Co.
TNK001 Floc Tank on RDT 1	4/13/2016	Tank (non-concrete) - FKC Co.
TNK001 Floc Tank on RDT 2	4/13/2016	Tank (non-concrete) - FKC Co.
RST001 Rotary Screen on RDT 1	4/13/2016	Rotary Screen - FKC Co.
RST001 Rotary Screen on RDT 2	4/13/2016	Rotary Screen - FKC Co.
MTR001 RST Screen Gearbox Drive Motor for R		Motor - 3 HP - Baldor
MTR001 RST Screen Gearbox Drive Motor for R		Motor - 3 HP - Baldor
GBX001 Gearbox Drive for RST Screen 1	4/13/2016	Gearbox Drive - FKC Co.
GBX001 Gearbox Drive for RST Screen 2	4/13/2016	Gearbox Drive - FKC Co.
PMP001 TWAS Lobe Pump on RDT 1	4/13/2016	Pump - Vogelsang
MTR001 TWAS Pump Motor		Motor - 5HP - Baldor
PMP001 TWAS Lobe Pump on RDT 2	4/13/2016	Pump - Vogelsang
TMR001 TWAS Pump 2 Motor		Motor - 5HP - Baldor
FIT12.93 TWAS Flow	2/11/1985	Flowmeter -
FIT12.81 WAS Flow 1	3/3/2008	Flowmeter -
FIT12.82 WAS Flow 2	3/4/2008	Flowmeter -
SHB 1st Floor - Generator Room		
E12.01 WAUKESHA Co-Generation Engine	10/24/2004	Engine - Waukesha Engine
E12.02 CUMMINS Emergency Diesel Engine	4/1/1990	Engine - Cummins West Inc
HRS12.1 Gas Engine Exhaust Heat Recovery Sil		Heat Recovery Silencer - Maxim Silencer Inc
HX12.1 Gas Engine Heat Exchanger, Auxillary L	1/1/1996	Engine Heat Exchanger - 8120 - ITT standard
HX12.2 Gas Engine Heat Exchanger, Load (Plan	1/1/1996	Engine Heat Exchanger -
HX12.3 Gas Engine Heat Exchanger, Jacket wat	1/1/1996	Engine Heat Exchanger - 10108 - ITT standard
SGC12.1 Cogen. Sludge Gas Compressor 12.1	8/14/2003	Sludge Gas Compressor - Garden Denver
SGC12.2 Cogen. Sludge Gas Compressor 12.2	8/14/2003	Sludge Gas Compressor - Garden Denver
T12.1 Gas Engine Expansion Tank, Auxillary Lo		Expansion Tank -
T12.2 Gas Engine Expansion Tank, Engine Jack		Expansion Tank -
FST12.01 Diesel Fuel Storage Tank		Fuel Storage Tank -
FTM12.01 Diesel Tank Monitor		Fuel Tank Monitor -
P12.21 Diesel Fuel Dispenser		Pump -
GE12.01 Kato Generator	4/2/2008	Generator - Kato
CP12.04 Engine Starting Air Compressor	4/1/1993	Air Compressor - Quincy Compressor
CP12.05 Engine Starting Air Compressor (Diese	3/8/2016	Air Compressor - 60 CFM - VMAC
CAT12.04 Generator Starting Compressed Air T	4/1/1999	Compressed Air Tank - Roy E Hanson MFG
CAT12.05 Engine Starting Compressed Air Tank	4/1/1999	Compressed Air Tank - Roy E Hanson MFG

Process/Area	Solids Handling Buildling (Area 12)	
Major Assets / Systems	**Install**	**Attributes**
SHB 1st Floor - Boiler Room		
BR12.01 BOILER #1	2/1/2008	Boiler - Bryan Steam Corp.
BR12.02 BOILER #2	2/1/2008	Boiler - Bryan Steam Corp.
HOV12.01Boiler #1 Sludge Gas Valve (hydraulic	4/19/2006	Hydraulic Sludge Gas Valve -
HOV12.02 Boiler #2 Sludge Gas Valve (Hydraul	4/19/2006	Hydraulic Sludge Gas Valve -
P12.16 Heating Water Pump #1	6/10/2011	Pump - paco pump
P12.17 Heating Water Pump #2	4/1/1996	Pump - paco pump
P12.18 Heating Water Pump #3	6/10/2011	Pump - paco pump
SHB 1st Floor - Polymer Storage		
TA12.01 Polymer Storage Tank	3/5/1985	Concrete Tank - 6000 Gal - Ace Buehler
PNL 001 Polymer Control Panel	4/13/2016	Control Panel - Pulsafeeder
P12.11 Polymer Feed Pump #1	8/22/2007	Pump - 550 GPH - Milton Roy
P12.12 Polymer Feed Pump #2	8/22/2007	Pump - 550 GPH - Milton Roy
P12.13 Polymer Feed Pump #3	8/22/2007	Pump - 550 GPH - Milton Roy
SHB 1st Floor - AHU and Electrical Room		
MCC12.01	1/1/1984	MCC -
MCC 12.02	1/1/1984	MCC -
XF12.01 SolidsTransformer 1	4/6/2016	Transformer - 75KVA - Eaton
XF12.02 Solids Transformer 2	7/13/1996	Transformer - 15KVA - Eaton
XFMR12.01 SOlids Transformer #1	6/25/2016	Transformer - 75KVA - Eaton
XFMR12.03 Solids Transformer 12.03	7/1/2010	Transformer - 15KVA - Eaton
AH12.01 SHB 1st Floor Air Handler	1/15/1985	Air Handling Unit - 1 Hp - Trane (Torrivent)
FT12.01 SG Filter (Dollinger) Boiler Room		Filter - Dollinger
FT12.02 SG Filter (Dollinger) at Engine		Filter - Dollinger
FT12.03 NG Filter (Dollinger) at Engine		Filter - Dollinger
FT12.04 SG Filter (Dollinger) at Siloxane		Filter - Dollinger
FT12.05 Siloxane Filter 1	2/18/2004	Filter - Applied Filter Technology
FT12.06 Siloxane Filter 2	2/18/2004	Filter - Applied Filter Technology
SHB 3rd Floor - Scrubber		
SCB001 Odor Scrubber	4/13/2016	ODOR SCRUBBER - Pure Air Filtration
FAN001 Odor Scrubber Fan		Fan (odor scrubber) - 500 CFM - Plasticair Inc
MTR001 Odor Scrubber Fan Motor	4/13/2016	Motor - 2 HP - Baldor
TNK001 Odor Scrubber Tank	4/13/2016	Tank (non-concrete) - Pure Air Filtration
OS12.01 ODOR SCRUBBER		ODOR SCRUBBER - 7.5 hp. - arovent
P12.23 Odor Scrubber Pump #1	4/1/1996	Pump - 3hp - Penguin
P12.24 Odor Scrubber Pump #2	4/1/1997	Pump - 3HP - Penguin
SHB 3rd Floor - Sludge Hoppers		
HOP12.01 Sludge Hopper #1	4/1/1990	Hopper, Grit / Sludge - no info
HOP12.02 Sludge Hopper #2	4/1/1990	Hopper, Grit / Sludge - no info
HOP12.03 Sludge Hopper #3	4/1/1990	Hopper, Grit / Sludge - no info
HP12.01 Hydraulic Pump Sludge Hopper Gates	1/1/1985	Grit Hopper, Hydraulic Pumps, Hopper Gate - Vickers

Process/Area	Solids Handling Buildling (Area 12)	
Major Assets / Systems	**Install**	**Attributes**
SHB 3rd Floor - Polymer Mixing/Feed		
TA12.07 Polymer Mix Tank #1		Concrete Tank -
TA12.08 Polymer Mix Tank #2		Concrete Tank -
PLY001 Polymer Metering Pumps for RDTs		Polymer Metering Pumps - Pulsafeeder
PMP001 Polymer Pump 1	4/13/2016	Pump - Flo-Line Technology Inc
MTR001 Polymer Pump 1 Motor		Motor - 0.75 HP - Baldor Reliance
PMP002 Polymer Pump 2	4/13/2016	Pump - Flo-Line Technology Inc
MTR001 Polymer Pump 2 Motor		Motor - 0.75 HP - Baldor Reliance
MIX001 Floc Tank 1 Mixer Gearbox Drive		Mixer Gearbox Drive - FKC
MTR001 Floc Tank Mixer Motor	4/13/2016	Motor - 1.5HP - Baldor
MIX001 Floc Tank 2 Mixer Gearbox Drive	4/13/2016	Mixer Gearbox Drive - FKC
PAU 12.31	4/1/2007	Polymer Activation Unit -
PAU 12.32	4/1/2007	Polymer Activation Unit -
SHB 4th Floor - Centrifuge		
CF12.01 CENTRIFUGE #1	2/1/2003	Centrifuge - 18 inch - Centrisys Centrifuge Systems
CF12.02 CENTRIFUGE #2	3/4/2002	Centrifuge - 18 inch - Centrisys Centrifuge Systems
CF12.03 CENTRIFUGE #3	4/1/2002	Centrifuge - 18 inch - Centrisys Centrifuge Systems
FIT12.01 #1 Centrifuge Sludge Flow Meter 4	6/5/2008	Flowmeter -
FIT12.02 #2 Centrifuge Sludge Flow Meter 4	6/5/2008	Flowmeter -
FIT12.03 #3 Centrifuge Sludge Flow Meter 4	6/5/2008	Flowmeter -
HUCF12.01 Centrifuge Hydraulic Unit	4/2/2008	Centrifuge Hydraulic Unit - Hochdruck / Viscotherm
HUCF12.02 Centrifuge Hydraulic Unit	4/2/2008	Centrifuge Hydraulic Unit - Hochdruck / Viscotherm
HUCF12.03 Centrifuge Hydraulic Unit	4/2/2008	Centrifuge Hydraulic Unit - Hochdruck
CAT12.08 Centrifuge Diverter Gate Compressed	4/1/1999	Compressed Air Tank - Manchester il
CP12.08 Centrifuge Pneumatic Control Compres	4/1/1993	Air Compressor - Quincy compressor

Missing Assets

Process/Area Digesters (Area 13)

Major Assets / Systems	Install	Attributes
Digesters		
DIG13.01 Digester #1		Digester -
DIG13.02 Digester #2		Digester -
Digester Control Building		
Digester Control Buildling		
AH13.01 Bldg. 13 Air Handler	1/15/1985	Air Handling Unit - Trane
13.03 H2S Gas Scrubber #1	5/15/2012	Scrubber - Superior Fabrication Inc.
FT13.01 Sludge Gas Filter #1 (Dollinger) Scrub		Filter -
13.04 H2S Gas Scrubber #2	5/16/2012	Scrubber - Superior Fabrication Inc.
FT13.02 Sludge Gas Filter #2 (Dollinger) Scrub		Filter -
P13.07 Digester Heating Water Pump #1	11/29/2011	Pump - 3hp - Amtrol Thrush
P13.08 Digester Heating Water Pump #2	12/12/2011	Pump - 3 hp - Amtrol Thrush
P13.16 Digester Ferric Feed Pump #1	2/10/2016	Pump - .11 ml/rev - Tuthill
Sludge Pumping Room (First Floor)		
P13.15 Digester Mixing Pump #1	10/1/2013	Pump - Wemco
P13.14 Digester Mixing Pump #2	10/1/2013	Pump - Wemco
Digester Cover Blower System		
B13.1 Dystor Cover Blower	10/1/2013	Air Blower - R16 - Twin City Fan & Blower
B13.2 Dystor Cover Blower	10/1/2013	Air Blower - R16 - Twin City Fan & Blower
B13.3 Dystor Cover Blower	10/1/2013	Air Blower - R16 - Twin City Fan & Blower
MB13.01 Motor		Motor, Blower -
MB13.1 Motor		Motor, Blower - 3 HP - Nidec
MB13.2 Motor		Motor, Blower - 3 HP - Nidec
MB13.3 Motor		Motor, Blower - 3 HP - Nidec
Sludge Pumping Room (Basement)		
GR13.01 Centrifuge Feed Grinder	1/29/1999	Grinder - JWC Muffin Monster
P13.04 Centrifuge Feed Pump #1	4/1/2008	Pump - Moyno Pump Company
P13.05 Centrifuge Feed Pump #2	4/1/2008	Pump - Liberty Pump
P13.06 Centrifuge Feed Pump #3	4/1/2008	Pump - Moyno Pump Company
P13.11 C-Fuge Ferric Feed Pump #1	2/10/2016	Pump - .38 ml/rev - Tuthill
P13.12 C-Fuge Ferric Feed Pump #2	2/11/2016	Pump - .38 ml/rev - Tuthill
P13.13 C-Fuge Ferric Feed Pump #3	2/10/2016	Pump - .38 ml/rev - Tuthill
Sprial Heat Exchanger 13.01	7/6/2016	Heat Exchanger - Alfa Laval Inc.
Sprial Heat Exchanger 13.02	10/13/1982	Heat Exchanger - American Heat Reclaiming Corp.
P13.01 Digester Heating Recirculation Pump #	8/22/2007	Pump - 10 Hp 600GPM - Vaughan
P13.02 Digester Heating Recirculation Pump #	7/27/1997	Pump - 10hp - Vaughan
(GR13.1) Sludge Recirc Grinder # 1	8/13/2013	Grinder - Moyno
(GR13.03) Sludge Recirc Grinder # 2	10/26/2011	Grinder - Moyno

Process/Area Digesters (Area 13)

Major Assets / Systems	Install	Attributes
Electrical		
LCP13.1 Digester Sump Pump Panel	5/26/2013	Control Panel - Turnbulltrol
MCC 13.01	1/1/1984	MCC -
MCC 13.02	1/1/1984	MCC -
FA13.02 MCC 13 Exhaust Fan		Fan - HP..17 - GREENHECK
#1 FERRIC DIGESTER FEED AFD	8/12/2014	Adjustable Frequency Drive - 1 HP - Teco- Westinghouse
#2 FERRIC DIGESTER FEED AFD	11/11/2014	Adjustable Frequency Drive - 1 HP - Teco- Westinghouse
#3 FERRIC CENTRIFUGE FEED AFD		Adjustable Frequency Drive - 1 HP - Teco- Westinghouse
#4 FERRIC CENTRIFUGE FEED AFD		Adjustable Frequency Drive - 1 HP - Teco- Westinghouse
#5 FERRIC CENTRIFUGE FEED AFD		Adjustable Frequency Drive - 1 HP - Teco- Westinghouse
XF13.01 Digester Transformer 1	7/13/1985	Transformer - 15KVA - Westinghouse

Missing Assets

Process/Area	Main Switchgear Facility (Area 14)	
Major Assets / Systems	**Install**	**Attributes**
Electrical Switchgear Buildling		
Electrical Switchgear Buildling		
FA14.01 Bldg. 14 Exhaust Fan		Fan - HP.1 - GREENHECK
FA14.02 Gallery D Exhaust Fan		Fan - HP. 1/25 - GREENHECK
MCCs		
MCC 14.01	1/1/1984	MCC -
MCC14.01-A01 Main Breaker	1/1/1984	MCC -
MCC14.01-A09 LT14.1 Lighting Transformer	1/1/1984	MCC -
MCC14.01-B01 F14.1 Switchgear Fan	1/1/1984	MCC -
MCC14.01-B03 Switchgear Outside Lighting Control	1/1/1984	MCC -
XF14.01 Switchgear Transformer 1	7/13/1985	Transformer - 5KVA - Acme
(For Reference) MCC Detailed Components		
SWG14.01-A1 Protective Relay		Switchgear Breakers -
SWG14.01-B3 Generator's Circuit Breaker		Switchgear Breakers -
SWG14.01-C1 Spare Breaker (800 Amp)		Switchgear Breakers -
SWG14.01-C2 Blank		Switchgear Breakers -
SWG14.01-C3 Spare Breaker (800 Amp)		Switchgear Breakers -
SWG14.01-C4 Blank		Switchgear Breakers -
SWG14.01-C5 Blank		Switchgear Breakers -
SWG14.01-D1 MCC7.2 (Aeration Tanks)		Switchgear Breakers -
SWG14.01-D2 MCC6.2 (Biotowers)		Switchgear Breakers -
SWG14.01-D3 MCC4/5.2 (Headworks)		Switchgear Breakers -
SWG14.01-D4 Spare Breaker (800 Amp)		Switchgear Breakers -
SWG14.01-D5 Spare Breaker (800 Amp)		Switchgear Breakers -
SWG14.01-E1 MCC13.2 (Digester Building)		Switchgear Breakers -
SWG14.01-E2 MCC12.2 (Solids Handling Building)		Switchgear Breakers -
SWG14.01-E3 MCC10.2 (Chlorination/Dechlor Bldg.)		Switchgear Breakers -
SWG14.01-E4 MCC9.2 (Chlorine Contact Building)		Switchgear Breakers -
SWG14.01-E5 MCC8.2 (Secondary Clarifiers)		Switchgear Breakers -
SWG14.01-F0 Protective Relay		Switchgear Breakers -
SWG14.01-F4 Tie Breaker		Switchgear Breakers -
SWG14.01-G1 MCC13.1 (Digester Building)		Switchgear Breakers -
SWG14.01-G2 MCC12.1 (Solids Handling Building)		Switchgear Breakers -
SWG14.01-G3 MCC10.1 (Chlor/Dechlor Bldg.)		Switchgear Breakers -
SWG14.01-G4 MCC9.1 (Chlorine Contact Tanks)		Switchgear Breakers -
SWG14.01-G5 MCC8.1 (Secondary Clarifiers)		Switchgear Breakers -
SWG14.01-H1 MCC7.1 (Aeration Tanks)		Switchgear Breakers -
SWG14.01-H2 MCC6.1 (Biotowers)		Switchgear Breakers -
SWG14.01-H3 MCC4/5.1 (Headworks)		Switchgear Breakers -
SWG14.01-H4 MCC3.1 (Maintenance Bldg.)		Switchgear Breakers -
SWG14.01-H5 MCC2.1 (Control Building)		Switchgear Breakers -
SWG14.01-I1 Blank		Switchgear Breakers -
SWG14.01-I2 Spare Breaker (800 Amp)		Switchgear Breakers -
SWG14.01-I3 Spare Breaker (800 Amp)		Switchgear Breakers -
SWG14.01-I4 Blank		Switchgear Breakers -
SWG14.01-I5 Blank		Switchgear Breakers -
SWG14.01-J3 Utility Circuit Breaker		Switchgear Breakers -
SWG14.01-K1 Protective Relay		Switchgear Breakers -

Missing Assets

Process/Area **Effluent PS (Area 20)**

Major Assets / Systems	Install	Attributes
Pumps		
P20.01 Wet Weather Pump #1	4/1/2010	Pump - 26" - Prime Pump Corp.
P20.02 Wet Weather Pump #2	4/1/2010	Pump - 26" - Prime Pump Corp.
P20.03 Wet Weather Pump #3	4/1/2010	Pump - 26" - Prime Pump Corp.
P20.04 Wet Weather Pump #4	4/1/2010	Pump - 26" - Prime Pump Corp.
P20.05 Wet Weather Pump #5	4/1/2010	Pump - 26" - Prime Pump Corp.
P20.11 Sump Pump	4/1/2010	Pump - 4"x4"x7" - Paco
Gates		
SG20.01 Effluent Pump Station Inlet Gate 1 (Mo	4/1/2010	Sluice Gate - 84"x60" - Rodney Hunt
EM20.01 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG20.02 Effluent Pump Station Inlet Gate 2 (Mo	4/1/2010	Sluice Gate - 84"x60" - Rodney Hunt
EM20.02 Electric Gate Operator	4/1/2010	Electric Gate Operator - Rotork
SG20.03 Effluent Pump Station Drain Gate (Man	4/1/2010	Sluice Gate - 12"12" - Rodney Hunt
Valves		
V20.01 Effluent Pump Station Valve Vault	4/1/2010	Valve - 66" - Pratt
V20.02 Final Effluent Valve - Pump #1	4/1/2010	Valve - 36" - Pratt
V20.03 Final Effluent Valve - Pump #2	4/1/2010	Valve - 36" - Pratt
V20.04 Final Effluent Valve - Pump #3	4/1/2010	Valve - 36" - Pratt
V20.05 Final Effluent Valve - Pump #4	4/1/2010	Valve - 36" - Pratt
V20.06 Final Effluent Valve - Pump #5	4/1/2010	Valve - 36" - Pratt
V20.07 Final Effluent Check Valve #1	4/1/2010	Valve - 36" - Pratt
V20.08 Final Effluent Check Valve #2	4/1/2010	Valve - 36" - Pratt
V20.09 Final Effluent Check Valve #3	4/1/2010	Valve - 36" - Pratt
V20.10 Final Effluent Check Valve #4	4/1/2010	Valve - 36" - Pratt
V20.11 Final Effluent Check Valve #5	4/1/2010	Valve - 36" - Pratt
Engines		
ED20.01 Caterpillar Engine #1	4/1/2010	Engine - 275 hp - Caterpillar
ED20.02 Caterpillar Engine #2	4/1/2010	Engine - 275 hp - Caterpillar
ED20.03 Caterpillar Engine #3	4/1/2010	Engine - 275 hp - Caterpillar
ED20.04 Caterpillar Engine #4	4/1/2010	Engine - 275 hp - Caterpillar
ED20.05 Caterpillar Engine #5	4/1/2010	Engine - 275 hp - Caterpillar
Fuel Tank		
TNK20.6 - Above Ground Fuel Tank	4/1/2010	Tank (non-concrete) - Convault
FM20.1 Fuel maint system		Fuel Maintenance System - Fuel technologies

Missing Assets

Process/Area	FOG/F2E Facility (Area 21)	
Major Assets / Systems	**Install**	**Attributes**
FOG Station (on grade)		
PF21.12 Paddle Finisher	10/1/2013	Paddle Finisher - Brown International Corp
OCS21.1 Odor Control Scrubber	8/21/2013	Odor Control Scrubber - PureAir Filtration
H21.1 San Quentin Motorized Hoist		Hoist - 1 Ton - Acco-Wright
HM21.01 Tank area JIB crane	3/1/2013	Hoist, Motorized - 1000 lbs - Yale
ME21.1 Gas Detection System		Gas Detection System - MSA
HOT21.01	11/19/2014	? -
FOG Station Pit (below grade)		
FOG/F2E Slurry Tank (20,000 gal)	1/0/1900	
P21.1 FOG/F2E Mix Pump #1	5/5/2016	Pump - 1680 GPH - Vaughan
P21.2 FOG/F2E Mix Pump #2	10/1/2013	Pump - 1100 GPM - Wemco
P21.3 Paddle Finisher Feed Pump	10/1/2013	Pump - Bredel
P21.4 Sludge Recirculation Pump	10/1/2013	Pump - 4x6 - Vaughn
P21.5 Digester Feed Pump	10/1/2013	Pump - Bredel
RTG21.1 Rock Trap Grinder	10/1/2013	Rock Trap Grinder - FR #100 - Borger
HM21.02 Equipment area JIB crane	3/1/2013	Hoist, Motorized - 1000 lbs - Yale
Electrical		
MCC 21.1	1/1/2014	MCC - Eaton
AFD21.1 Adjustable Frequency Drive for Fog M	7/16/2014	Adjustable Frequency Drive - 46A - Eaton
AFD21.2 Adjustable Frequency Drive for FOG M	7/16/2014	Adjustable Frequency Drive - 46A - Eaton
AFD21.3 Adjustable Frequency Drive for Paddle	7/16/2014	Adjustable Frequency Drive - 16A - Eaton
AFD21.4 Adjustable Frequency Drive for Sludge	7/16/2014	Adjustable Frequency Drive - 23A 15HP - Eaton
AFD21.5 Adjustable Frequency Drive for FOG F	7/16/2014	Adjustable Frequency Drive - 16A 10HP - Eaton
AFD21.6 Adjustable Frequency Drive for Paddle	7/16/2014	Adjustable Frequency Drive - 61A - Eaton

Missing Assets

APPENDIX B – DETAILED COST ESTIMATES

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	04-1	**PREPARED BY :**	DBH
TITLE :	Hydraulic Unit Replacement	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Headworks Actuator Conversion**					
	New Motorized Gate Actuators	17	EA	$10,000	$170,000	
	New Motorized Grit Hopper Actuator	3	EA	$5,000	$15,000	
	Demo Existing Hydraulic Unit and Actuators	1	LS	$10,000	$10,000	
	Total					$195,000
	SUBTOTAL					**$195,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	60	%		$117,000	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$39,000	
	Coating/Painting Allowance	5	%		$10,000	
	Total					$166,000
	SUBTOTAL					**$361,000**
	Estimating Contingency	30	%			$108,300
	SUBTOTAL					**$469,300**
	Sales Tax on 50% of Subtotal Above	9.25	%			$21,800
	SUBTOTAL					**$491,100**
	General Conditions, Contractor Overhead, & Profit	25	%			$123,000
	CONSTRUCTION COST SUBTOTAL					**$614,100**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$123,000
	PROJECT COST					**$737,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	04-2	**PREPARED BY :**	DBH
TITLE :	Grit Classifiers and Hoppers Replacement	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Grit System Components**					
	Replace Grit Classifiers	4	EA	$50,000	$200,000	
	Replace Grit Hoppers	4	EA	$20,000	$80,000	
	Replace Grit Pumps	3	EA	$18,000	$54,000	
	Replace Grit Piping	200	LF	$100	$20,000	
	Total					$354,000
	SUBTOTAL					**$354,000**
5	**Allowances**					
	Installation, Startup, and Comissioning	30	%		$107,000	
	Process Mechanical Allowance	15	%		$54,000	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$71,000	
	Coating/Painting Allowance	5	%		$18,000	
	Total					$250,000
	SUBTOTAL					**$604,000**
	Estimating Contingency	30	%			$182,000
	SUBTOTAL					**$786,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$37,000
	SUBTOTAL					**$823,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$206,000
	CONSTRUCTION COST SUBTOTAL					**$1,029,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$206,000
	PROJECT COST					**$1,235,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	04-3	**PREPARED BY :**	DBH
TITLE :	Grit Blower and Diffuser Replacements	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Grit Tank Aeration**					
	Blowers	2	EA	$58,613	$117,300	
	Diffusers (already budgeted)	0	EA	$0	$0	
	Total					$117,300
	SUBTOTAL					**$117,300**
2	**Allowances**					
	Installation, Startup, and Comissioning	60	%		$71,000	
	Process Mechanical Allowance	25	%		$30,000	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$24,000	
	Coating/Painting Allowance	5	%		$6,000	
	Total					$131,000
	SUBTOTAL					**$248,300**
	Estimating Contingency	30	%			$75,000
	SUBTOTAL					**$323,300**
	Sales Tax on 50% of Subtotal Above	9.25	%			$15,000
	SUBTOTAL					**$338,300**
	General Conditions, Contractor Overhead, & Profit	25	%			$85,000
	CONSTRUCTION COST SUBTOTAL					**$423,300**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$85,000
	PROJECT COST					**$508,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	04-4	**PREPARED BY :**	DBH
TITLE :	Grit Room Rehabilitation	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Corrosion Repair**					
	Gates and Rails Repair	7	EA	$5,000	$35,000	
	Odor Scrubber Equipment Costs (from B&C report)	1	LS	$505,100	$505,100	
	Total					$540,100
	SUBTOTAL					**$540,100**
2	**Allowances**					
	Installation, Startup, and Comissioning	60	%		$325,000	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	10	%		$55,000	
	Coating/Painting Allowance	5	%		$28,000	
	Total					$408,000
	SUBTOTAL					**$948,100**
	Estimating Contingency	30	%			$284,500
	SUBTOTAL					**$1,232,600**
	Sales Tax on 50% of Subtotal Above	9.25	%			$57,100
	SUBTOTAL					**$1,289,700**
	General Conditions, Contractor Overhead, & Profit	25	%			$323,000
	CONSTRUCTION COST SUBTOTAL					**$1,612,700**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$323,000
	PROJECT COST					**$1,936,000**

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2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	04-5	**PREPARED BY :**	DBH
TITLE :	Ferric Room Floor Coating	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Floor Recoating**					
	Miscellaneous Repair	1	LS	$15,000	$15,000	
	Vinyl Ester Coating	1500	SF	$25	$38,000	
	Total					$53,000
	SUBTOTAL					**$53,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	0	%		$0	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	0	%		$0	
	Total					$0
	SUBTOTAL					**$53,000**
	Estimating Contingency	30	%			$15,900
	SUBTOTAL					**$68,900**
	Sales Tax on 50% of Subtotal Above	9.25	%			$3,200
	SUBTOTAL					**$72,100**
	General Conditions, Contractor Overhead, & Profit	25	%			$19,000
	CONSTRUCTION COST SUBTOTAL					**$91,100**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$19,000
	PROJECT COST					**$110,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	05-1	**PREPARED BY :**	DBH
TITLE :	Primary Clarifier Rehabilitation	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**PStructural Rehabilitation**					
	Concrete Resurfacing	8700	SF	$18	$157,000	
	Repair Spall w/o Rebar Repair	100	SF	$70	$7,000	
	Repair Spall w/ Rebar Repair	200	SF	$140	$28,000	
	Crack Sealant	300	LF	$70	$21,000	
	Epoxy Injection	10	LF	$700	$7,000	
	Concrete Coating	8400	SF	$33	$278,000	
	Expansion Joint Sealant	240	LF	$70	$17,000	
	Total					$515,000
2	**Mechanical and Appurtenances Replacements**					
	Scum Skimmer Drive and Motor Replacement	5	EA	$10,000	$50,000	
	Replace Weir Launders with FRP	5	EA	$15,000	$75,000	
	Replace mechanisms for flights and chains	5	EA	$10,000	$50,000	
	Replace Metal Piping with Sch. 80 PVC	1	LS	$35,000	$35,000	
	Total					$210,000
	SUBTOTAL					**$725,000**
3	**Allowances**					
	Installation, Startup, and Comissioning	4	%		$30,000	
	Process Mechanical Allowance	10	%		$73,000	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	2	%		$15,000	
	Coating/Painting Allowance	1	%		$8,000	
	Total					$126,000
	SUBTOTAL					**$851,000**
	Estimating Contingency	30	%			$256,000
	SUBTOTAL					**$1,107,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$52,000
	SUBTOTAL					**$1,159,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$290,000
	CONSTRUCTION COST SUBTOTAL					**$1,449,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$290,000
	PROJECT COST					**$1,739,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	06-1	**PREPARED BY :**	DBH
TITLE :	Biotower Pump Room Corrosion Repair	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Floor grating**					
	Pump Base Corrosion Repair	3	LS	$5,000	$15,000	
	Pipe Support Corrosion Repair	3	LS	$5,000	$15,000	
	Piping Corrosion Repair	1	LS	$5,000	$5,000	
	Recoat floor with Vinyl Ester Coating	1921	SF	$25	$49,000	
	Total					$84,000
	SUBTOTAL					**$84,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	0	%		$0	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	10	%		$9,000	
	Total					$9,000
	SUBTOTAL					**$93,000**
	Estimating Contingency	30	%			$27,900
	SUBTOTAL					**$120,900**
	Sales Tax on 50% of Subtotal Above	9.25	%			$5,600
	SUBTOTAL					**$126,500**
	General Conditions, Contractor Overhead, & Profit	25	%			$31,700
	CONSTRUCTION COST SUBTOTAL					**$158,200**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$31,700
	PROJECT COST					**$190,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	06-2	**PREPARED BY :**	DBH
TITLE :	Biotower No. 1 Upgrade	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Biotower Distributor Mechanism Replacement**					
	Distributor Mechanism, Motor Actuated	1	EA	$119,000	$119,000	
	Total					$119,000
2	**Biotower Media Replacement**					
	Biotower Media - Top 2 Layers	11000	CF	$8	$88,000	
	Existing Media Disposal - Top 2 Layers	407	CY	$42	$18,000	
	Biotower Media - Lower 9 Layers	49500	CF	$8	$396,000	
	Existing Media Disposal - Lower 9 Layers	1833	CY	$42	$77,000	
	Total					$579,000
	SUBTOTAL					**$698,000**
3	**Allowances**					
	Installation, Startup, and Comissioning	20	%		$140,000	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$140,000	
	Coating/Painting Allowance	0	%		$0	
	Total					$280,000
	SUBTOTAL					**$978,000**
	Estimating Contingency	30	%			$293,400
	SUBTOTAL					**$1,271,400**
	Sales Tax on 50% of Subtotal Above	9.25	%			$58,900
	SUBTOTAL					**$1,330,300**
	General Conditions, Contractor Overhead, & Profit	25	%			$333,000
	CONSTRUCTION COST SUBTOTAL					**$1,663,300**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$333,000
	PROJECT COST					**$1,996,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	06-3	**PREPARED BY :**	DBH
TITLE :	Biotower Scrubber and Air Handling Unit Replacement	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Civil and Structural Costs**					
	Concrete Support Pad & Curb	2	EA	$26,000	$52,000	
	Earthwork	1	LS	$10,400	$10,400	
	Drainage Piping & Associated Valves	2	EA	$5,200	$10,400	
	Demo Existing Ductwork, Repair Ducting Holes	1	LS	$10,400	$10,400	
	Duct Supoorts	1	LS	$41,600	$41,600	
	Total					$124,800
2	**Odor Control Equipment**					
	Activated Carbon Absorbers (includes fans)	2	EA	$215,000	$430,000	
	Total					$430,000
3	**FRP Ducting and Dampers**					
	36" FRP Duct (to each absorber)	50	LF	$90	$4,500	
	36" FRP Volume Control Dampers	2	EA	$1,300	$2,600	
	36" FRP Fittings (elbows and tees)	6	EA	$900	$5,400	
	48" FRP Duct (combined flow to absorbers)	100	LF	$110	$11,000	
	48" FRP Volume Control Dampers	1	EA	$1,600	$1,600	
	48" FRP Fittings (elbows and tees)	8	EA	$900	$7,200	
	Total					$32,000
4	**Air Handling Unit**					
	Air Handling Unit	1	EA	$11,000	$11,000	
	Total					$11,000
	SUBTOTAL					**$597,800**
5	**Allowances**					
	Installation, Startup, and Comissioning	60	%		$359,000	
	Process Mechanical Allowance	10	%		$60,000	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	10	%		$60,000	
	Coating/Painting Allowance	0	%		$0	
	Total					$479,000
	SUBTOTAL					**$1,076,800**
	Estimating Contingency	30	%			$324,000
	SUBTOTAL					**$1,400,800**
	Sales Tax on 50% of Subtotal Above	9.25	%			$65,000

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	06-3	**PREPARED BY :**	DBH
TITLE :	Biotower Scrubber and Air Handling Unit Replacement	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	SUBTOTAL					**$1,465,800**
	General Conditions, Contractor Overhead, & Profit	25	%			$367,000
	CONSTRUCTION COST SUBTOTAL					**$1,832,800**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$367,000
	PROJECT COST					**$2,200,000**

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CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	08-1	**PREPARED BY :**	DBH
TITLE :	Secondary Clarifier Rehabilitation	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Rehabilitation**					
	Resurface concrete on effluent trough wall 2 feet under V-notch weirs and apply a coating	4	EA	$36,250	$145,000	
	Perform touch-up coating on the approx. 10% of surface area of clarifier mechanism and appurtenances including the cat-walk	4	EA	$21,750	$87,000	
	During clarifier mechanism touch-up coating, apply filler compound to fill in corrosion pits with less than 25% wall thickness loss as necessary	4	EA	$5,500	$22,000	
	During clarifier mechanism touch-up coating, perform weld repairs where wall thickness loss is greater than 25% as necessary	4	EA	$17,250	$69,000	
	Remove the top steel walkways, blast and coat walkway girders, and replace walking surface with FRP grating.	4	EA	$15,000	$60,000	
	Total					$383,000
	SUBTOTAL					**$383,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	5	%		$20,000	
	Process Mechanical Allowance	5	%		$20,000	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	10	%		$39,000	
	Total					$79,000
	SUBTOTAL					**$462,000**
	Estimating Contingency	30	%			$138,600
	SUBTOTAL					**$600,600**
	Sales Tax on 50% of Subtotal Above	9.25	%			$27,800
	SUBTOTAL					**$628,400**
	General Conditions, Contractor Overhead, & Profit	25	%			$158,000
	CONSTRUCTION COST SUBTOTAL					**$786,400**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$158,000
	PROJECT COST					**$944,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	08-2	**PREPARED BY :**	DBH
TITLE :	RAS/WAS Pump Replacements	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Pump Replacement**					
	RAS Pumps	6	EA	$30,000	$180,000	
	RAS Pump VFD's	6	EA	$40,000	$240,000	
	WAS Pumps	2	EA	$15,000	$30,000	
	Total					$450,000
	SUBTOTAL					**$450,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	60	%		$270,000	
	Process Mechanical Allowance	20	%		$90,000	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$90,000	
	Coating/Painting Allowance	5	%		$23,000	
	Total					$473,000
	SUBTOTAL					**$923,000**
	Estimating Contingency	30	%			$276,900
	SUBTOTAL					**$1,199,900**
	Sales Tax on 50% of Subtotal Above	9.25	%			$55,500
	SUBTOTAL					**$1,255,400**
	General Conditions, Contractor Overhead, & Profit	25	%			$314,000
	CONSTRUCTION COST SUBTOTAL					**$1,569,400**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$314,000
	PROJECT COST					**$1,883,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	09-1	**PREPARED BY :**	DBH
TITLE :	CCT Gate Replacement	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Gate Replacement**					
	72" Stainless Steel Slide Gates (SG9.1, SG9.2, SG9.3)	2	EA	$70,000	$140,000	
	Total					$140,000
	SUBTOTAL					**$140,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	20	%		$28,000	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$28,000	
	Coating/Painting Allowance	0	%		$0	
	Total					$56,000
	SUBTOTAL					**$196,000**
	Estimating Contingency	30	%			$59,000
	SUBTOTAL					**$255,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$12,000
	SUBTOTAL					**$267,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$67,000
	CONSTRUCTION COST SUBTOTAL					**$334,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$67,000
	PROJECT COST					**$401,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	09-2	**PREPARED BY :**	DBH
TITLE :	CCT Valve Rehabilitation	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Valves and Screen Improvements**					
	Refurbish telescoping valves	4	EA	$7,500	$30,000	
	New Recycled Water Barscreen	1	EA	$75,000	$75,000	
	Total					$105,000
	SUBTOTAL					**$105,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	30	%		$32,000	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$21,000	
	Coating/Painting Allowance	0	%		$0	
	Total					$53,000
	SUBTOTAL					**$158,000**
	Estimating Contingency	30	%			$48,000
	SUBTOTAL					**$206,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$10,000
	SUBTOTAL					**$216,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$54,000
	CONSTRUCTION COST SUBTOTAL					**$270,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$54,000
	PROJECT COST					**$324,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	10-1	**PREPARED BY :**	DBH
TITLE :	CCT Effluent Pipe Corrosion Repair	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Effluent Pipe Corrosion Repair**					
	Effluent Pipe Replacement	1	LS	$200,000	$200,000	
	Bypass Pumping	30	Day	$5,000	$150,000	
	Total					$350,000
	SUBTOTAL					**$350,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	0	%		$0	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	5	%		$18,000	
	Total					$18,000
	SUBTOTAL					**$368,000**
	Estimating Contingency	30	%			$110,400
	SUBTOTAL					**$478,400**
	Sales Tax on 50% of Subtotal Above	9.25	%			$22,200
	SUBTOTAL					**$500,600**
	General Conditions, Contractor Overhead, & Profit	25	%			$126,000
	CONSTRUCTION COST SUBTOTAL					**$626,600**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$126,000
	PROJECT COST					**$753,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	10-2	**PREPARED BY :**	DBH
TITLE :	Gallery C Pump Replacements	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Pump Replacements**					
	Carrier Water Pumps - 30 hp	3	EA	$9,000	$27,000	
	Total					$27,000
	SUBTOTAL					**$27,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	60	%		$17,000	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$6,000	
	Coating/Painting Allowance	5	%		$2,000	
	Total					$25,000
	SUBTOTAL					**$52,000**
	Estimating Contingency	30	%			$16,000
	SUBTOTAL					**$68,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$4,000
	SUBTOTAL					**$72,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$18,000
	CONSTRUCTION COST SUBTOTAL					**$90,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$18,000
	PROJECT COST					**$108,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	12-5	**PREPARED BY :**	DBH
TITLE :	Solids Handling Building Elevator Replacement	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Elevator Replacement**					
	Demo Existing Elevator	1	LS	$20,000	$20,000	
	New Elevator	1	EA	$250,000	$250,000	
	Total					$250,000
	SUBTOTAL					**$250,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	0	%		$0	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	0	%		$0	
	Total					$0
	SUBTOTAL					**$250,000**
	Estimating Contingency	30	%			$75,000
	SUBTOTAL					**$325,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$16,000
	SUBTOTAL					**$341,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$86,000
	CONSTRUCTION COST SUBTOTAL					**$427,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$86,000
	PROJECT COST					**$513,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	13-2	**PREPARED BY :**	DBH
TITLE :	Digester Basement Floor Slab Repair	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Floor Recoating**					
	Staging and Mobilization Allowance	1	LS	$50,000	$50,000	
	Replace Leveling Grout in Saw-Cut Area	65	SF	$100	$6,500	
	Expansion Joint Repair	1	LS	$1,500	$1,500	
	Total					$58,000
	SUBTOTAL					**$58,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	0	%		$0	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	0	%		$0	
	Total					$0
	SUBTOTAL					**$58,000**
	Estimating Contingency	30	%			$17,400
	SUBTOTAL					**$75,400**
	Sales Tax on 50% of Subtotal Above	9.25	%			$3,500
	SUBTOTAL					**$78,900**
	General Conditions, Contractor Overhead, & Profit	25	%			$19,800
	CONSTRUCTION COST SUBTOTAL					**$98,700**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$19,800
	PROJECT COST					**$119,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	14-1	**PREPARED BY :**	DBH
TITLE :	Main Switchgear Replacement	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Switchgear Replacement**					
	Electrical demolition	1	LS	$25,000	$25,000	
	New switchgear	1	LS	$420,000	$420,000	
	HVAC unit	1	LS	$100,000	$100,000	
	Total					$545,000
	SUBTOTAL					**$545,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	0	%		$0	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	0	%		$0	
	Total					$0
	SUBTOTAL					**$545,000**
	Estimating Contingency	35	%			$190,800
	SUBTOTAL					**$735,800**
	Sales Tax on 50% of Subtotal Above	9.25	%			$34,100
	SUBTOTAL					**$769,900**
	General Conditions, Contractor Overhead, & Profit	10	%			$77,000
	CONSTRUCTION COST SUBTOTAL					**$846,900**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$170,000
	PROJECT COST					**$1,017,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	21-1	**PREPARED BY :**	DBH
TITLE :	OWRF Pump Replacement	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Pipe Reconfiguration**					
	FOG/F2E Mix Pumps (with hardened stainless steel pump internals and casings)	2	EA	$20,000	$40,000	
	Total					$40,000
	SUBTOTAL					**$40,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	0	%		$0	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	6	%		$3,000	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	0	%		$0	
	Total					$3,000
	SUBTOTAL					**$43,000**
	Estimating Contingency	30	%			$12,900
	SUBTOTAL					**$55,900**
	Sales Tax on 50% of Subtotal Above	9.25	%			$2,600
	SUBTOTAL					**$58,500**
	General Conditions, Contractor Overhead, & Profit	25	%			$15,000
	CONSTRUCTION COST SUBTOTAL					**$73,500**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$15,000
	PROJECT COST					**$89,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	00-1	**PREPARED BY :**	DBH
TITLE :	Roof Repairs	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Roof Repairs**					
	Headworks Roof	8700	SF	$3	$26,100	
	Biotower Control Room Roof	600	SF	$3	$1,800	
	Switchgear Facility Roof	900	SF	$3	$2,700	
	Total					$30,600
	SUBTOTAL					**$30,600**
2	**Allowances**					
	Installation, Startup, and Comissioning	0	%		$0	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	0	%		$0	
	Total					$0
	SUBTOTAL					**$30,600**
	Estimating Contingency	30	%			$9,200
	SUBTOTAL					**$39,800**
	Sales Tax on 50% of Subtotal Above	9.25	%			$1,900
	SUBTOTAL					**$41,700**
	General Conditions, Contractor Overhead, & Profit	25	%			$11,000
	CONSTRUCTION COST SUBTOTAL					**$52,700**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$11,000
	PROJECT COST					**$64,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	00-2	**PREPARED BY :**	DBH
TITLE :	Gallery Pipe Reconfiguration	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Pipe Reconfiguration**					
	Replace and Reroute Chemical Piping	1	LS	$50,000	$50,000	
	Total					$50,000
	SUBTOTAL					**$50,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	0	%		$0	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	5	%		$3,000	
	Total					$3,000
	SUBTOTAL					**$53,000**
	Estimating Contingency	30	%			$15,900
	SUBTOTAL					**$68,900**
	Sales Tax on 50% of Subtotal Above	9.25	%			$3,200
	SUBTOTAL					**$72,100**
	General Conditions, Contractor Overhead, & Profit	25	%			$19,000
	CONSTRUCTION COST SUBTOTAL					**$91,100**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$19,000
	PROJECT COST					**$110,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	1 - EQUIPMENT AND FACILITY CONDITION ASSESSMENT	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR JANUARY 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	10/12/2017
PROJECT ID :	00-4	**PREPARED BY :**	DBH
TITLE :	Crack and Leak Repairs	**REVIEWED BY :**	AG

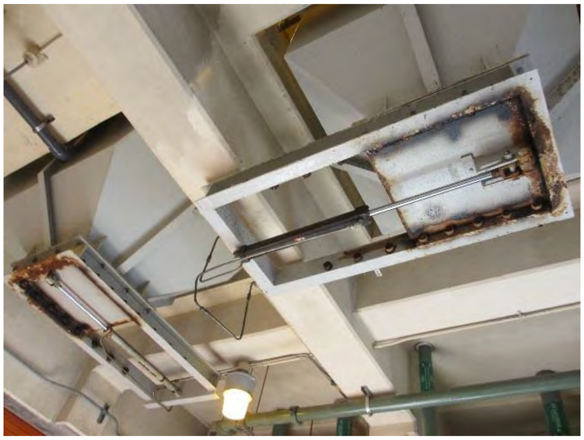
ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Pipe Reconfiguration**					
	Crack and Leak Repairs	1	LS	$60,000	$60,000	
	Total					$60,000
	SUBTOTAL					**$60,000**
2	**Allowances**					
	Installation, Startup, and Comissioning	0	%		$0	
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	5	%		$3,000	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	1	%		$1,000	
	Total					$4,000
	SUBTOTAL					**$64,000**
	Estimating Contingency	30	%			$20,000
	SUBTOTAL					**$84,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$4,000
	SUBTOTAL					**$88,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$22,000
	CONSTRUCTION COST SUBTOTAL					**$110,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$22,000
	PROJECT COST					**$132,000**

APPENDIX C – SITE PHOTOS

Select site photos are included in this appendix. The photos are organized by process area.

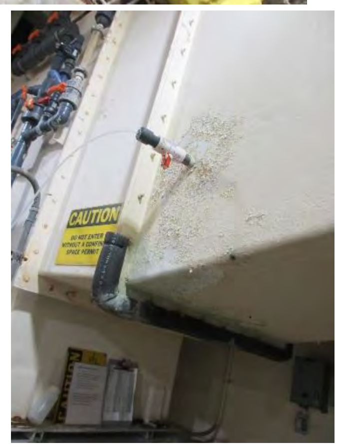
Headworks (Area 04)

The grit chamber room is classified as a Class 1, Division 2, area and the team did not take any electronic equipment into the room, this included cameras.



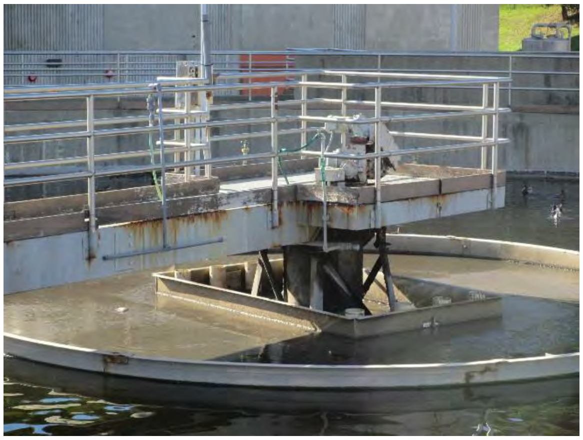
Primary Clarifiers and Pumping (Area 05)

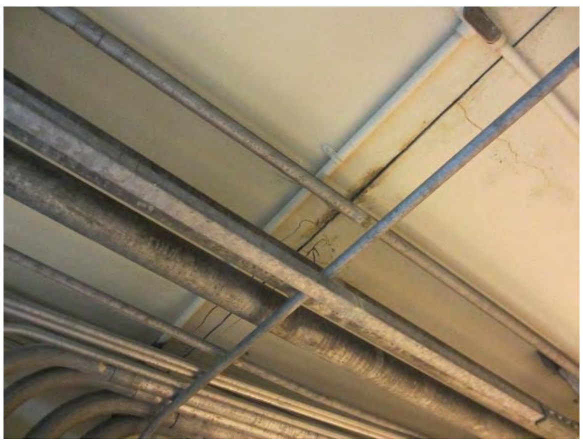
Bio-towers (Area 06)

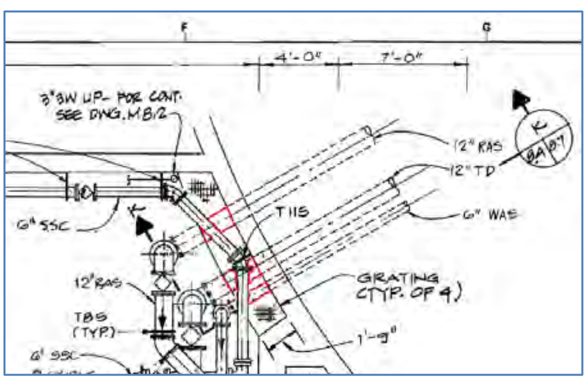


Aeration (Area 07)

Secondary Clarifiers and Pumping (Area 08)



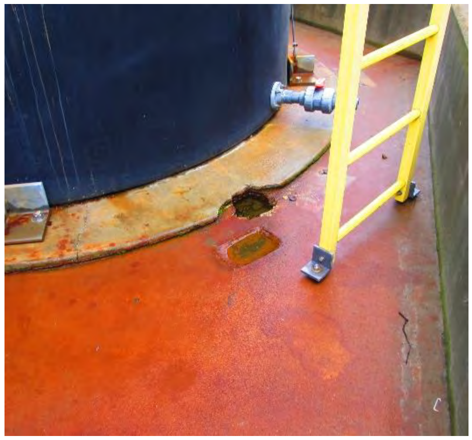




Chlorine Contact Tanks (Area 09)

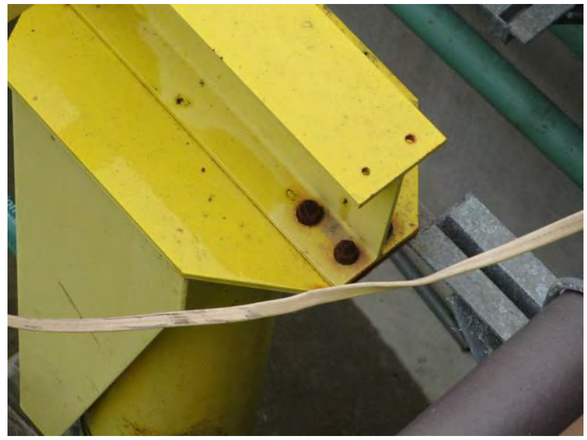
Disinfection (Area 10)

Solids Handling Building (Area 12)



Digesters (Area 13)

Food to Energy Facility (Area 21)



Additional Observations and Areas

APPENDIX D – RISK ANALYSIS DETAILS

No.	Area	Project Num	Project Title	Project Description	Timing	PoF Score	CoF - Regulatory & Environment	CoF - Safety & Community	CoF - Financial	CoF - Operational	Total CoF Score	Risk Score	Risk Rank
1	Headworks (04)	04-1	Hydraulic Unit Replacement	Remove the hydraulic unit located in the headworks building and associated fluid lines. Convert all existing pneumatic units to electric operation and decommissioning hydraulic unit.	3-5 years	4	2	3	3	4	4	16	2
2	Headworks (04)	04-2	Grit Classifiers and Hoppers Replacement	Replace four of the five grit classifiers, associated grit pumps, and repair or replace the associated grit hoppers. The fifth classifier was installed around 2008 and does not need replacement. Remove and replace grit piping with glass-lined pipe.	3-5 years	4	1	2	2	2	2	8	16
3	Headworks (04)	04-3	Grit Blower and Diffuser Replacements	Replace the original blowers and associated diffusers for the aerated grit tanks. The budget estimates replacing two blower units only because there is money in the FY18 CIP to replace the diffusers with new a generation of diffuser for this application.	3-5 years	4	1	1	3	3	3	12	7
4	Headworks (04)	04-4	Grit Room Rehabilitation	Rehabilitation of most metal components within the grit room, including repair corrosion on slide gates, replacement of bar screen motors, replacing non-explosion proof control panels (for arcing or sparking contacts) and conduit seals inside the classified area, and upgrade the air handling system with a activated carbon system per the recommendations in the 2015 Brown and Caldwell Odor Control study.	5-10 years	3	3	1	2	3	3	9	14
5	Headworks (04)	04-5	Ferric Room Floor Coating	Recoat the floor in the ferric room.	10-15 years	2	1	1	2	1	2	4	24
6	Primaries (05)	05-1	Primary Clarifier Rehabilitation	Recoat clarifier interior concrete, repair cracks in columns and under walkways, replace scum skimmer drives and motors, replace metal piping and appurtenances in Clarifier Nos. 1 thru No. 5, including weir launders.	3-5 years	4	3	2	4	4	4	16	2
7	Bio-towers (06)	06-1	Biotower Pump Room Corrosion Repair	Repair corrosion in bio-tower pump room. The floor coating and grating was damaged from a chlorine spill in this room. Replace corroded areas of floor grating, recoat concrete floor, repair and recoat corroded pump bases and pipe supports.	5-10 years	3	1	2	2	1	2	6	20
8	Bio-towers (06)	06-2	Biotower No. 1 Upgrade	Replace rotating mechanism and media of bio-tower no. 1. (Budgetary number includes replacement of all media. Alternative option to replace only the top two layers of media upon detailed inspection of lower layers.)	3-5 years	4	1	1	3	3	3	12	7
9	Bio-towers (06)	06-3	Biotower Scrubber and Air Handling Unit Replacement	Replace the odor scrubber and air handling unit. Per detailed recommendations in 2015 Brown and Caldwell design report for plant odor control systems, recommended alternative is to replace existing scrubber with with two activated carbon units located adjacent to the building.	10-15 years	2	3	3	3	2	3	6	20
10	Secondaries (08)	08-1	Secondary Clarifier Rehabilitation	Repair corrosion on the mechanisms and metal components inside the clarifiers, resurface the effluent trough concrete, and retrofit the catwalk with FRP. (Per detailed recommendations from 2016 condition assessment of the secondary clarifiers by V&A.)	0-2 years	5	1	1	2	3	3	15	4
11	Secondaries (08)	08-2	RAS/WAS Pump Replacements	Replace RAS and WAS pumps, secondary scum and drain pumps, and VFDs for the RAS pumps.	3-5 years	4	2	1	2	3	3	12	7
12	CCT (09)	09-1	CCT Gate Replacement	Replace the influent gates of all tanks with stainless steel gates.	3-5 years	4	1	1	2	2	2	8	16
13	CCT (09)	09-2	CCT Valve Rehabilitation	Refurbish the telescoping valves on chlorine contact tanks 1 to 4. Replace recycled water (3W) bar screen (consider replacing with better technology with finer screens). Alternative option is to replace telescoping valves with rotating pipe skimmers with motorized actuators..	5-10 years	3	1	1	2	2	2	6	20
14	Gallery L (10)	10-1	CCT Effluent Pipe Corrosion Repair	Repair corrosion on the 54" effluent pipe in Gallery L. Repair the leaks in the concrete overhead.	0-2 years	5	3	2	3	4	4	20	1
15	Gallery C (10)	10-2	Gallery C Pump Replacements	Replace scum pumps, carrier water pumps, effluent sample pump, and the two adjacent sample pumps.	3-5 years	4	2	1	1	3	3	12	7
16	SHB (12)	12-5	Solids Handling Building Elevator Replacement	Replace the elevator of the solids handling building	5-10 years	3	1	2	1	1	2	6	20
17	Multiple	00-1	Roof Repairs	Repair the roofs for the following areas: headworks, bio-tower control room, solids handling building, and switchgear facility.	3-5 years	4	1	1	3	2	3	12	7
18	Multiple	00-2	Gallery Pipe Reconfiguration	Replace leaking chemical lines located along the gallery walls with double contained PVC pipe. If necessary, reconfigure the piping to relocate chemical lines to the bottom row.	3-5 years	4	2	1	2	2	2	8	16
19	Multiple	00-4	Crack and Leak Repairs	Repair cracks in concrete walls, floors, and ceilings using injection in the following areas: Galley E ceiling, Gallery L ceiling above RAS piping, multiple locations along Gallery B walls, primary clarifier wall in Gallery A.	5-10 years	3	3	1	3	1	3	9	14
20	Digesters (13)	13-1	Digester Mixing Pump Study	Conduct a study to investigate the cause of the pump vibration, possible remedies, its relationship to the cracks on the wall of the pump mix room, and the need for additional supports for the discharge header.	0-2 years	5	1	1	2	3	3	15	4
21	Digesters (13)	13-2	Digester Basement Floor Slab Repair	Repair the saw cut area in the digester basement. (Per detailed recommendations from 2016 condition assessment of the secondary clarifiers by V&A.)	3-5 years	4	1	1	1	1	1	4	24
22	Switchgear (14)	14-1	Main Switchgear Replacement	Replace the main switchgear in the existing building. Based on our experience, the 30-year old main switchgear will need to be replaced by the time it is 45 years old.	10-15 years	2	1	1	4	5	5	10	13
23	Food to Energy Facility (21)	21-1	OWRF Pump Replacement	Replace the two FOG/F2E Mix Pumps with pump more suited for this type of process. Replace the pumps with hardened stainless steel pump internals and casings.	3-5 years	4	1	2	2	2	2	8	16
24	Multiple	99-1	Seismic Study	Evaluate seismic impacts due to site settlement. Subsidence of the ground was observed in multiple areas of the plant, including the bio-tower building and between the aeration and secondary clarifier areas. Because the plant was constructed on piles, the settlement has produced gaps under the bottom of buildings. There is potential that the seismic design was dependent on the tops of the piles being at grade and fully supported. With the tops of the piles exposed, the unsupported pile length may be over stressed during an earthquake resulting in pile failure. The settlement may have affected buried piping between the major processes. An assessment is recommended to evaluate the risk posed by structural changes resulting from settlement.	3-5 years	4	1	1	3	1	3	12	7
25	FOG (21)	99-3	OWRF Crane Optimization Evaluation	Evaluate alternatives for replacing the existing two-crane system in the Food to Energy area with a single crane system. This system may be best implemented during a future expansion of the facility.	10-15 years	2	1	1	1	2	2	4	24
26	Headworks (04)	99-4	Influent Flow Meter Alternatives Study	The influent flow meters appear to be oversized for typical plant flows. Prepare a study that evaluates potential alternatives or options that can measure high and low flows. Potential alternatives include a low-flow bypass with a dedicated meter or adding redundant meters with better accuracy at low flows that can be disregarded during high flows.	0-2 years	5	1	1	3	2	3	15	4

APPENDIX E – AGENCY'S CONDITION ASSESSMENT ACTION PLAN

CMSA Facilities Masterplan - Condition Assessment TM Evaluation and Action Plan

Area	Item#	TM pg.	Action	Status
General	1		Carollo to add standard NFPA 820 language at beginning of findings section, to say that areas not in compliance with NFPA 820 do not need to be immediately brought into compliance since they were constructed before the current NFPA 820 standards were implemented. CMSA will consider bringing specific areas into compliance as projects are implemented in those areas.	
	2		Carollo to revise cost estimates to calculate each item that is based on a multiplier of the construction cost separately then add them together.	
	3		Remove notes/findings from report based on "conversations with staff."	
	4		Engineering/Ops to prepare Agency flow meter reference document- where located, type, flow measured, etc.	
Headworks	5	1-13	Engineering to check records to see if roof has been replaced. If original roof add to CIP.	
	6	1-13	CMSA will replace screen motors as part of routine maintenance work	
	7	1-13	Scrubber fiberglass leaks will be repaired if possible. Replacement in CIP for 10yr.	
	8		Maintenance to remove control valves and flow meters on scrubber piping.	
	9	1-14	PM for engineering to annually check deflection on RV Interceptor.	
	10	1-14	Hydraulic unit: separate clarifier and grit tank and grit dewatering hopper gate opening systems. Grit "handling systems" tanks will use a new hydraulic unit and clarifiers will use electric openers. Add both to CIP.	
	11	1-14	Ferric room floor to be coated in 10 years – add to CIP	
	12		Maintenance to replace room kick-boards and repair corner concrete.	
	13	1-14	Engineering to commission influent meter evaluation study – to determine if more accurate meters exist	
	14	1-14 1-17	Grit Handling Study –evaluate system efficiency and options for pumping, pipe replacement, and dewatering. Add to CIP with placeholder funds for replacement of each component.	

Area	Item#	TM pg.	Action	Status
Headworks	15		CMSA will not separate the aeration channel air system from the Headworks air system. Both will remain in the headworks compressor room.	
Primary Clarifiers	16	1-15 1-16	Bundle Primary Clarifier rehab projects to: replace launder with fiberglass units, replace piping with plastic pipe, replace coatings above waterline, apply epoxy over worn concrete in sludge collection sump area, recoat any metal components, and replace skimmer motor/drive unit assemblies. Plan is to implement projects for two clarifiers one year and three clarifiers the following year.	
	17	1-16	Maintenance project to replace the sludge pump bases with stainless bases.	
	18	1-17	Replace gallery A air handling units – add to CIP for year 10	
Biotowers	19	1-17	Engineering project to replace Biotower 1 rotating mechanism and top two layers of media. Adjust CIP amount as needed. Decide if hydraulic or electric drive system. Maintenance prefers electric motor.	
	20	1-17	Include roof replacement in CIP (if not there) to resolve minor leaks.	
	21	1-17	Referenced Cl2 odor was a one-time event.	
	22	1-18	Replace control room air handling unit in approximately 10 years. Add to CIP.	
	23	1-18	Maintenance to procure and replace corroded grating with FRP grating.	
	24	1-18	Maintenance to repair pump bases.	
	25		Apply chemical resistant coating to floor – CIP project	
	26		Maintenance to remove control valves and flow meters on scrubber piping.	
Aeration			Nothing	
Secondary Clarifiers	27	1-19	Collector drives need to be cleaned and recoated. Maintenance project.	

Area	Item#	TM pg.	Action	Status
Secondary Clarifiers	28	1-19	Collector mechanism and RAS pump replacement dependent on RWB blending requirements in next NPDES permit. If additional secondary capacity not required, mechanisms will be rehabilitated.	
	29	1-19	CMSA agrees that RAS and WAS pumps will be replaced in future. Schedule and capacities dependent on #26 above. May consider using only RAS pumps with diverter valves for RAS/WAS.	
	30	1-19	Maintenance to inspect RAS, WAS, and drain lines to determine extent of corrosion, and scope of project. Hire V&A to ultrasonically measure the existing pipe wall thickness. Future possible project to replace expansion joints as part of pump replacement project.	
CCTS	31	1-21	Maintenance to coat CCT 1-6 gate frames. Add to CIP a project to apply coating to CCT wall above waterline and all piping.	
	32	1-21	Replace CCT 1-4 gates with stainless units within 10 years. Add to CIP.	
	33		Install new slide gate on channel leading to CCTs 5 and 6. Add to CIP.	
	34	1-21	Maintenance to reseat CCT 5 gate to stop leaking.	
	35	1-21	Replace RW screen with unit that has smaller openings. Add to CIP – 2 years +/-	
Chemical Storage Bldg.	36	1-22	Engineering to review CMSA basis of design report to learn original intent/uses for 54" pond drain line, then CIP team to evaluate future need for line.	
	37	1-22	Maintenance to replace CCT scum pumps, drip trays, and isolation valves.	
	38	1-22	Maintenance to clean and recoat carrier water pumps.	
	39	1-22	Maintenance to replace sanitary sump access hatches.	
	40	1-22	CIP team to investigate leak at CCT wall pipe penetration and determine the repair scope of work, then make/coordinate repairs.	
	41	1-22	Maintenance to continue to rebuild bioassay and turtle pond pumps monthly, recoat their bases and pump pad, and keep spare parts on hand for them and the dechlor sample pump.	

Area	Item#	TM pg.	Action	Status
Solids Handling	42	1-23	Ferric facility concrete rehab and coating in FY18 CIP	
	43	1-23	Process waste sump hatch on SHB roof will be replaced by maintenance	
	44	1-23	Engineering to include elevator control replacement project in CIP	
	45	1-23	Biogas compressors may be replaced when cogeneration system replaced	
	46	1-24	Carollo should note that 2 heat exchangers were replaced and the waste heat unit will be this FY	
	47	1-25	Biosolids hoppers coating to be inspected and repaired as needed; new hopper skirts will be installed soon; CIP team to evaluate hopper configurations when centrifuges replaced.	
	48		Maintenance to remove control valves and flow meters on scrubber piping.	
Digesters	49	1-25	Basement floor near heat exchanger to be repaired in near future.	
	50		Maintenance to replace the basement sanitary sump cover plate.	
	51	1-26	Maintenance to replace mixing pump piping supports with new style.	
	52	1-26	Digester wall to be recoated by Maintenance.	
	53	1-26	E/I to place Arc Flash labels on 480V panels in pump mixing room.	
	54	1-26	Maintenance to anchor new mixing pump bleed-off piping to floor.	
Switchgear	55	1-27	Engineering will include project to replace switchgear in 10 years in CIP; reassess then.	
	56	1-27	Engineering to include roof replacement in a larger facility project, if needed.	
	57	1-27	CIP team to schedule project to cover room louvers and add air conditioner	
	58	1-27	E/I to inspect bus duct condition and report findings and make recommendations.	
OWRF	59	1-28	Project to coat or replace corroding crane bolts.	

Area	Item#	TM pg.	Action	Status
OWRF	60	1-28	Team decided to not replace cranes with a single crane, per facility pre-design decision.	
	61	1-28	Team decided to not replace mixing pump impellers with hardened stainless steel pumps.	
Other	62	1-29	Engineering to plan seismic study of pile supported structures given soil consolidation.	
	63	1-29	E/I to continue to replace light fixtures per plan with LED units.	
	64	1-29	CIP team to scope out gallery wall and ceiling crack sealing project, then add to CIP.	
	65	1-29	Maintenance to relocate all chemical lines to below DI pipes.	
	66	1-29	CIP team to plan project to replace gallery pipe hangers.	

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM NO. 2
BIOGAS UTILIZATION

FINAL
October 2018

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN
TECHNICAL MEMORANDUM
NO. 2
BIOGAS UTILIZATION

TABLE OF CONTENTS

Page No.

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

DISCLOSURE STATEMENT

Funding for this document has been provided in full or in part through an agreement with the State Water Resources Control Board. California's Clean Water State Revolving Fund is capitalized through a variety of funding sources, including grants from the United States Environmental Protection Agency and state bond proceeds. The contents of this document do not necessarily reflect the views and policies of the foregoing, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

1.0 INTRODUCTION

This technical memorandum (TM) summarizes the estimated quantity of biogas that would be generated at the Central Marin Sanitation Agency's (Agency) Wastewater Treatment Plant (WWTP) for three scenarios from importing more organic waste (fats, oils, and grease [FOG]) and food waste (FW).

The TM also summarizes an assessment of three alternatives to beneficially use the additional biogas generated by maximizing the organic loading capacity of the two anaerobic digesters at the WWTP. The three biogas utilization alternatives evaluated include: 1) feeding the additional biogas to a new engine generator to produce electricity, 2) converting the additional biogas to produce renewable natural gas (RNG) for off-site vehicle fueling, and 3) converting the additional biogas to produce RNG for off-site pipeline injection.

2.0 SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

The key findings are:

- Three planning scenarios were considered to estimate the future production of biogas assuming increased high-strength waste (HSW) in the digester feed. The first scenario would achieve plant self-sufficiency, the second scenario would maximize existing cogeneration capacity, and the third scenario would maximize existing digestion capacity.
- The three scenarios developed were reviewed with Agency staff, and Scenario 2 was selected for planning purposes to evaluate the expansion of the existing Organic Waste Receiving Facility, as discussed in TM No. 3.
- This TM also considered potential uses for the additional biogas that could be generated by Scenario 3. This additional biogas would exceed the existing cogeneration capacity of the Agency, so three alternate biogas uses were considered:
  - Producing electricity from an additional cogeneration system.
  - Producing RNG for off-site vehicle refueling.
  - Producing RNG for off-site pipeline injection.
- The cogeneration alternative has the lowest capital cost at $8.9 million as well as the simplest implementation. Additionally, the price obtained for electricity sold back to

the grid is fixed for the term of the agreement, providing certainty for the revenue generating potential.

- The RNG for fueling station alternative has a capital cost of $13.3 million. This alternative takes advantage of RNG's relatively higher value as a vehicle fuel and the currently available LCFS credits and RIN value. However, there is uncertainty regarding the future value of LCFS credits and RINs and there is no guarantee of a long-term fixed RNG price, so this alternative is inherently more risky. Additionally, further coordination with PG&E is needed to confirm the assumptions made in this TM which are based on the Agency's preliminary conversations with PG&E.
- The RNG for pipeline injection alternative has the highest capital cost of $22.6 million. Furthermore, no credits are assumed for pipeline injection. Like the RNG for fueling station alternative, further coordination with PG&E is needed to confirm this option is viable. Thus, this alternative has a high implementation risk and high capital cost, as well as limited revenue generating capability.

3.0 BACKGROUND

The Agency's WWTP has two anaerobic digesters that are each 80 feet in diameter with a side water depth of 26 feet. The digesters were constructed in the early 1980s and are used to digest primary sludge (PS) and thickened waste activated sludge (TWAS). The biogas produced in the digesters is used to heat plant process water and to generate electricity to supplement the Agency's power needs.

In 2012, an Organic Waste Receiving Facility (OWRF) was constructed to accept FOG from private haulers and pre-processed FW slurry. Shortly thereafter, FOG and FW were also being processed by the digesters along with the PS and TWAS to increase biogas production and electrical power generation at the WWTP.

Electrical power generation is currently accomplished by feeding the biogas to a 750 kW Waukesha lean-burn, reciprocating engine generator that is housed inside the Solids Handling Building. A biogas treatment system is provided ahead of the engine generator to remove hydrogen sulfide, siloxanes, and moisture to minimize fouling and corrosion of the cogeneration equipment.

In August 2016, an Interconnection Agreement Study (Study) was completed to evaluate the Agency's then current Interconnection Agreement (IA) with Pacific Gas & Electric (PG&E). The Study also analyzed potential modifications to the IA and evaluated various alternatives for the Agency to reduce existing electricity cost and potentially generate additional revenue from the sale of additional renewable energy produced at the WWTP above that needed to achieve plant self-sufficiency.

In May 2017, the Agency approved a new IA with PG&E that allows the Agency to supply power to the PG&E electrical grid. Modifications to PG&E's electrical system and the

Agency's cogeneration electrical system are underway to comply with the new IA. In addition, the Agency has also completed a separate power purchase agreement with Marin Clean Energy for their Feed-In-Tariff (FIT) power sale program.

4.0 BIOGAS PRODUCTION

4.1 Current Operation

Operations and performance data for fiscal year 2016/17 (FY 16/17) were analyzed to develop a basis for estimating future average and peak biogas production. As described in the background section, the Agency currently digests PS, TWAS, FOG, and FW to produce biogas for use in an existing 750 kW engine generator.

To monitor this operation, the WWTP reports the daily volume of PS and TWAS fed to the digesters and measures the total solids (TS) concentration and volatile solids (VS) fraction typically three times per week. The volume of each FOG delivery and weight of each FW delivery are also reported. During the first half of FY 16/17, the TS concentration and VS fraction of each FOG and FW delivery were measured. If there were multiple deliveries of either stream on a given day, a daily volume-weighted (FOG) or weight-weighted (FW) TS concentration and VS fraction were calculated for this analysis. However, starting in January 17, 2017, the TS concentration and VS fraction were measured twice per week in the blended FOG and FW pumped to the digesters. Accordingly, for this analysis, the corresponding FW volume was calculated using an average bulk density of 8.34 lb/gal., similar to the density of water.

Digester feed flow rate and VS load were calculated using the sum of the PS, TWAS, FOG, and FW volumes and VS loads. The corresponding volatile solids loading rate (VSLR) and hydraulic residence time (HRT) were calculated based on both digesters in service. The average digested sludge VS fraction in each digester was used to calculate the overall volatile solids reduction (VSr). All of these values for FY 16/17 are shown in Table 2.1.

The Agency also reports the daily volume of biogas produced, daily average electrical power from cogeneration (cogen), and the fraction of time the cogen engine is powered by biogas. These data were used to calculate the specific biogas production (i.e., standard cubic feet per pound of VS removed (scf/lb VSr)) and biogas (electrical) energy generation. These historical values are also shown in Table 2.1. Average biogas flow rate for the existing data is the average biogas flow rate measured from FY 16/17 while peak biogas flow rate is 1.4 times the average biogas flowrate and represents peak week biogas flow.

Note that the calculated average power generation of 567 kW for FY 16/17, shown in Table 2.1, represents engine operation on biogas only. During FY 16/17, natural gas was purchased during certain periods to provide an additional 49 kW of power production on average. Additionally, an average of 37 kW of electrical power was purchased from PG&E to meet the overall Agency's WWTP electrical power demand of 653 kW.

Table 2.1 Projected Biogas Energy Production
2017 Facilities Master Plan
Central Marin Sanitation Agency

	FY 16/17[(1)]	Scenario 1[(2)]	Scenario 2[(3)]	Scenario 3[(4)]
Digester Feed				
PS+TWAS VS Load, klb VS/d (@8.03 mgd ADWF)	16.2	16.2	16.2	16.2
FOG VS Load, klb VS/d	3.32	4.80	6.66	21.5
FW VS Load, klb VS/d	3.84	4.22	4.22	4.22
Total VS Load, klb VS/d	23.4	25.2	27.1	41.9
PS+TWAS Load Fraction, %	69	64	60	39
FOG Load Fraction, %	14	19	25	51
FW Load Fraction, %	16	17	16	10
FOG+FW Load Fraction, %	31	36	40	61
VSLR, lb VS/d-cf	0.083	0.096	0.104	0.160
Hydraulic Residence Time (HRT), d	31.7	29.8	28.1	17.5
Digester Performance				
VSr, %	65.9	67.4	68.9	76.4
Average Biogas Flowrate, scfm[(5)]	190	215	243	466
Average Biogas Flowrate, scfd[(5)]	273,600	309,600	349,920	671,040
Peak Biogas Flowrate, scfm[(5,6)]	266	301	340	652
Peak Biogas Flowrate, scfd[(5,6)]	383,040	433,440	489,888	939,456
Biogas Methane Fraction, %	62.2	63.2	64.3	68.1
Average Biogas Gross Energy Production Rate, MBtu/hr	6.44	7.43	8.53	17.3
Electrical Power Generation				
Average Electrical Power, kW[(7)]	567	653	750	1,520

Notes:

(1) Calculated based on FY 16/17 average PS+TWAS, FOG, and FW VS loads; Q=8.03 mgd ADWF.
(2) FY 16/17 average PS+TWAS VS load, 10% increase in FW VS load, average electrical power goal = 653 kW (excludes NG and PG&E power purchases).
(3) FY 16/17 average PS+TWAS VS load, 10% increase in FW VS load, average electrical power goal = 750 kW (maximum cogen system power output).
(4) FY 16/17 average PS+TWAS VS load, digester feed VS load = 41.9 klb/d (VSLR = 0.160 lb/d-cf), 10% increase in FW VS load, FOG VS load by difference (maximum digester loading capacity).
(5) Standard conditions of 60 deg F, 1 atm.
(6) Peak:average biogas flowrate = 1.4.
(7) Assumes cogeneration electrical efficiency of 30%.

4.2 Potential Future Operation with Increased HSW

While future PS and TWAS are not expected to substantially increase in the future, the amount of high-strength waste (HSW), specifically FOG and FW, accepted by the Agency is anticipated to increase over time. To account for this, three planning scenarios were developed and described below.

- **Scenario 1, Achieve Plant Self-Sufficiency:** This scenario is based on increasing the digester FOG and FW VS load to offset the current natural gas and electrical power purchases and become energy self-sufficient. Assuming a maximum FW VS load increase of 10 percent above FY 16/17 levels, the FOG VS load would need to increase to 4.80 klb VS/d to generate sufficient biogas to recover 653 kW of electrical power from the existing cogeneration system. Accordingly, the total FOG and FW VS load fraction of the total digester feed would need to increase from 31 percent to approximately 36 percent.

- **Scenario 2, Maximize Cogeneration Capacity:** This scenario is based on increasing the digester FOG and FW VS load to go beyond energy neutrality and recover 750 kW of electrical power, which equates to the capacity of the existing cogeneration system. Assuming a maximum FW VS load increase of 10 percent above FY 16/17 levels, the FOG VS load would need to increase to 6.66 klb VS/d to recover 750 kW of electrical power. Accordingly, the total FOG and FW VS load fraction of the total digester feed would need to increase from 31 percent to approximately 40 percent.

- **Scenario 3, Maximize Digestion Capacity:** This scenario is based on maximizing biogas energy production by maximizing the digester feed VS load and maximizing the fractional digester FOG VS load. A combined digester feed VS load of 41.9 klb/d was calculated using a maximum VSLR of 0.16 lb VS/d-cu ft and existing volume of the two digesters. Assuming a maximum FW VS load increase of 10 percent above FY 16/17 levels, the FOG VS load would need to increase to 21.5 klb VS/d to achieve the maximum VSLR and generate sufficient biogas to recover 1,520 kW of electrical power assuming 30 percent generation efficiency, similar to the existing cogeneration system. Accordingly, the total FOG and FW VS load fraction of the total digester feed would need to increase from 31 percent to approximately 61 percent.

For each of these three scenarios, the additional biogas produced with the increased quantity and proportion of HSW fed to the digesters was calculated. A chemical oxygen demand (COD) based method was used for this biogas calculation. This approach accounts for differences in characteristics, digestibility, and biogas energy content of the PS+TWAS, FOG, and FW digester feed fractions.

First, the COD:VS ratio and biogas methane fraction were assumed for each digester feed fraction based on other characterization studies and the stoichiometry of biological methane generation. The VSr for each digester feed fraction was also assumed based on the reported overall VSr described above. Methane production was then calculated based on the equivalent COD reduction for each digester feed fraction and a yield of 0.35 liters per gram (L/g) of COD removed (at 0 degrees Celsius, 1 atmosphere [atm]) (Rittmann and McCarty, 2001). Accounting for operating temperatures, this equates to 5.93 cubic feet per pound (cu ft/lb) at 60 degrees Fahrenheit and 1 atm, the typical flowmeter standard conditions. From this, biogas energy production was then calculated, assuming a methane energy content of 909 British thermal units per cubic foot (Btu/cu ft) at 60 degrees Fahrenheit and 1 atm (or 35.8 kilojoules per liter [kJ/L] at 0 degrees Celsius, 1 atm) (Rittmann and McCarty, 2001). Finally, biogas production was calculated by dividing the calculated methane production by the biogas methane fraction for each digester feed fraction. The results of this analysis are shown for each scenario in Table 2.1.

The three scenarios shown in Table 2.1 were reviewed with Agency staff and Scenario 2 was selected for planning purposes to evaluate alternatives to expand the existing OWRF as discussed in TM No. 3, Organic Waste Receiving Facility Evaluation. In addition, Scenario 3 was selected for planning purposes to evaluate potential beneficial uses of the additional biogas generated above Scenario 2 as discussed in the following section.

While the projected biogas energy production estimates in Scenarios 2 and 3 were assumed for use, a detailed assessment of any future additional organic loading of FOG and FW to the digester would need to be completed prior to any increase in loading fraction above FY 16/17 levels.

5.0 BIOGAS UTILIZATION ALTERNATIVES ANALYSIS

Three alternatives were evaluated to assess the beneficial use of the additional biogas generated by maximizing the organic loading capacity of the two anaerobic digesters at the Agency. The three alternatives considered are cogeneration, RNG for transportation fueling station and RNG for pipeline injection and use as power plant fuel. Average biogas flow rate was used to size the cogeneration unit to ensure it was not oversized, and peak biogas flow rate was used to size the RNG treatment systems, biogas treatment system, and storage facilities to ensure all biogas produced could be processed.

5.1 Cogeneration

Cogeneration is the process of burning fuel to create electricity and capture the heat produced. Wastewater treatment plants typically use the generated heat to maintain target digester temperatures, while using the energy to run other plant processes and reduce peak electricity demands and charges from utilities. There are three main types of cogeneration technologies: conventional reciprocating engines, microturbines, and fuel cells. As previously described, the Agency currently has a conventional lean-burn, reciprocating engine. Thus for this analysis, only the conventional reciprocating engine technology was considered so that the new cogeneration facilities would be technologically similar to the Agency's current cogeneration system for ease of operation.

Several lean-burn, reciprocating engine suppliers have new generation, high efficiency, low emission units designed for use with biogas, including Cummins, Caterpillar, and General Electric (GE)/Jenbacher. These engines have overall efficiencies of approximately 80 to 85 percent, which remains nearly constant throughout the typical operating range of 50 to 100 percent engine load. Approximately 40 percent of the fuel (as a percentage of fuel input energy content) is converted to electrical output and 40 to 45 percent to heat using heat exchangers (provided with the engines) to recover energy from the engine cooling water and exhaust. The Agency currently has a Waukesha conventional lean-burn, reciprocating engine generator. This older engine generally has an overall efficiency of around 70 to 80 percent, similar to the new high efficiency engine proposed in this alternative. However, the electrical efficiency of this older engine is only 30 to 33 percent efficient. This is much lower than the electrical efficiency of the new lean-burn engines.

A lean-burn engine is also designed to run with a relatively low fuel-to-air ratio, which increases efficiency while decreasing nitrogen oxide (NOx) formation. These engines can be fitted with exhaust after-treatment equipment to control NOx and carbon monoxide (CO) emissions if required.

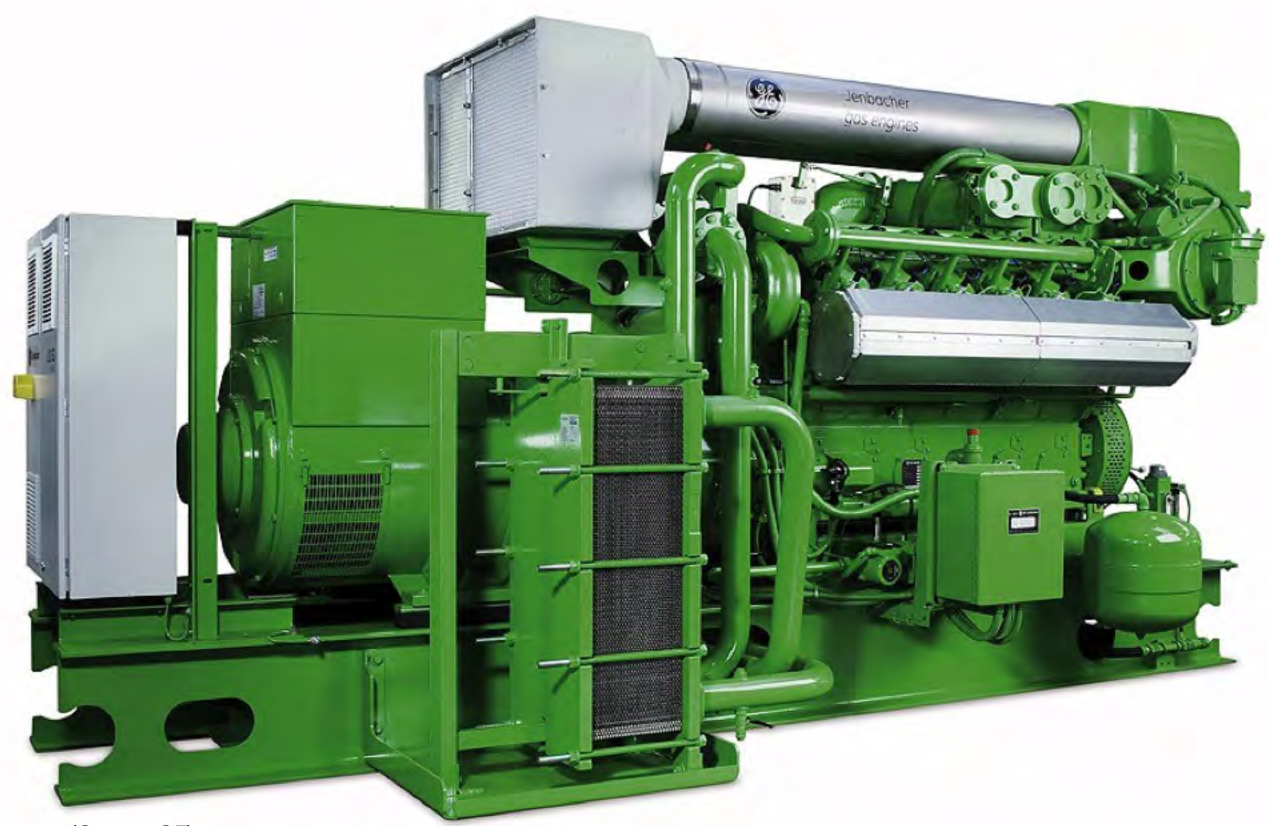
A GE/Jenbacher cogeneration engine is shown in Figure 2.1.

For this analysis, the average biogas available for use in the additional cogeneration engine is approximately 223 scfm, which is the difference between Scenarios 3 and 2’s biogas production estimates. Accordingly, a new 850 kW cogeneration engine is recommended.

5.1.1 Biogas Treatment and Storage Requirements

To prevent fouling of the equipment and comply with emission requirements, engine manufacturers recommend that the biogas is treated to remove moisture, siloxanes, and H2S. Biogas treatment will increase the performance and reliability of the cogeneration equipment while reducing operating and maintenance costs. A typical biogas treatment schematic for cogeneration is presented in Figure 2.2.

For this analysis, it was assumed that all components of the existing biogas treatment system would be doubled in size to accommodate conditioning of the additional biogas. This assumption should be confirmed during preliminary design if this alternative moves forward.



(*Source: GE*)

GE JENBACHER ENGINE

FIGURE 2.1

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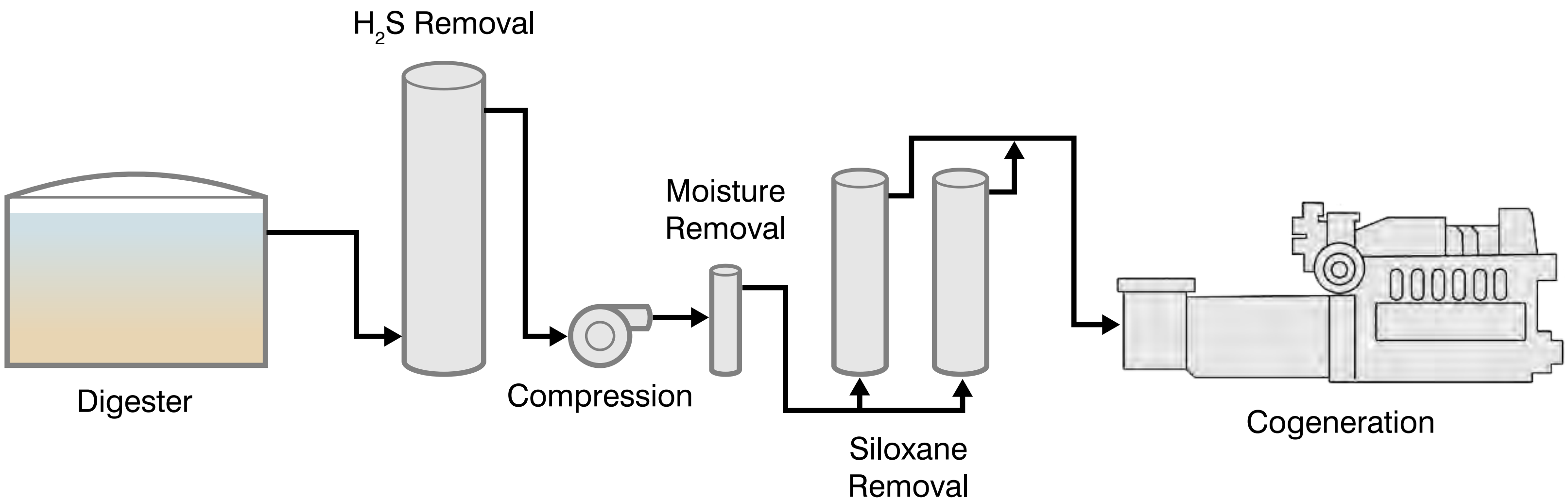

TYPICAL TREATMENT SKID FOR COGENERATION

FIGURE 2.2

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When utilized, biogas storage functions to smooth out biogas production and usage peaks and valleys that occur in typical digester operation. During periods when production exceeds usage, excess biogas fills the storage. Conversely, when usage exceeds production, biogas is withdrawn from storage. While difficult to quantify, cogeneration systems operating without storage tend to flare more biogas and/or use more natural gas than those with storage. However, the cost/savings impact of this is anticipated to be relatively minor.

For this evaluation, it was assumed that additional digester storage is not required beyond what the Agency currently has in the Dystor membrane gasholder covers for the digesters.

5.1.2 <u>Siting Considerations</u>

The existing cogeneration engine is located in the Solids Handling Building which is northeast of the existing digesters. The Solids Handling Building has adequate space to house an additional cogeneration engine adjacent to the existing unit.

The existing biogas treatment system is located outside under a canopy to the west of the Solids Handling Building. For this analysis, additional biogas treatment equipment would be located adjacent to the existing system.

Figure 2.3 presents a proposed layout of the cogeneration system alternative.

5.1.3 <u>Cost Offsets</u>

A cogeneration plant that is fueled with the biogas produces two (2) potentially marketable products, thermal energy (heat) and electricity.

The optimal off-taker for the cogeneration plant's thermal energy (heat) is the Agency's WWTP where it can be used for the baseline heating of the WWTP's anaerobic digesters to facilitate biogas production. Excess heat can also be used for space heating at the treatment plant. Any remaining thermal energy could be used for off-site processes if there are any nearby entities that require process heat.

Although thermal energy (heat) is a potentially useful biogas product, the more marketable product from the cogeneration plant is electricity. The existing pathways relevant to the Agency for monetizing the electricity generation include:

- Generating bill credits through PG&E RES-BCT Program.
- Exporting the electricity to the local electric grid.

These revenues are described in the sections that follow.

COGENERATION SYSTEM LAYOUT

FIGURE 2.3

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5.1.3.1 Bill Credits through PG&E RES-BCT

Local governmental agencies benefit from an additional program available from the California IOUs that in essence extends net metering to cover electricity consumption at other agency-owned sites. The Renewable Energy Self Generation – Bill Credit Transfer (RES-BCT) Program allows excess renewable power produced at the generating facility site (Generating Account) to be used to offset utility bills at other sites owned by the same agency (Benefitting Account) including joint powers authority (JPA) entities. The bill credit could be shared with any or all of the Agency's member agencies up to a total of 50 individual PG&E meters.

The members of the Agency's JPA, including City of Larkspur, Sanitation District No. 2 - Town of Corte Madera, Ross Valley Sanitation District, and San Rafael Sanitation District, could utilize the power through the RES-BCT program. The value of electricity used in this manner is a credit on the bill of participating JPA member that is calculated under the rate at the meter where the power is introduced to the PG&E system (i.e. the Agency's electricity meter). The bill credits are valued at the time-of-use, generation-only portion of the electric bill. The average value would range from $0.07 to $0.09 per kWh depending on when the excess power is generated and what rate schedule is in effect at either the existing, or a newly installed, meter.

Marin Clean Energy (MCE), the Agency's current electricity supplier, does not offer a similar program. Accordingly, to utilize this program, both the Agency's Generating Account and the Member Agencies' Benefitting Accounts, would need to be switched to PG&E as the power supplier.

5.1.3.2 Revenue from Sale of Electricity

Under the 10-year Power Purchase Agreement recently signed with MCE, the Agency is obligated to sell up to 150 kW of electricity to MCE, which is the estimated maximum power that could be produced by the existing cogeneration unit above the Agency's existing electricity demand. Additional electricity produced by a new power generating unit, could be sold to others.

For Scenario 3, it is estimated that up to approximately 1,520 kW of electricity could be produced, provided sufficient additional feedstocks were utilized. This is about 770 kW of electrical power more that the amount estimated for Scenario 2 to maximize the existing cogeneration capacity. For this alternative it was assumed that a new cogeneration engine would be installed to produce this excess electrical power above the amount estimated for Scenario 2. This excess electricity could be sold to produce additional revenue for the Agency. Potential electric off-takers for this power include:

- PG&E's BioMAT Feed in Tariff (FIT), which currently pays $0.1272 per kWh, is available for new generation facilities (new combustion engine and generator). This tariff is not available for existing generation facilities.

- MCE, the community choice energy agency that is currently serving the Agency, has a FIT program for projects within their service territory up to 1 MW in size. The current payment level is $0.085/kWh offered without escalation for a 10, 15, or 20 year term. The availability of this pricing is limited to 2 MW total of which 2 MW are still available at this time. Pricing declines by $0.005/kWh increments for every 2 MW of additional capacity that is contracted for.
- Other buyers of renewable electricity including public utilities such as the Northern California Power Agency and its individual members (Alameda, Palo Alto, Santa Clara etc.) and private energy aggregators such as Direct Energy and The Energy Authority.
- It may be possible to utilize PG&E's RES-BCT program to extend Bill Credits to specified accounts of the Agency's JPA Member Agencies. The challenge is that the existing generator is under contract to sell all of its power to MCE, while the RES-BCT program requires that the Generating Account be served by PG&E. It may be possible to isolate the two sources of generation, though the legal mechanisms, electrical engineering and interconnection system requirements could be complex and costly.

It is unclear how MCE would respond if the Agency installed a second cogeneration unit and attempted to sell any power produced by this unit to another buyer. The legal and administrative aspects of this should be researched further if this alternative is chosen and the Agency wishes to sell additional power produced above the 150 kW promised to MCE to another buyer.

Electricity pricing varies depending on the selected cost offsetting pathway taken (site electricity offset, bill credit generation, or export of electricity with each pathway offering varying prices and terms and conditions. The site electricity offset and bill credit generation value will vary over time with the utility's electricity rates. The observed trend is that utility electricity rates are increasing over time which may lead to higher offset/credit values into the future.

The electricity export value will vary depending on the off taker. Under both available program's (PG&E's BioMAT and MCE's FIT), the price is fixed for the term of the agreement. This provides certainty of the value of the electricity as well as protection against the observed decline in wholesale power prices (prices paid to generators).

5.1.3.3 Potentially Available Credits and Grants

5.1.3.3.1 Renewable Energy Certificates

Renewable energy certificates (RECs) are tradeable energy commodities that signify that 1,000 kWh of electricity was generated using renewable energy. Other names for the programs include Green Tags, Renewable Energy Credits, or Tradeable Renewable Certificates. RECs are assigned identification numbers by certifying agencies for tracking purposes. The credits are used to track renewable energy contributions to the electrical grid and to give entities the ability to prove the purchase of renewable energy. Once the REC has been used, it is considered retired and cannot be traded or utilized again. Each 1,000 kWh produced by the cogeneration facility would result in one REC that can be sold in addition to the energy sale, providing an additional revenue source. Typically in renewable energy sales arrangements RECs are "bundled" with the electricity and sold as a combined product which has a premium value over non-renewable electricity. For this analysis, RECs are not included as an available revenue source.

5.1.3.3.2 Federal Department of Energy – Funding Opportunities

The US Department of Energy provides funding for energy efficiency and conservation programs and projects communitywide, as well as renewable energy installations on government buildings. Availability varies from year to year and depending on the timing, this funding may or may not be available. See the website below for additional information concerning these funding opportunities.

(https://www.energy.gov/eere/funding/eere-funding-opportunities)

5.1.3.3.3 California State Water Resources Control Board – Clean Water State Revolving Fund – Green Project Reserve

The Green Project Reserve (GPR) requires all Clean Water State Revolving Fund (CWSRF) programs to direct a portion of their capitalization grant toward projects that address green infrastructure, water efficiency, energy efficiency, or other environmentally innovative activities. CWSRF can forgive 50 percent of actual GPR eligible cost, up to $4 million. See the website below for additional information concerning these funds.

(https://www.waterboards.ca.gov/water_issues/programs/grants_loans/srf/docs/gpr_fact_sheet.pdf)

5.1.3.3.4 Self-Generation Incentive Program (SGIP)

The California IOU's administer the Self-Generation Incentive Program (SGIP) which provides incentives for distributed energy resources that are located on the customer side of the meter and produce energy for on-site use. Qualifying technologies include wind turbines, waste heat to power technologies, pressure reduction turbines, internal combustion engines, microturbines, gas turbines, fuel cells, and advanced energy storage systems. Presently, the incentive for a cogeneration system is $0.60/W of installed capacity plus up to $0.60/W for fueling the system with biogas. See the website below for more information.

(https://www.selfgenca.com/)

5.1.3.3.5 California State Agency Grant Funding

Both the California Energy Commission and CalRecycle offer grant programs that have historically included funding for food waste anaerobic digestion to produce biogas for electric power and transportation fuels. These grants are typically in the $3 to $5 million range.

5.2 RNG for Transportation Fueling Station

Use of biogas for the production of RNG for vehicle fuel has gained increasing interest over the past decade due to the economic benefit of offsetting vehicle fuel rather than electricity. With municipal fleet and private sector vehicles across the country converting to RNG, there is a great opportunity for collaboration by locating vehicle fueling stations near existing WWTPs and making use of an already available fuel source. While implementation of these types of projects at or near WWTPs is relatively new, the technology for conditioning and compressing the biogas into RNG is well-established, and is currently used at the City of San Mateo's wastewater treatment plant and is in design at the City of Petaluma's wastewater treatment facility. Newly developed regulations and goals geared toward greenhouse gas (GHG) emission reductions are providing newfound incentives for implementing these types of projects.

For this analysis, the peak biogas available for converting to RNG for fueling station use is approximately 312 scfm, which is the difference between Scenarios 3 and 2's biogas production estimates.

BioCNG is one of several leading producers of turnkey systems for treatment, storage, and fueling for equipment of the size required for this facility. Figure 2.4 shows an example of one such BioCNG turnkey system. Given the projected biogas flow rate of 312 scfm, BioCNG recommends the use of its BioCNG 400 unit, which can treat up to 400 scfm of biogas. This system converts a majority of the biogas to CNG, and the remaining biogas, known as the tail gas (roughly 30 percent of the initial CH4 content, along with the stripped CO2) can be flared, burned in a thermal oxidizer, or potentially used for digester heating. This tail gas has a heating value lower than normal biogas so beneficial use of this tail gas is more challenging and it may need to be blended with natural gas if beneficial use is desired.

As the digesters at the Agency are currently heated with cogeneration waste heat, the tail gas produced would not be used for digester heating. Thus either flaring or thermal oxidation could be employed. If the Agency chooses to flare the tail gas, a new expensive flare may be needed because there are expected regulatory changes that may come into effect in 2020 that would require the lowest available emissions reduction requirements for biogas flaring. This would not eliminate flaring as an option for biogas, but it would make the flare more expensive. For this analysis, it was assumed that the tail gas would be burned in a thermal oxidizer. However, if this option moves forward the decision of whether the Agency wants to pursue an updated flare or a thermal oxidizer would need to be made and would likely depend on regulations at the time of implementation.

Two options were considered for utilizing RNG for vehicle fuel. The first option would include a new vehicle fueling station at the Agency's WWTP. While initially considered, this option is not recommended due to the increased truck traffic it would create at the facility. The second option considered would send RNG for vehicle fuel to an existing fueling station at a nearby PG&E facility. This is the recommended option for further consideration as the PG&E facility is close by, located approximately 0.2 miles from the Agency, and is shown in Figure 2.5. However, prior to implementation the Agency should coordinate with PG&E to confirm the assumptions made in this TM which are based on the Agency's preliminary conversations with PG&E.

Two options are available to convey the RNG produced at the WWTP to the PG&E fueling station. Option 1 includes installation of a new pipeline along Andersen Drive and Option 2 includes use of a trailer mounted mobile storage tank to be transported by a semi-truck. The routing of a pipeline, although small in diameter, poses implementation concerns with respect to coordination with local businesses and permitting constraints. Thus, for this analysis, a trailer storage and semi-truck transport was assumed.

The trailer storage would be filled at the WWTP and then transported to the PG&E fueling station, where it would then be discharged into the fueling station’s storage tanks. Additional compression may be required to reach the required fueling station storage pressure. A similar approach is currently used in Saint Landry Parish, Louisiana, which transports a portion of its RNG to a fueling station inside a refuse hauling company.

5.2.1 Biogas Treatment and Storage Requirements

For fueling station RNG supply, the required equipment consists of treatment, compression, storage, and transport to the fueling station. In order to produce RNG, the biogas is cleaned to remove H2S, siloxanes, moisture, and the majority of CO2, resulting in greater than 95 percent CH4 content. After treatment, the biogas is compressed and depending on fueling station demand, stored before conveyance to the fueling station. The cleaning systems utilized are well proven biogas treatment systems to remove the undesired constituents. A typical biogas treatment schematic for RNG is presented in Figure 2.6.

A typical RNG fueling station receives pipeline natural gas and pressurizes the gas to supply either fast-fill or slow-fill fueling stations. Fast-fill fueling stations compress RNG to roughly 3,000 psi. At this pressure, it takes roughly the same amount of time to fill a RNG vehicle as a traditional gasoline or diesel powered vehicle. Slow-fill fueling stations are often used for fleet vehicles that are not in operation for a significant portion of the day. For these stations, the biogas is pressurized to 2,000 psi and is fed to the vehicles overnight so that they are ready for use the next day.

(*Source: BioCNG*)

TYPICAL BIOCNG PACKAGE SYSTEM

FIGURE 2.4

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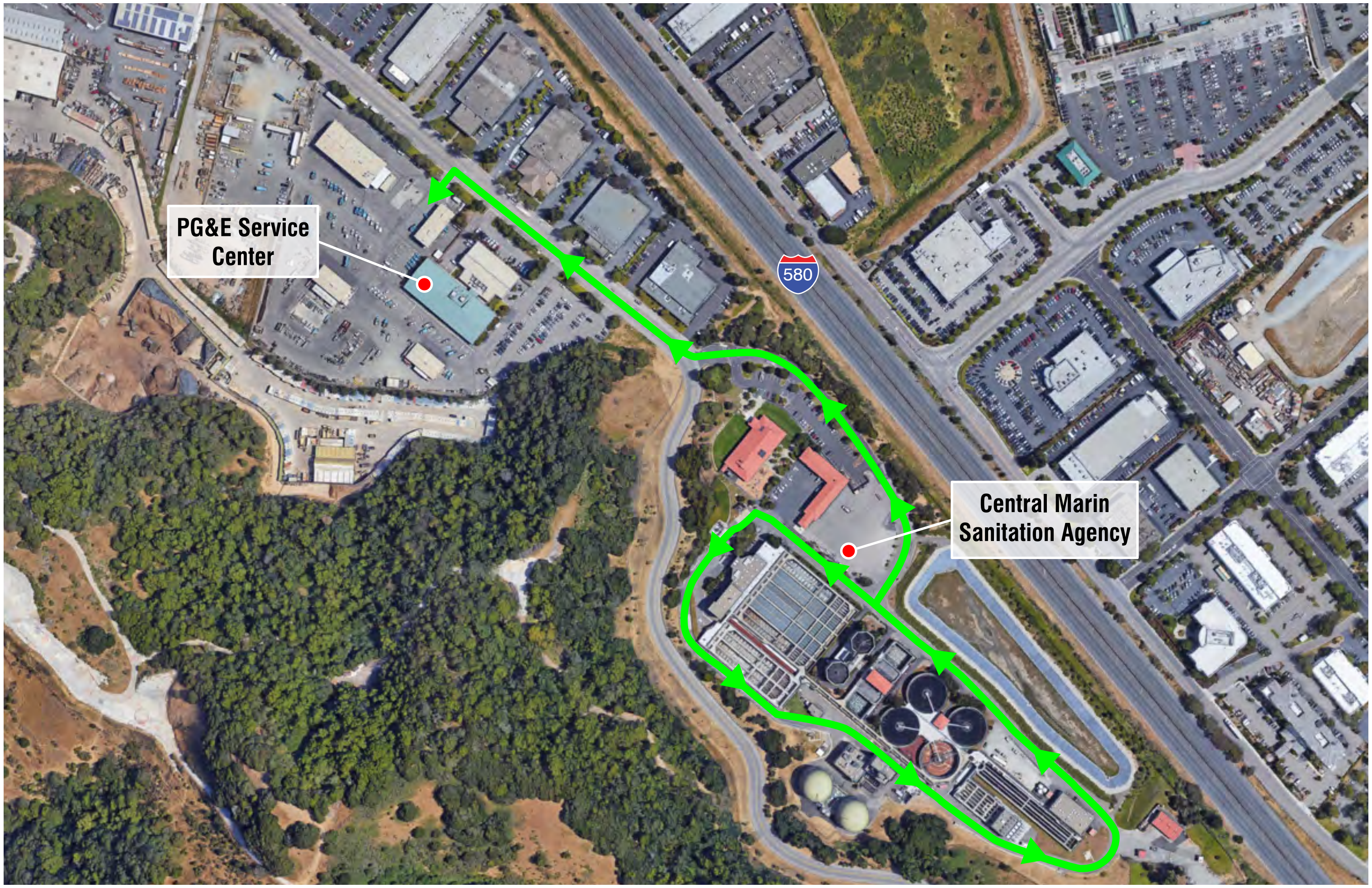

LOCATION OF EXISTING PG&E FUELING STATION

FIGURE 2.5

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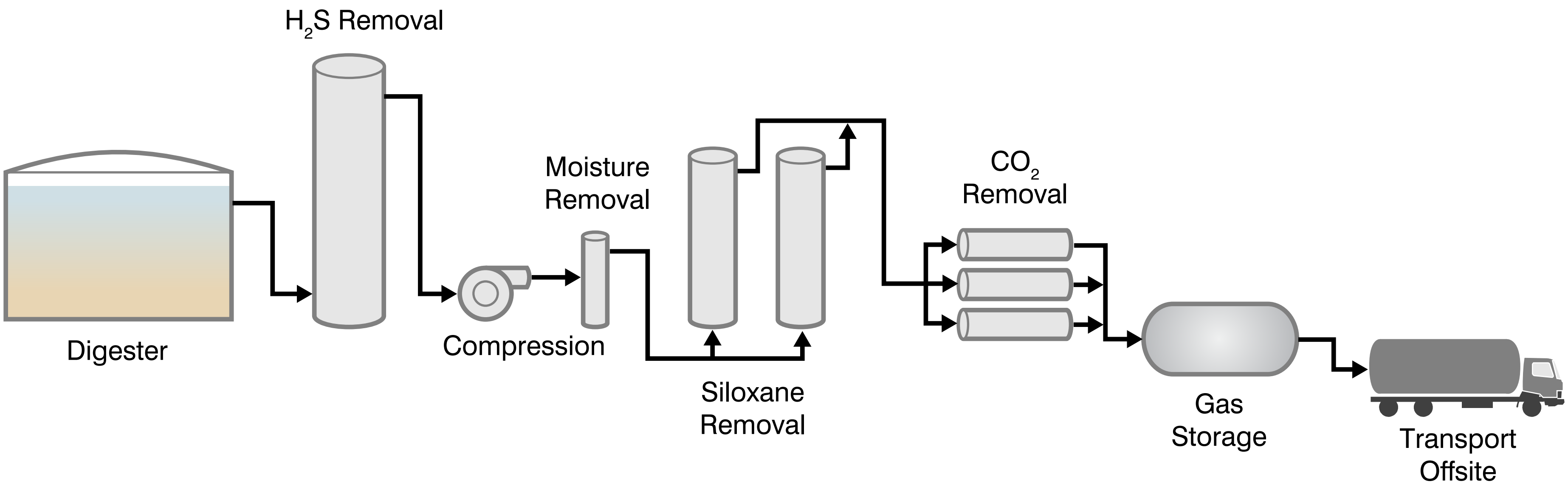

TYPICAL TREATMENT SKID FOR RNG

FIGURE 2.6

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For this analysis, it was assumed that the RNG fueling station at PG&E will require some modification to its on-site gas compression system in order to achieve the required fueling pressures. Thus, an allowance for existing RNG station integration is included in the cost estimate.

The system at the fueling station would be designed to use either RNG from the WWTP or natural gas (as it is currently operated). The fuel system would utilize a pressure regulating valve so that RNG is used before natural gas. During times when production exceeds demand, the excess can either be stored, or flared if storage is full.

Depending on the amount of storage volume that is available at the fueling station, additional storage may be required in order to use all of the biogas available from the WWTP. For example, storing some of the biogas that is produced overnight for use the next day can increase the overall utilization. If the storage is full and production exceeds demand, the remainder will be flared using the existing flare. For this alternative, it was assumed that two trucks with trailer storage would alternate filling and delivery of RNG to PG&E. One day of onsite storage would also be provided at the WWTP.

Figure 2.7 shows an example bank of high pressure storage tubes that would be included for the RNG fueling alternative.

5.2.2 Siting Considerations

For this alternative, it was assumed that the biogas treatment, compression, storage, and trailer filling station would be located outside. The estimated footprint required for this facility is approximately 80 feet by 40 feet. In addition to this, a thermal oxidizer is needed to handle the tail biogas. This facility would be approximately 10 feet by 15 feet.

Figure 2.8 presents the proposed location of the RNG Filling Station alternative. This location was chosen for ease of truck access and proximity to the existing digesters.

5.2.3 Cost Offsets

There are three revenue components to consider when producing RNG in California. The first revenue component is the direct sale of the RNG. The second and third revenue streams come from available credits: Renewable Identification Number (RIN) credits and California-based Low Carbon Fuel Standard (LCFS) credits. Combined, these three revenue streams can be used to offset the cost of producing RNG. These three value streams are described below.

The transportation fuel-based RNG market with its RINs and LCFS revenue components usually do not offer a long term, fixed contract price because the RIN and LCFS components have significant price volatility. The typical contract term for this market is five (5) years or less.

HIGH PRESSURE STORAGE TUBES FOR RNG

FIGURE 2.7

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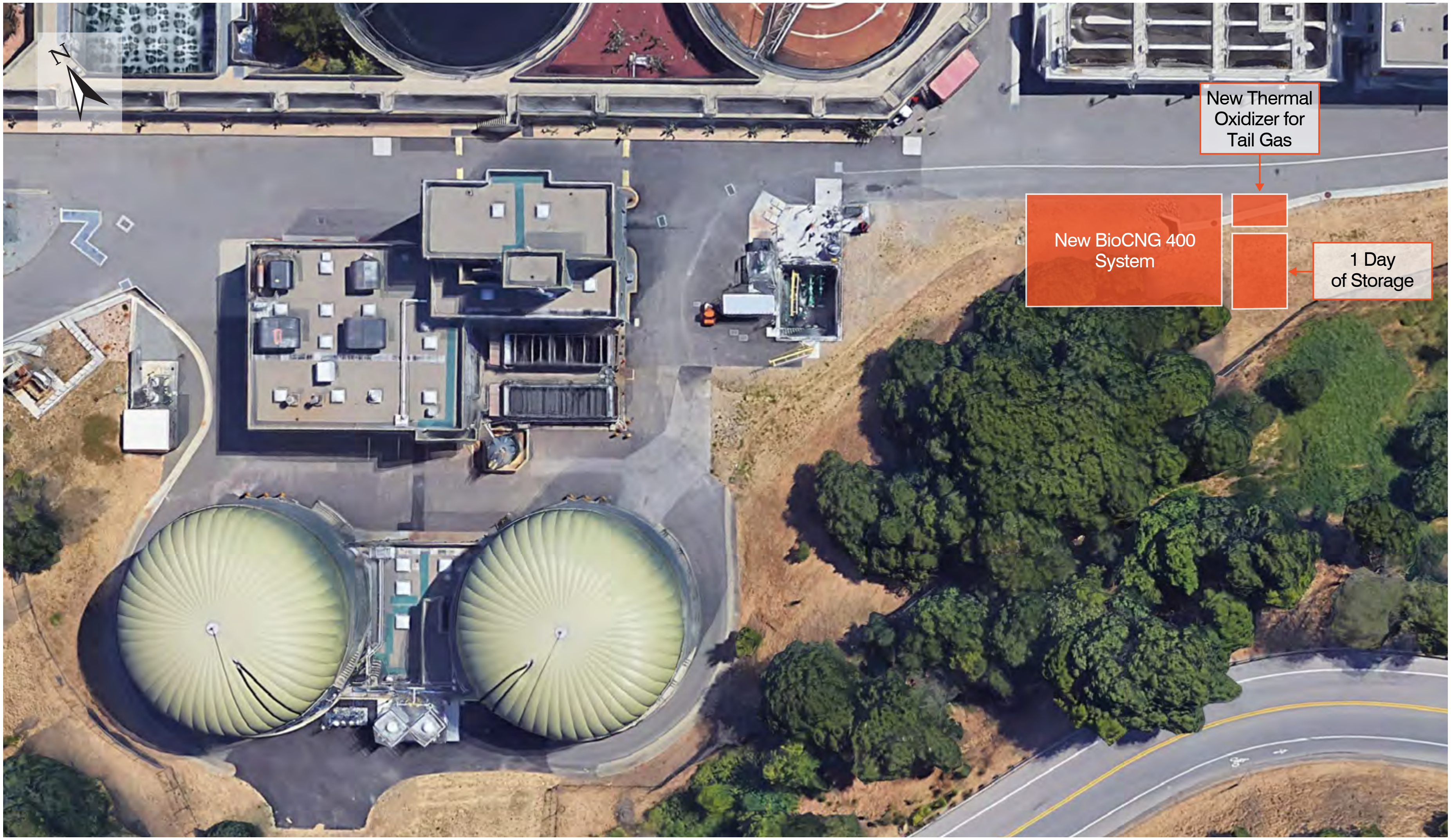

RNG FOR FUELING STATION SYSTEM LAYOUT

FIGURE 2.8

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5.2.3.1 Revenue from Sale of RNG

The "brown gas" component, i.e., natural gas fuel, presently has a commodity price of approximately $3 per MMBtu or $0.66 per gallon of diesel fuel equivalent based on it replacing diesel fuel (DGE).

5.2.3.2 Potentially Available Credits and Grants

5.2.3.2.1 Environmental Protection Agency's Renewable Fuel Standard Program

The Renewable Fuel Standard (RFS) program was created under the Energy Policy Act of 2005, and established the first renewable fuel volume mandate in the United States. The program requires oil and gas producers to purchase specified amounts of fuel credits each year to increase the amount of renewable fuel used. Each 77,000 BTUs of biogas used for vehicle fuel generates a renewable credit, named as a RIN.

The RFS program defines four types of renewable fuels: cellulosic biofuel, biomass-based diesel, advanced biofuel, and renewable fuel. As of 2018, the RFS program allows digester biogas from municipal wastewater treatment facility digesters as a transportation fuel feedstock. Biogas from digesters is designated as a "cellulosic" biofuel (D3) or an "advanced" biofuel (D5) depending on its feedstock (D3 biofuels originate from a high proportion of cellulosic feedstock (e.g. sewage sludge) while biofuel originating from food waste is considered D5). The D3 designation carries the greatest RIN value of the four categories. At the Agency since sewage sludge is co-digested with FOG and FW, all of the biogas produced is designated as D5 per current regulatory interpretation. This definition will be reconsidered over the next 24 months.

RINs are traded on the open market, and their value is dependent upon the price of oil and the renewable volume obligation, which is the amount of RINs obligated parties have to purchase. D5 RINs are currently trading for approximately $0.66 per DGE.

In order to become a RIN producer, the WWTP must be certified with the EPA. This is typically done by a third-party with experience in the process. Carbon offset brokers can provide RIN registration and ongoing reporting and management. The carbon offset brokers also handle the sale of RINs to producers. In exchange, they receive an agreed upon percentage of the RIN value, anticipated to be 30 percent for this size of project.

Another option is for an obligated party (i.e., oil and gas producer) to purchase the RINs directly from the WWTP. See the website below for additional information concerning this program.
(https://www.epa.gov/renewable-fuel-standard-program)

5.2.3.2.2 California-Based Low Carbon Fuel Standard

The LCFS program was created under Assembly Bill 32 (Global Warming Solutions Act of 2006) Scoping Plan. The LCFS mandates a 10 percent reduction in the carbon intensity of transportation fuel in California by 2020. Under the LCFS, clean fuel providers can earn credits and these credits can be sold for cash to certain compliance-based buyers in California which include, among many other parties, California's oil refineries and California's electric utilities. The LCFS credits vary depending on the carbon intensity (CI) of the conversion pathway. Currently, the equivalent price is approximately $1.75 per DGE for biosolids conversion and $2.45 for food waste conversion. The analysis assumes a ratio of 39 percent biosolids and 61 percent food waste.

Our economic analysis assumes an energy content ratio of 39 percent biosolids (D3 RINs) and 61 percent food waste (D5 RINs) based on the biogas production model described in Section 2.

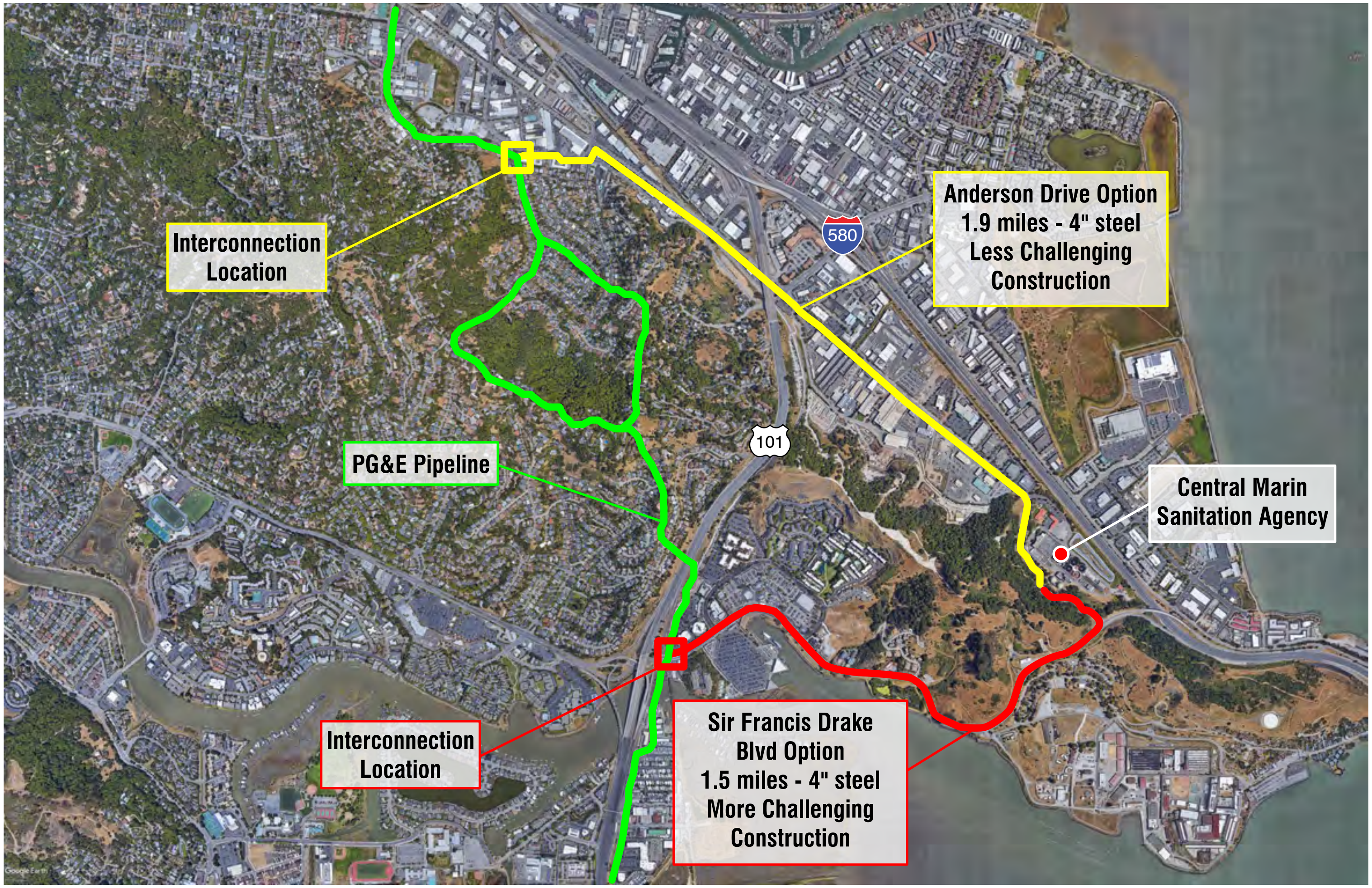
5.3 RNG for Pipeline Injection and Use as Power Plant Fuel

RNG for pipeline injection is the third alternative considered, and is similar to the RNG for fueling station alternative except the treated RNG is sent directly into the pipeline of a utility for use with its gas products. Because a higher quality of biogas is required when injecting into a utility's pipeline, this alternative requires additional cleaning of the biogas. Given this additional biogas treatment step, a thermal oxidizing flare or similar technology for disposal of the very low BTU waste biogas would be needed, since the waste gas contains mostly CO2.

Converting biogas to RNG for pipeline injection has been implemented in California at the Point Loma Wastewater Treatment Plant in San Diego. The Point Loma RNG pipeline injection has been in operation since 2011. In addition, the wastewater treatment facilities at Clean Water Services in Oregon and CR&R's food and green waste BioDigester in Riverside County, CA have implemented RNG for pipeline projects that have been in operation since 2017. Other states such as Colorado, Iowa, and North Carolina have wastewater treatment RNG for pipeline projects currently under construction.

Like the RNG for fueling station alternative, the peak biogas available for RNG for pipeline injection is approximately 312 scfm. Accordingly, the recommended BioCNG unit for use is the BioCNG 400, which can treat up to 400 scfm of biogas. For this analysis, it is assumed that the tail gas from this system would be flared.

At the Agency's request, an Initial Feasibility Study was conducted by PG&E to determine whether an interconnection for pipeline injection could be made near the WWTP. Based on PG&E's initial analysis, two possible interconnection locations and pipeline routings were identified and these are shown in Figure 2.9. As shown in the figure, the Andersen Drive Option is about 1.9 miles away from the WWTP whereas the Sir Francis Drake Boulevard Option is approximately 1.5 miles away from the WWTP. The Andersen Drive Option is the



POSSIBLE RNG PIPELINE ROUTES BASED ON PG&E INITIAL FEASIBILITY STUDY

FIGURE 2.9

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more direct route but crosses under Highway 101. The Sir Francis Drake Boulevard Option, while more circuitous, is shorter in distance, but is along a very congested roadway near Larkspur Ferry. Both options would connect to a distribution feeder main with a normal operating pressure of 165 psig and a maximum allowable operating pressure of 175 psig.

Similar to the RNG for fueling station alternative, conveying the RNG from the WWTP the pipeline injection point could be accomplished by using a pipeline or by a trailer mounted mobile storage tank on a semi-truck. Given the implementation challenges with constructing a pipeline, it was assumed that a trailer mounted mobile storage tank would be used. For this analysis, it was also assumed that the Andersen Drive injection location would be used. However, prior to implementation the Agency should coordinate with PG&E to confirm the assumptions made in this TM which are based on the Agency's preliminary conversations with PG&E.

5.3.1 Biogas Treatment and Storage Requirements

Pipeline injection would require a similar treatment of the biogas as RNG for vehicles, but would include an extra treatment step (an additional set of membranes) for additional CO_2 removal, resulting in greater than 99 percent CH_4 in the biogas. As discussed above, pipeline injection would also require a thermal oxidizing flare or similar technology for disposal of the very low BTU waste biogas, since it contains mostly CO_2. PG&E, the local natural gas utility, has indicated that they are amenable to receiving the treated biogas, provided it meets their RNG specifications outlined in Gas Rule No. 21. A summary of the RNG quality requirements of this rule is shown in Table 2.2.

In addition to ensuring RNG quality, Gas Rule 21 also lays out the facilities needed at the point of interconnection. Per Gas Rule 21, the costs for these facilities would be borne by the applicant (Agency). Such facilities may include, but are not limited to, pressure regulation and flow equipment, taps, valves, piping, measuring equipment, odorizing equipment, land rights, permits, and communication equipment. The Agency would also responsible for computer programming changes to PG&E’s scheduling system, if any, required to add the Agency’s new interconnection point for the purpose of nominating the biogas. Per PG&E's website, the estimated cost of this interconnection typically ranges from $2 million to $5 million dollars for design and construction. For this analysis, it was assumed the interconnection cost would be $3 million.

Typically one of the appeals of pipeline injection is that 100 percent of the generated biogas can be used without requiring storage, since the pipeline represents a constant demand. However, in this case, RNG would be trucked to the PG&E pipeline so storage will be required. Like the RNG for fueling station alternative, it was also assumed for this alternative that two trucks with trailer storage would alternate filling and delivery of RNG to the pipeline. One day of onsite storage would also be provided at the WWTP.

Table 2.2 PG&E Gas Rule 21 Requirements for WWTP Biomethane Quality(1) 2017 Facilities Master Plan Central Marin Sanitation Agency					
Constituent	**Unit**	**Limit**	**Trigger Level(2)**	**Lower Action Level(3)**	**Upper Action Level(4)**
Traditional Gas Quality Requirements(5)					
Carbon Dioxide	% by volume	1	-	-	-
Oxygen	% by volume	0.1	-	-	-
Hydrogen Sulfide	ppmv	4	-	-	-
Mercaptan Sulfur	ppmv	8	-	-	-
Total Sulfur	ppmv	17	-	-	-
Water Vapor	ppm at 800 psig	7	-	-	-
Hydrocarbon dewpoint	degrees F at 400 psig	≤ 45	-	-	-
Temperature	degrees F	60 - 100	-	-	-
Health Protective Constituents - Carcinogenic(6)					
p-Dicholorobenzene	ppmv	-	0.95	9.5	24
Ethylbenzene	ppmv	-	6.0	60	150
Vinyl Chloride	ppmv	-	0.33	3.3	8.3
Health Protective Constituents - Non-Carcinogenic(6)					
Hydrogen Sulfide	ppmv	-	22	216	1080
Mercaptans (Alkl Thiols)	ppmv	-	12	120	610
Toluene	ppmv	-	240	2400	12000
Pipeline Integrity Protective Constituents(7)					
Ammonia	%	-	0.001	TBD(8)	TBD(8)
Biologicals	per scf	-	40,000(9)	TBD(8)	TBD(8)
Hydrogen	%	-	0.10	TBD(8)	TBD(8)
Mercury	mg/m^3	-	0.08	TBD(8)	TBD(8)
Siloxanes	$mg\ Si/m^3$	-	0.1	0.1	TBD(8)

Notes:

(1) Source is the PG&E Gas Rule No. 21 effective August 9, 2017.
(2) Level above which additional periodic testing and analysis is needed.
(3) Level used to screen Biomethane during Pre-Injection Testing, Periodic Testing, and in the Biomethane Restart Procedure.
(4) Level above which immediate shut-off of the Biomethane supply occurs.
(5) Traditional gas quality requirements found in Gas Rule 21.C in Sections 1-12. These requirements also stipulate that the gas shall be interchangeable with the gas in the receiving pipeline and shall have a heating value that is consistent with the standards established by PG&E for each receipt point.
(6) Health Protective Constituents are shown in Table V-3 of the CARB/OEHHA Report.
(7) Pipeline integrity protective constituents are shown in Section 4.4.3.3 of D.14-01-034.
(8) The lower and upper action levels will be established in the next update proceeding.
(9) Based on qPCR per acid-producing bacteria, sulfate-reducing bacteria, and iron oxidizing bacteria. Also gas shall be free of bacteria of > 0.2 microns.

5.3.2 Siting Considerations

The proposed site of the biogas treatment, compression, storage, and trailer fill station would be the same as shown for the RNG Filling Station alternative. These facilities would be located outside. In addition to this, a thermal oxidizer is needed to handle the tail biogas. This facility would be approximately 10 feet by 15 feet. See Figure 2.10 for the preliminary layout of these facilities.

A new pipeline injection station would be needed at the PG&E pipeline near the intersection of Irwin Street and Woodland Avenue. The exact configuration and location would need to be further coordinated with PG&E.

5.3.3 Cost Offsets

RNG produced for pipeline injection can be sold to California utilities to fuel their gas-fired power generation plants to meet certain of their renewable portfolio standards. There are no credits offered for RNG pipeline injection at this time; however Assembly Bill 2312 provides partial grant funding for the interconnection system costs. Both the revenue from sale of RNG and potential grant funding options are described below.

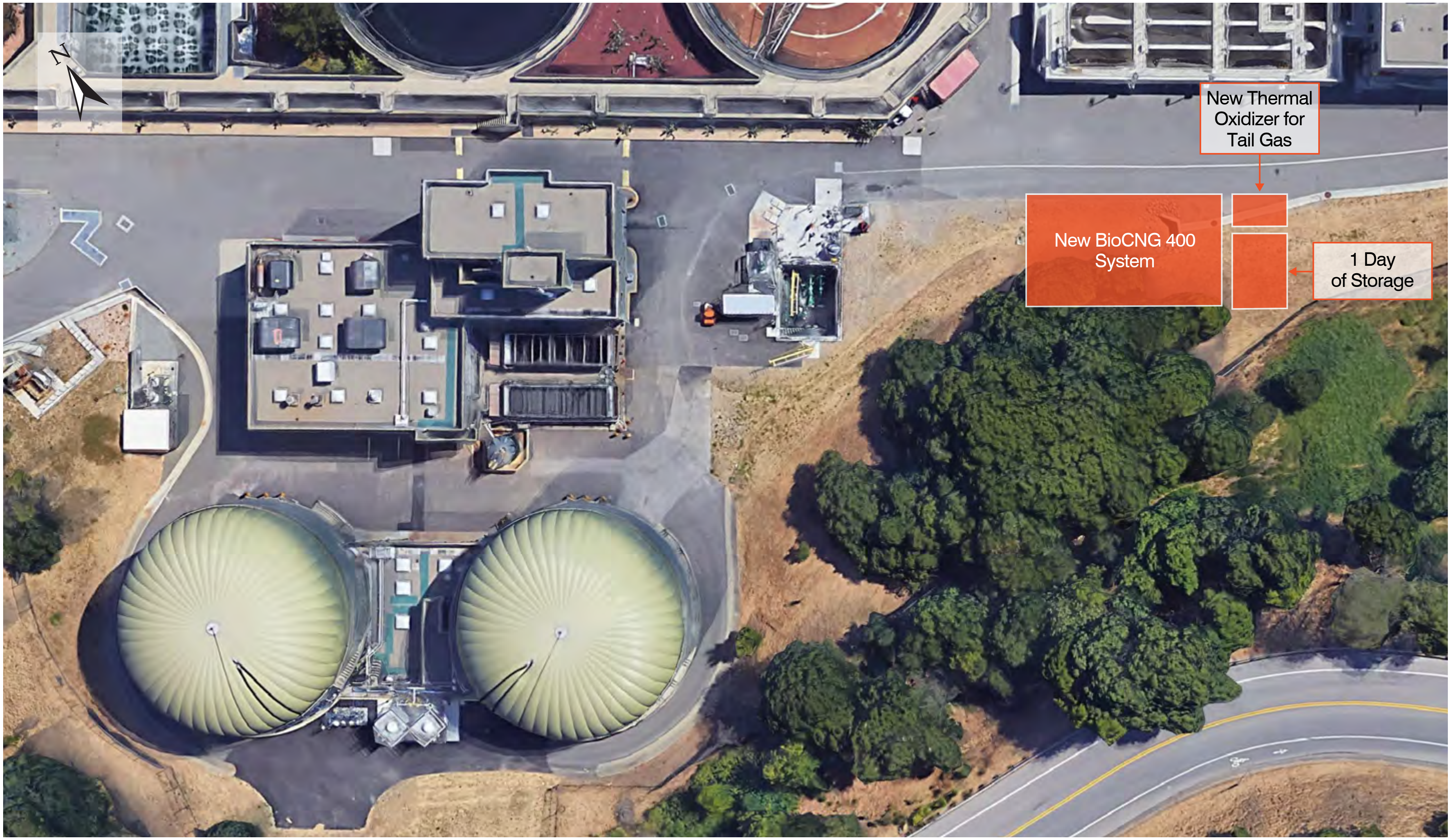
5.3.3.1 Revenue from Sale of RNG

California's electric utilities are looking to generate Renewable Portfolio Standard eligible electricity via the use of pipeline quality RNG to fuel their existing gas-fired electric power plants. They are currently paying a significantly greater RNG price then they have in the last few years. Prices for this RNG market, which do not include any RIN or LCFS revenue elements and which had declined in the last few years to a fixed long-term price of $9.00 to $10.00 per MMBtu, have been recently trending between a 10-year to 20-year fixed RNG contract price of $14.00 to $19.00 per MMBtu. The economic analysis assumes the mid-point of this range- a $16.50/MMbtu fixed price for pipeline RNG.

The price for this particular RNG market has been increasing due to the California electric utility off-takers (for RNG) having to compete with the RNG's transportation fuel market. While the transportation based market is currently paying a significantly greater price then the Utility market because of the additional RINs and LCFS revenue components, the Utility market is attractive because they are willing to enter into long-term, stable price contracts.

What drives the viability of the California electric utility-based RNG off-taker market is the following:

- The utilities' fixed contract price that is not subject to price volatility based on the uncertainty of the value and duration of the RIN and LCFS subsidies. This provides revenue certainty.
- The creditworthiness of the utility off-takers (i.e., the publicly-owned and the investor-owned electric utilities in California).
- The utilities' long-term off-take agreement, with many of the electric utility off-takers offering a 20-year off-take agreement and others offering 10 to 15 years.



RNG FOR PIPELINE INJECTION SYSTEM LAYOUT

FIGURE 2.10

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2017 FACILITIES MASTER PLAN

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Additionally, non-recourse debt financing for RNG projects can be secured for the term of the RNG off-take agreement less one year; this, in turn, allows the 70 percent to 80 percent non-recourse debt financing component of the project's total funding requirements to be amortized, in most instances, over 19 years which, in turn, lowers this RNG project's all-in effective RNG production costs.

5.3.3.2 Potentially Available Credits and Grants

5.3.3.2.1 California Assembly Bill 2313

Assembly Bill 2313 was approved on September 24, 2016 and updates the Public Utilities Commission's (PUC's) 2015 decision to adopt a five year monetary incentive program for biomethane projects. The bill requires the PUC to modify their monetary incentive program to provide a one-time payment of 50 percent of the interconnection costs incurred by the biomethane producer, up to $3 million. The total cost of the incentive program is limited to $40 million over the life of the program, which expires at the end of the 2021 calendar year. It is possible that the Agency could receive funds from this PUC incentive program to help cover the cost of the pipeline interconnection station. See the website below for additional information concerning this bill.

(https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB2313)

6.0 ECONOMIC COMPARISON

6.1 Project and O&M Costs Evaluation

Table 2.3 presents the estimated capital and annual operations and maintenance (O&M) costs for the three biogas utilization alternatives. Project costs reflect a December 2017 ENR of 10870 and are based on quantity takeoffs and similar facilities with allowances for civil, mechanical, structural, and electrical improvements, as well as engineering cost. O&M costs include maintenance, labor, and power costs. Detailed capital and O&M costs are included in Appendix A.

**Table 2.3 Project and O&M Costs for Biogas Utilization Alternatives
2017 Facilities Master Plan
Central Marin Sanitation Agency**

	Cogeneration	RNG for Fueling Station	RNG for Pipeline Injection
Project Cost(1)	$8,916,000	$13,297,000	$22,648,000
Annual O&M Cost(2)	$149,000(3)	$399,000	$611,000

Notes:

(1) Project costs for new units are based on December 2017 ENR of 10870.
(2) O&M costs include power ($0.17/kWh), labor, and maintenance.
(3) O&M costs for cogeneration is based on 2 cents/kWh.

6.2 Life Cycle Cost Evaluation

Table 2.4 presents the preliminary life cycle cost of the three biogas utilization alternatives. The life cycle cost analysis uses a 20-year discounted cash flow model to determine the net present value, return on investment, and break-even year. The model includes capital, O&M, and insurance costs as well as revenue streams from sale of the commodity (electricity or RNG) and any applicable credits and/or incentives. For an equivalent comparison using the best available data, the model assumed all alternatives would be implemented in 2018.

Table 2.4 Life Cycle Cost for Biogas Utilization Alternatives
2017 Facilities Master Plan
Central Marin Sanitation Agency

	Cogeneration	RNG for Fueling Station	RNG for Pipeline Injection
Capital Cost	$8,916,000	$13,297,000	$22,648,000
First Year Revenue	$903,000	$2,774,000	$2,499,750
Net Present Value	$(725,000)	$7,020,000	$(2,699,000)
Return on Investment	3.8%	16%	3.2%
Benefit-Cost Ratio	1.23	1.52	1.16
Break-Even Year	14.1	6.0	14.7

Below is a list of the economic assumptions:

All Alternatives:

- Discount rate: 5%.
- Insurance cost: 1% of capital cost.

Cogeneration:

- Utility annual escalation rate: 1.8%.
- Annual production: 7,073,000 kWh.
- BioMAT Tariff: $0.12772/kWh.

RNG for Fueling Station:

- LCFS, RINs revenue share to Agency: 70%.
- RNG annual escalation rate: 3%.
- RNG annual production: 151,000 MMBtu (1,179,000 gal diesel equivalent).
- RNG retail market price: $0.386/GDE.

- LCFS credit value: $1.503/GDE.

- RINs value: $0.464/GDE.

RNG for Pipeline Injection:

- RNG annual escalation rate: 0% (fixed contract).

- RNG annual production: 151,000 MMBtu.

- RNG contract price: $16.50/MMBtu.

The life cycle cost proformas are included in Appendix B.

6.3 Summary

The cogeneration alternative has the lowest capital cost at around $8.9 million. It is also the easiest to implement, as all construction would occur onsite, and does not require approval from or coordination with PG&E. Additionally, while the break-even year is longer than the RNG for fueling station alternative, the price obtained for electricity sold back to the grid is fixed for the term of the agreement. This provides certainty in the value of the electricity, which is something not offered by the other alternatives considered.

The RNG for fueling station alternative has a capital cost of around $13.3 million. While this is higher than the capital cost for the cogeneration alternative, the break-even year for this alternative is the lowest of the three alternatives considered. This low break-even year is due to the incentives and high price of RNG currently offered. This alternative takes advantage of RNG's relatively higher value as a vehicle fuel as well as the currently available LCFS credits and RIN value. However, there is a degree of uncertainty regarding the future value of LCFS credits and RINs, so the results presented in this TM need to be revisited if the Agency decides to pursue this further to confirm that the credits available at the time of implementation still outweigh the project costs. Furthermore, the revenue generated from the sale of RNG is not fixed in a long-term agreement made with PG&E, adding risk to the project. Additionally, prior to implementation the Agency should coordinate with PG&E to confirm the assumptions made in this TM which are based on the Agency's preliminary conversations with PG&E.

The RNG for pipeline injection alternative has the highest capital cost of around $22.6 million and the highest break-even year. Like the RNG for fueling station alternative, this alternative has a number of implementation challenges that would need to be considered. While preliminary conversations with PG&E were positive, further coordination is needed to confirm this option is viable and allowed by PG&E. Furthermore, this alternative has the highest break-even year because no credits are assumed for pipeline injection. Thus, this alternative has a high implementation risk and high capital cost, as well as limited revenue generating capability.

APPENDIX A – PROJECT AND O&M COST ESTIMATES

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	2 - BIOGAS UTILIZATION	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/6/2018
ALT. # :	1	**PREPARED BY :**	EAC
ALT. :	Cogeneration	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Cogeneration System**					
	850 kW Cogeneration Engine	1	LS	$2,500,000	$2,500,000	
	Biogas Treatment System	1	LS	$1,000,000	$1,000,000	
	Total					$3,500,000
	SUBTOTAL					**$3,500,000**
2	**Allowances**					
	Process Mechanical Allowance	5	%		$175,000	
	Yard Piping & Site Civil Allowance	5	%		$175,000	
	EIC Allowance	10	%		$350,000	
	Coating/Painting Allowance	5	%		$175,000	
	Total					$875,000
	SUBTOTAL					**$4,375,000**
	Estimating Contingency	30	%			$1,313,000
	SUBTOTAL					**$5,688,000**
	Sales Tax on 50% of Subtotal Above	9.00	%			$256,000
	SUBTOTAL					**$5,944,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$1,486,000
	CONSTRUCTION COST SUBTOTAL					**$7,430,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$1,486,000
	PROJECT COST					**$8,916,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	2 - BIOGAS UTILIZATION	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	7/31/2018
ALT. # :	2	**PREPARED BY :**	EAC
ALT. :	RNG for Fueling Station	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Biogas Cleanup Equipment**					
	BioCNG 400 System	1	EA	$2,630,000	$2,630,000	
	Retaining Wall and Hill Modifications	1	LS	$75,000	$75,000	
	Total					$2,705,000
2	**Fueling Station Equipment**					
	Trailer Fill Fueling Station	1	EA	$1,240,000	$1,240,000	
	Existing CNG Station Integration	1	LS	$150,000	$150,000	
	Total					$1,390,000
3	**Storage**					
	Storage Cylinders	1	LS	$600,000	$600,000	
	Total					$600,000
4	**Tail Gas Destruction and Heat Recovery**					
	Thermal Oxidizer	1	LS	$376,000	$376,000	
	Low Pressure Storage Tank	1	LS	$149,000	$149,000	
	Total					$525,000
	SUBTOTAL					**$5,220,000**
5	**Allowances**					
	Process Mechanical Allowance	5	%		$261,000	
	Yard Piping & Site Civil Allowance	5	%		$261,000	
	EIC Allowance	10	%		$522,000	
	Coating/Painting Allowance	5	%		$261,000	
	Total					$1,305,000
	SUBTOTAL					**$6,525,000**
	Estimating Contingency	30	%			$1,958,000
	SUBTOTAL					**$8,483,000**
	Sales Tax on 50% of Subtotal Above	9.00	%			$382,000
	SUBTOTAL					**$8,865,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$2,216,000
	CONSTRUCTION COST SUBTOTAL					**$11,081,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	2 - BIOGAS UTILIZATION	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	7/31/2018
ALT. # :	2	**PREPARED BY :**	EAC
ALT. :	RNG for Fueling Station	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$2,216,000
	PROJECT COST					**$13,297,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	2 - BIOGAS UTILIZATION	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/6/2018
ALT. # :	3	**PREPARED BY :**	EAC
ALT. :	RNG for Pipeline Injection	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Biogas Cleanup Equipment**					
	BioCNG 400 System, Dual Pass	1	EA	$3,000,000	$3,000,000	
	Retaining Wall and Hill Modifications	1	LS	$75,000	$75,000	
	Total					$3,075,000
2	**Fueling Station Equipment**					
	Trailer Fill Fueling Station	1	EA	$1,240,000	$1,240,000	
	Existing CNG Station Integration	1	LS	$150,000	$150,000	
	Total					$1,390,000
3	**Storage**					
	Storage Cylinders	1	LS	$900,000	$900,000	
	Total					$900,000
4	**Tail Gas Destruction and Heat Recovery**					
	Thermal Oxidizer	1	LS	$376,000	$376,000	
	Low Pressure Storage Tank	1	LS	$149,000	$149,000	
	Total					$525,000
5	**Pipeline Injection Station**					
	Interconnection to PG&E Pipeline Cost Allowance	1	LS	$3,000,000	$3,000,000	
	Total					$3,000,000
	SUBTOTAL					**$8,890,000**
6	**Allowances**					
	Process Mechanical Allowance	5	%		$445,000	
	Yard Piping & Site Civil Allowance	5	%		$445,000	
	EIC Allowance	10	%		$889,000	
	Coating/Painting Allowance	5	%		$445,000	
	Total					$2,224,000
	SUBTOTAL					**$11,114,000**
	Estimating Contingency	30	%			$3,334,000
	SUBTOTAL					**$14,448,000**
	Sales Tax on 50% of Subtotal Above	9.00	%			$650,000

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	2 - BIOGAS UTILIZATION	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/6/2018
ALT. # :	3	**PREPARED BY :**	EAC
ALT. :	RNG for Pipeline Injection	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	SUBTOTAL					**$15,098,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$3,775,000
	CONSTRUCTION COST SUBTOTAL					**$18,873,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$3,775,000
	PROJECT COST					**$22,648,000**

CMSA 2017 Facilities Master Plan
TM No. 2 - Biogas Utilization

O&M Cost Estimates for RNG Alternatives

	Alternative 2 RNG for Fueling Station		Alternative 3 RNG for Pipeline Injection	
Maintenance	Interval	Annualized cost	Interval	Annualized cost
Hydrogen Sulfide Media	9 months	$64,665	4.5 months	$131,625
VOC/Siloxane Media	3 months	$57,200	1 year	$10,500
Oil, CO2 Sensor and Align	1 year	$4,000	1 year	$6,000
Gas Compressor (refurbish)	10 years	$1,640	10 years	$1,640
Modulating Valve (refurbish)	5 years	$1,000	5 years	$1,000
Chiller Compressor (new)	5 years	$2,000	5 years	$2,000
Thermal Oxidizer Maintenance	1 year	$37,500	1 year	$37,500
RIN Broker Fee	3 years	$12,333	3 years	$12,333
TOTAL per year		**$180,338**		**$202,598**
Labor	Hours per year	Annualized cost	Hours per year	Annualized cost
Labor ($75/hr)	150	$15,000	200	$15,000
Management ($150/hr)	30	$4,500	30	$4,500
TOTAL per year		**$19,500**		**$19,500**
Power	kWh per year	Annualized cost	kWh per year	Annualized cost
Power ($0.17/kWh)	1,172,080	$199,254	2,285,556	$388,545
TOTAL per year		**199,254**		**388,545**
Overall Total O&M per year		**399,092**		**610,643**

APPENDIX B – LIFE CYCLE COST ESTIMATES

Economic Analysis: Cogeneration 850 kW

Turn-key Co-generation Plant Cost $8,916,000

Discount Rate 5.00%

Utility Rate Escalation 1.80%

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	TOTAL 20 YEARS
Annual Energy Production	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	7,073,700	141,474,000
BioMAT Tariff	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	$0.128	
Benefits	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	
BioMAT Revenue	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$18,069,059
																					$0
Annual Benefits	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$903,453	$18,069,059
Costs																					
Upfront capital cost	$8,916,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$8,916,000
Operations and Maintenance	$149,000	$151,980	$155,020	$158,120	$161,282	$164,508	$167,798	$171,154	$174,577	$178,069	$181,630	$185,263	$188,968	$192,747	$196,602	$200,534	$204,545	$208,636	$212,809	$217,065	$3,620,308
Insurance	$89,160	$90,943	$92,762	$94,617	$96,510	$98,440	$100,409	$102,417	$104,465	$106,554	$108,686	$110,859	$113,076	$115,338	$117,645	$119,998	$122,398	$124,846	$127,342	$129,889	$2,166,353
Recapitalization																					$0
Annual Costs	$9,154,160	$242,923	$247,782	$252,737	$257,792	$262,948	$268,207	$273,571	$279,042	$284,623	$290,316	$296,122	$302,044	$308,085	$314,247	$320,532	$326,943	$333,481	$340,151	$346,954	$14,702,662
Annual Cash Flows	-$8,250,707	$660,530	$655,671	$650,716	$645,661	$640,505	$635,246	$629,882	$624,411	$618,830	$613,137	$607,331	$601,408	$595,368	$589,206	$582,921	$576,510	$569,971	$563,302	$556,499	$3,366,398
Cumulative Cash Flows	-$8,250,707	-$7,590,177	-$6,934,506	-$6,283,790	-$5,638,129	-$4,997,624	-$4,362,378	-$3,732,496	-$3,108,086	-$2,489,256	-$1,876,119	-$1,268,788	-$667,379	-$72,012	$517,194	$1,100,115	$1,676,626	$2,246,597	$2,809,899	$3,366,398	$3,366,398
														1.12	0.12						

20-Year Analysis Results

Real Value of Lifecycle Cash Flow ($2018)	$ 3,366,398
NPV of lifecycle cash flow	$ (725,120)
Average Annual Cash Flow ($2018)	$ 112,213
NPV of Costs	$ 11,984,141
Return on Investment	3.80%
Benefit-Cost Ratio	1.23
Break even year	14.1

Economic Analysis: RNG Fueling Station

Turn-key RNG Fueling Station Cost	$13,297,000	
	MMBtu	DGE
Natural gas	$3.00	$ 0.39
LCFS Value (biosolids)	$13.77	$ 1.77
LCFS Value (food waste)	$19.11	$ 2.46
D3 RINs (biosolids)	$28.73	$ 3.69
D5 RINs (food waste)	$5.16	$ 0.66
LCFS, RINs share to producer	70%	
Percentage energy from biosolids	45%	
Percentage energy food waste	55%	
Discount Rate	5.00%	
RNG escalation rate	3.00%	
LCFS Credit escalation rate	0.00%	
RINs escalation rate	0.00%	

	1	2	3	4	5	6	7	8	9	10
Annual RNG Production (MMBtu/yr)	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500
Annual RNG Production (gal diesel equivalent/yr)	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000
RNG Retail Market Price ($/gal diesel equivalent)	$0.386	$0.397	$0.409	$0.421	$0.434	$0.447	$0.460	$0.474	$0.488	$0.503
LCFS Credit Value ($/gal diesel equivalent)	$1.503	$1.503	$1.503	$1.503	$1.503	$1.503	$1.503	$1.503	$1.503	$1.503
RINs Value ($/gal diesel equivalent)	$0.464	$0.464	$0.464	$0.464	$0.464	$0.371	$0.297	$0.238	$0.190	$0.152
Benefits	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
RNG Sales Revenue	$454,505	$468,140	$482,184	$496,649	$511,549	$526,895	$542,702	$558,983	$575,753	$593,025
LCFS Credit Revenue	$1,771,795	$1,771,795	$1,771,795	$1,771,795	$1,771,795	$1,771,795	$1,771,795	$1,771,795	$1,771,795	$1,771,795
RINs Revenue	$547,223	$547,223	$547,223	$547,223	$547,223	$437,779	$350,223	$280,178	$224,143	$179,314
Annual Benefits	$2,773,523	$2,787,158	$2,801,202	$2,815,668	$2,830,567	$2,736,469	$2,664,720	$2,610,956	$2,571,690	$2,544,134
Costs										
Upfront capital cost	$13,297,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operations and Maintenance	$399,000	$406,980	$415,120	$423,422	$431,890	$440,528	$449,339	$458,326	$467,492	$476,842
Insurance	$132,970	$135,629	$138,342	$141,109	$143,931	$146,810	$149,746	$152,741	$155,796	$158,911
Recapitalization										
Annual Costs	$13,828,970	$542,609	$553,462	$564,531	$575,821	$587,338	$599,085	$611,066	$623,288	$635,753
Annual Cash Flows	-$11,055,447	$2,244,549	$2,247,741	$2,251,137	$2,254,746	$2,149,131	$2,065,635	$1,999,890	$1,948,403	$1,908,381
Cumulative Cash Flows	-$11,055,447	-$8,810,899	-$6,563,158	-$4,312,021	-$2,057,276	$91,855	$2,157,491	$4,157,381	$6,105,784	$8,014,165
						0.957	(0.04)			

	11	12	13	14	15	16	17	18	19	20	TOTAL 20 YEARS
Annual RNG Production (MMBtu/yr)	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	3,030,000
Annual RNG Production (gal diesel equivalent/yr)	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	
RNG Retail Market Price ($/gal diesel equivalent)	$0.518	$0.534	$0.550	$0.566	$0.583	$0.601	$0.619	$0.637	$0.656	$0.676	
LCFS Credit Value ($/gal diesel equivalent)	$1.503	$1.503	$1.503		$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	
RINs Value ($/gal diesel equivalent)	$0.122	$0.097	$0.078		$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	
Benefits	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	
RNG Sales Revenue	$610,816	$629,141	$648,015	$667,455	$687,479	$708,103	$729,346	$751,227	$773,763	$796,976	$12,212,706
LCFS Credit Revenue	$1,771,795	$1,771,795	$1,771,795	$0	$0	$0	$0	$0	$0	$0	$23,033,334
RINs Revenue	$143,451	$114,761	$91,809	$0	$0	$0	$0	$0	$0	$0	$4,557,775
Annual Benefits	$2,526,062	$2,515,696	$2,511,618	$667,455	$687,479	$708,103	$729,346	$751,227	$773,763	$796,976	$39,803,815
Costs											
Upfront capital cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$13,297,000
Operations and Maintenance	$486,379	$496,106	$506,028	$516,149	$526,472	$537,001	$547,741	$558,696	$569,870	$581,268	$9,694,651
Insurance	$162,090	$165,331	$168,638	$172,011	$175,451	$178,960	$182,539	$186,190	$189,914	$193,712	$3,230,821
Recapitalization											$0
Annual Costs	$648,468	$661,438	$674,667	$688,160	$701,923	$715,962	$730,281	$744,886	$759,784	$774,980	$26,222,472
Annual Cash Flows	$1,877,594	$1,854,259	$1,836,952	-$20,705	-$14,444	-$7,858	-$935	$6,340	$13,979	$21,997	$13,581,343
Cumulative Cash Flows	$9,891,758	$11,746,017	$13,582,969	$13,562,264	$13,547,820	$13,539,962	$13,539,027	$13,545,367	$13,559,347	$13,581,343	$13,581,343

20-Year Analysis Results

Real Value of Lifecycle Cash Flow ($2018)	$ 13,581,343
NPV of lifecycle cash flow	$ 7,019,620
Average Annual Cash Flow ($2018)	$ 452,711
NPV of Costs	$ 20,465,363
Return on Investment	16.02%
Benefit-Cost Ratio	1.52
Break even year	6.0

Economic Analysis: RNG Pipeline Injection

Turn-key RNG Pipeline Injection	$22,648,000																				
Discount Rate	5.00%																				
RNG escalation rate	0.00%																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	TOTAL 20 YEARS
Annual RNG Production (MMBtu/yr)	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	151,500	3,030,000
RNG Fixed Contract Price ($/MMBtu)	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	$16.50	
Benefits	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	
RNG Sales Revenue	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$49,995,000
																					$0
Annual Benefits	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$2,499,750	$49,995,000
Costs																					
Upfront capital cost	$22,648,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$22,648,000
Operations and Maintenance	$611,000	$623,220	$635,684	$648,398	$661,366	$674,593	$688,085	$701,847	$715,884	$730,202	$744,806	$759,702	$774,896	$790,394	$806,202	$822,326	$838,772	$855,548	$872,658	$890,112	$14,845,693
Insurance	$226,480	$231,010	$235,630	$240,342	$245,149	$250,052	$255,053	$260,154	$265,357	$270,665	$276,078	$281,599	$287,231	$292,976	$298,836	$304,812	$310,909	$317,127	$323,469	$329,939	$5,502,868
Recapitalization																					$0
Annual Costs	$23,485,480	$854,230	$871,314	$888,740	$906,515	$924,646	$943,139	$962,001	$981,241	$1,000,866	$1,020,883	$1,041,301	$1,062,127	$1,083,370	$1,105,037	$1,127,138	$1,149,681	$1,172,674	$1,196,128	$1,220,050	$42,996,561
Annual Cash Flows	-$20,985,730	$1,645,520	$1,628,436	$1,611,010	$1,593,235	$1,575,104	$1,556,611	$1,537,749	$1,518,509	$1,498,884	$1,478,867	$1,458,449	$1,437,623	$1,416,380	$1,394,713	$1,372,612	$1,350,069	$1,327,076	$1,303,622	$1,279,700	$6,998,439
Cumulative Cash Flows	-$20,985,730	-$19,340,210	-$17,711,774	-$16,100,764	-$14,507,530	-$12,932,425	-$11,375,814	-$9,838,065	-$8,319,556	-$6,820,672	-$5,341,806	-$3,883,357	-$2,445,734	-$1,029,354	$365,359	$1,737,971	$3,088,041	$4,415,117	$5,718,739	$6,998,439	$6,998,439
															0.74						

20-Year Analysis Results	
Real Value of Lifecycle Cash Flow ($2018)	$ 6,998,439
NPV of lifecycle cash flow	$ (2,699,094)
Average Annual Cash Flow ($2018)	$ 233,281
NPV of Costs	$ 33,851,505
Return on Investment	3.21%
Benefit-Cost Ratio	1.16
Break even year	14.7

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM NO. 3
ORGANIC WASTE RECEIVING FACILITY EVALUATION

FINAL
October 2018

CENTRAL MARIN SANITATION AGENCY

2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM
NO. 3
ORGANIC WASTE RECEIVING FACILITY EVALUATION

TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF FIGURES

DISCLOSURE STATEMENT

Funding for this document has been provided in full or in part through an agreement with the State Water Resources Control Board. California's Clean Water State Revolving Fund is capitalized through a variety of funding sources, including grants from the United States Environmental Protection Agency and state bond proceeds. The contents of this document do not necessarily reflect the views and policies of the foregoing, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ORGANIC WASTE RECEIVING FACILITY EVALUATION

1.0 INTRODUCTION

This technical memorandum (TM) summarizes the findings from the Organic Waste Receiving Facility (OWRF) evaluation for the Wastewater Treatment Plant (WWTP) at the Central Marin Sanitation Agency (Agency). The purpose of this evaluation is to assist the Agency in determining whether to expand the existing OWRF as originally designed or to construct a dedicated receiving facility for liquid waste.

This evaluation includes an analysis of both economic and non-economic factors and a life cycle cost comparison for four alternatives. The economic factors include estimated capital costs and operations and maintenance (O&M) costs (power, chemicals, labor, and maintenance). Other preliminary factors evaluated include siting requirements, uniformity of organic waste feed to the digesters, and relative ease of operations.

2.0 SUMMARY OF KEY FINDINGS

The key findings are:

- Alternative 1, New Below-Grade Storage to Double Capacity. The estimated total project cost and present worth of this alternative is $1,590,000 and $7,900,000, respectively. The non-economic evaluation score for this alternative is 18 (higher is better).
- Alternative 2, New Aboveground Storage to Double Capacity. The estimated total project cost and present worth of this alternative is $2,330,000 and $9,210,000, respectively. The non-economic evaluation score for this alternative is 14 (higher is better).
- Alternative 3, New Below-Grade Storage for 1 day HRT. The estimated total project cost and present worth of this alternative is $1,220,000 and $7,510,000, respectively. The non-economic evaluation score for this alternative is 19 (higher is better).
- Alternative 4, New Aboveground Storage for 1 day HRT. The estimated total project cost and present worth of this alternative is $1,440,000 and $8,037,000, respectively. The non-economic evaluation score for this alternative is 16 (higher is better).

3.0 BACKGROUND

In 2012, the Agency constructed an OWRF that includes a 25,000 gallon below-grade storage tank to increase biogas production that the WWTP uses for plant power. Shortly after construction, the Agency began receiving fats, oils and grease (FOG) from private haulers and pre-processed food waste (FW) slurry from Marin Sanitary Service (MSS) under the cooperative Food-to-Energy (F2E) Program. In FY 16/17, the Agency received an average of approximately 9,700 gallons per day (gpd) of FOG and 6 tons per day (tpd) of FW, which increased the average volatile solids (VS) loading to the digesters by approximately 7,200 pounds per day (ppd).

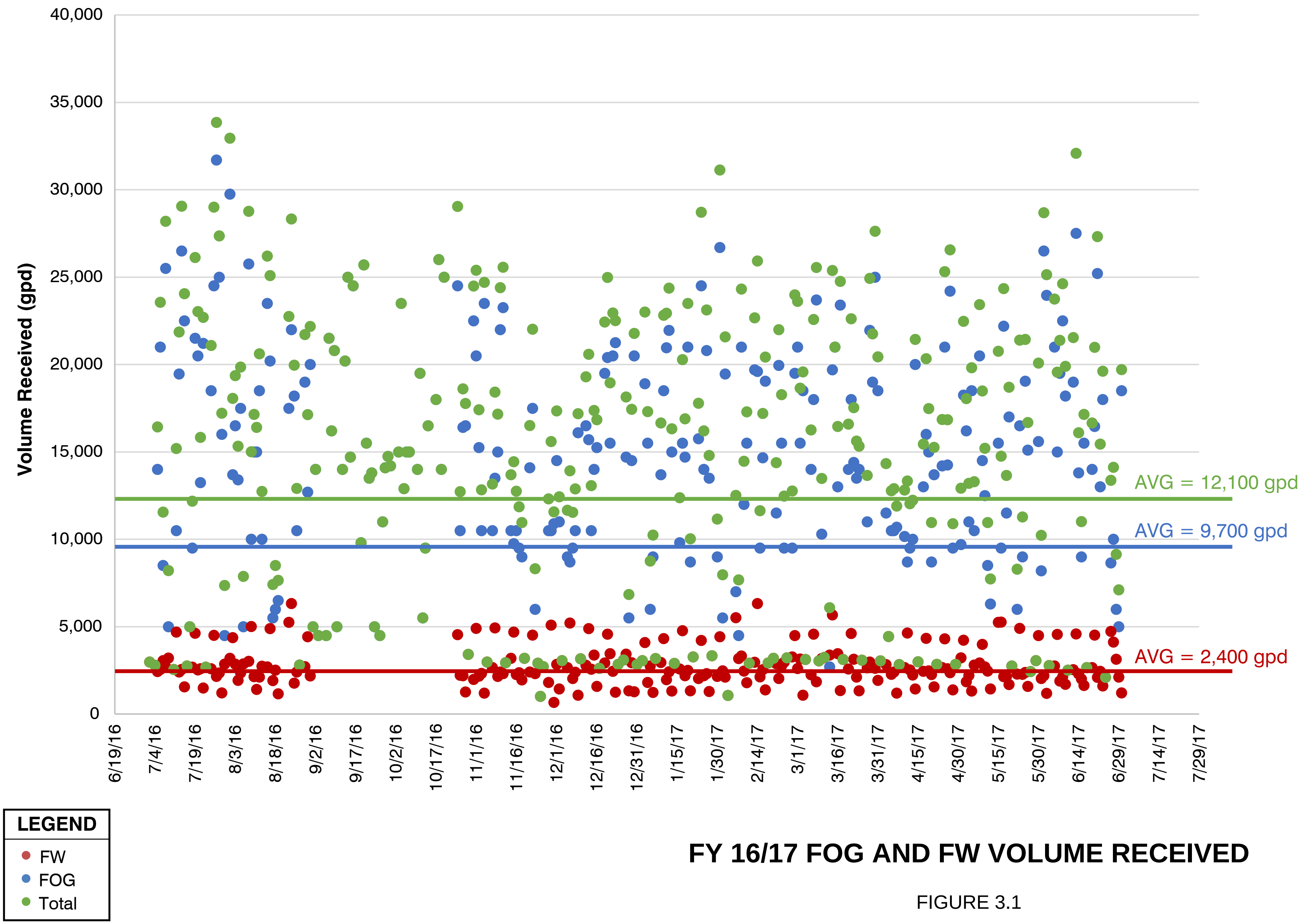
Figures 3.1 and 3.2 summarize the FOG and FW quantities received and VS loading on a daily basis during FY 16/17, respectively.

During FY 16/17, the digestion process produced an average of 200 standard cubic feet per minute (scfm) of digester gas, which resulted in an average energy recovery of 13,500 kilowatt hours per day (kW-hr/d) and an average electrical power production of 600 kW. The Agency is interested in expanding its organic waste receiving capacity to increase the electrical power recovery at the WWTP.

3.1 OWRF Operations and Equipment Summary

In FY 16/17, the Agency received on average three FOG deliveries and one FW delivery per day, with the exception of Sundays when they do not receive. The FOG deliveries are screened through a Heavy Object Trap to remove contaminants prior to transfer to the below-grade storage tank. The FW slurry delivery is off-loaded from trucks into an 8-ft by 8-ft double-leaf hatch in the roof of the storage tank. Once offloading is complete and the level in the slurry tank is above a minimum setpoint, the FOG/FW Mixing Pumps mix the FOG/FW blend for about an hour. Once the mixing cycle has timed out, the paddle finisher loop is initiated, where the FOG/FW blend is pumped through a rock trap grinder and paddle finisher for discharge into the Screened FW Sump. Once the level in this sump rises to an adjustable setpoint, the FOG/FW feed pumps are initiated and the FOG/FW blend is pumped into the digesters in a dedicated pipeline.

Table 3.1 provides a summary of the OWRF equipment design criteria.



FY 16/17 FOG AND FW VOLUME RECEIVED

FIGURE 3.1

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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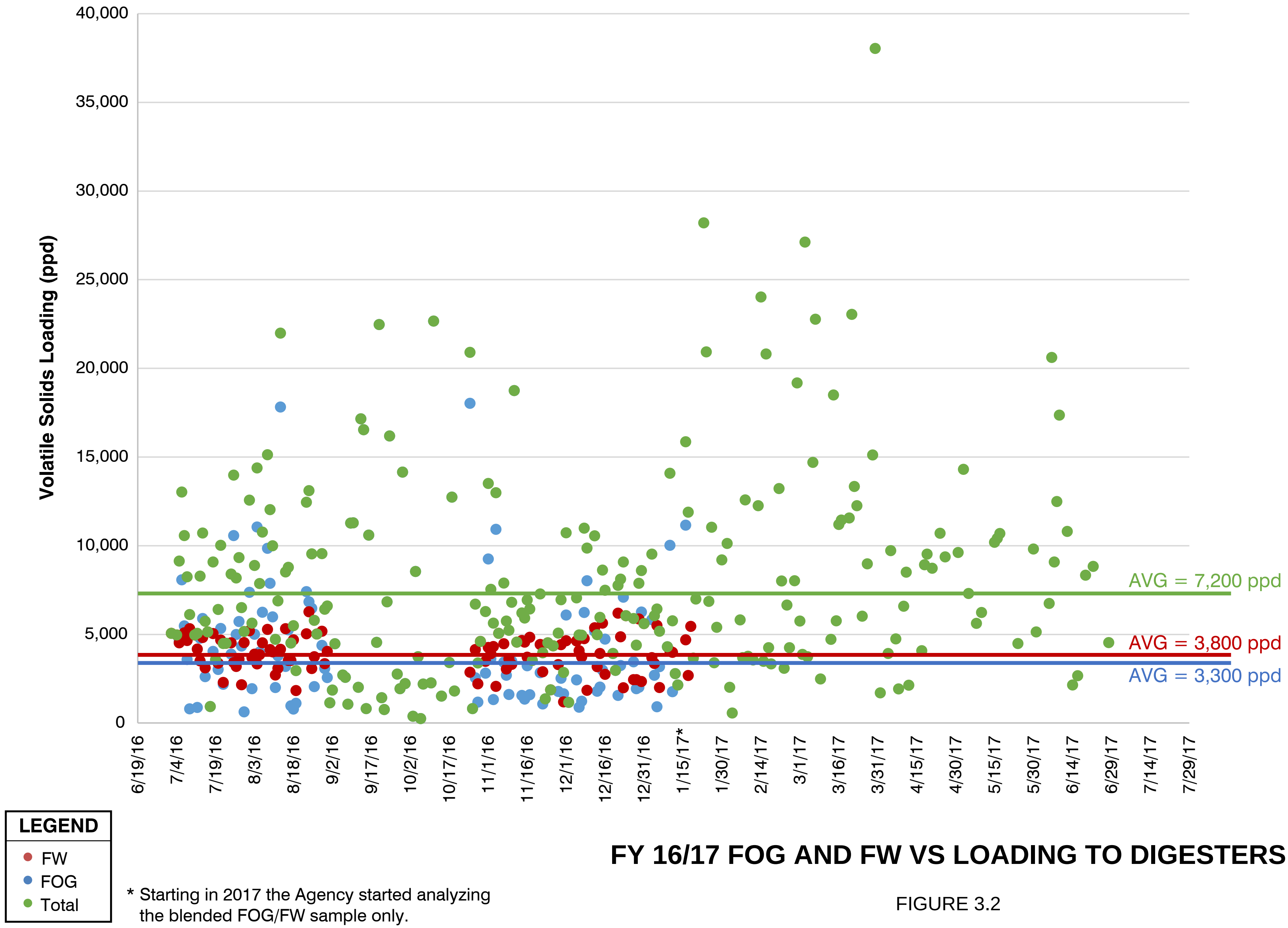

* Starting in 2017 the Agency started analyzing the blended FOG/FW sample only.

FY 16/17 FOG AND FW VS LOADING TO DIGESTERS

FIGURE 3.2

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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Table 3.1 OWRF Design Criteria
2017 Facilities Master Plan
Central Marin Sanitation Agency

Item	Value(1)
Storage Tank Volume	25,000 gal(2)
FOG/FW Feed Pump, P 21.5	
Number	1
Type	Hose Pump
Capacity	60 gpm
Motor	10 hp, VFD
FOG/FW Mixing Pumps, P 21.1 and P 21.2	
Number	2
Type	Chopper
Capacity	1,700 gpm
Motor	25 hp, VFD
Sludge Recirculation Pump, P 21.4	
Number	1
Type	Chopper
Capacity	300 gpm
Motor	15 hp, VFD
Rock Trap Grinder, RTG 21.1	
Number	1
Motor	3 hp
Paddle Finisher, PF 21.1	
Number	1
Motor	40 hp
Paddle Finisher Feed Pump, P 21.3	
Number	1
Type	Hose
Capacity	60 gpm
Motor	10 hp, VFD
Odor Control	
Type	Carbon Adsorption

Table 3.1 OWRF Design Criteria 2017 Facilities Master Plan Central Marin Sanitation Agency	
Item	**Value(1)**
Odor Control Fans, OCS 21.1	
Number	1
Type	Centrifugal
Capacity	600 cfm
Motor	5 hp
MCC 21.1	
Feeder Capacity	300 A
Bus Capacity	600 A

Notes:
(1) Referenced from the 2014 record drawings for the Digester Improvements and FOG/Food to Energy Facility Project, unless noted otherwise.
(2) Usable volume assumed for this evaluation.

4.0 EVALUATION BASIS AND FACILITY SIZING

This section establishes the planning level sizing basis for the organic waste receiving alternatives. Records of the recent digester feed characteristics at the plant outlined in the 2017-3-25 OWRF Weekly document showed that the FOG/FW slurry comprised approximately 31 percent of total digester feed on a VS loading fraction basis cumulatively from January through March 2017. While published research recommends limiting import of FOG and FW to approximately 30 percent of the total digester feed on a VS loading fraction basis, the Agency has successfully kept the digesters stable above this limit. Therefore, it is assumed that the microorganisms within the digesters are accustomed to the feedstock characteristics and could potentially accommodate an even higher percentage of organic slurry. While this was assumed for planning purposes, a detailed assessment of any future additional organic loading to the digester would need to be completed prior to any increase in loading above FY 16/17 levels.

In TM No. 2 - Biogas Utilization, three scenarios were evaluated to establish the amount of additional biogas that would be generated from importing more organic waste in order to increase electrical power recovery at the WWTP:

- Scenario 1, Achieve Plant Self-Sufficiency: Increase biogas production by increasing FOG/FW quantities to achieve a total average electrical power of approximately 650 kW, which equates to the average total power requirements in FY 16/17. In order to meet this goal, the FOG/FW quantity received would need to increase from 31 percent to approximately 36 percent of the total digester feed on a VS loading fraction basis.

- Scenario 2, Maximize Cogeneration Capacity: Increase biogas production by increasing FOG/FW quantities to produce a total average electrical power of 750 kW, which equates to the capacity of the existing cogeneration facility. In order to meet this goal, the FOG/FW quantity received would need to increase from 31 percent to approximately 40 percent of the total digester feed on a VS loading fraction basis.

- Scenario 3, Maximize Digestion Capacity: Increase biogas production by increasing FOG/FW to reach a maximum digester capacity VS loading rate of 0.16 lb VS/cf/day, which equates to an average electrical power production of approximately 1,280 kW. In order to meet this goal, the FOG/FW quantity received would need to increase from 31 percent to approximately 61 percent of the total digester feed on a VS loading fraction basis.

As discussed in TM No. 2, Scenario 2 was selected for planning purposes of future biogas utilization alternatives by the Agency. Accordingly, the additional FOG and FW increases associated with Scenario 2 will be used to evaluate the expanded OWRF storage alternatives.

Table 3.2 summarizes the sludge, FOG, and FW quantities and digester operating conditions for the current FY 16/17 conditions and the selected Scenario 2. With this scenario, the average FOG volume received would increase from 9,700 gpd to 19,500 gpd and the average FW volume received would increase from 2,400 gpd to 2,600 gpd. This additional FOG and FW volume necessitates an expansion of the existing OWRF.

Table 3.2 Daily Average Digester Feed
2017 Facilities Master Plan
Central Marin Sanitation Agency

	Average FY 16/17	Scenario 2 Max Out Cogen Capacity
Total PS+TWAS(1)		
gal/day	46,200	46,200
% TS	5%	5%
TS, lb/d	19,286	19,286
% VS	84%	84%
VS, lb/d	16,200	16,200
VS load fraction	69%	60%
FOG		
gal/delivery(2)	13,884	27,912
% TS	4%	4%(3)
TS, lb/delivery(2)	5,110	10,250

Table 3.2 Daily Average Digester Feed 2017 Facilities Master Plan Central Marin Sanitation Agency		
	Average FY 16/17	**Scenario 2 Max Out Cogen Capacity**
% VS	93%	93%(3)
VS, lb/delivery(2)	4,752	9,533(4)
VS load fraction	14%	25%
FW Slurry		
gal/delivery(2)	3,344	3,622
% TS	21%	21%(3)
TS, lb/delivery(2)	5,879	6,460
% VS	91%	91%(3)
VS, lb/delivery(2)	5,350	5,879(4)
VS load fraction	16%	16%
FOG/FW Slurry		
gal/delivery(2)	17,228	31,534
% TS	8%	6%
TS, lb/delivery(2)	10,989	16,711
% VS	92%	92%
VS, lb/delivery(2)	10,102	15,412
VS load fraction	31%	40%
Total Digester Feed (PS, TWAS, FOG, and FW)		
gal/day	61,700	69,600
% TS	5%	5%
TS, lb/d	27,075	31,084
% VS	86%	87%
VS, lb/d	23,360	27,080
Percent of Total Digester Capacity Used in Scenario (Based on VSLR)	56%	65%

Table 3.2	Daily Average Digester Feed 2017 Facilities Master Plan Central Marin Sanitation Agency	
	Average FY 16/17	**Scenario 2 Max Out Cogen Capacity**

Notes:

(1) Based on Agency input it was assumed that PS and WAS flows and loads would stay constant over the planning horizon.
(2) These are daily averages on the days the Agency receives FOG or FW. These values do not represent annual averages and thus these values differ from the annual averages shown in Figures 3.1 and 3.2.
(3) %TS and %VS were held constant over the planning horizon.
(4) Scenario 2 projections were based on increasing VS load to match the existing cogeneration capacity. It was assumed that the increased VS load would be split between FOG and FW, with FW increasing up to a maximum of 10 percent over the planning period.

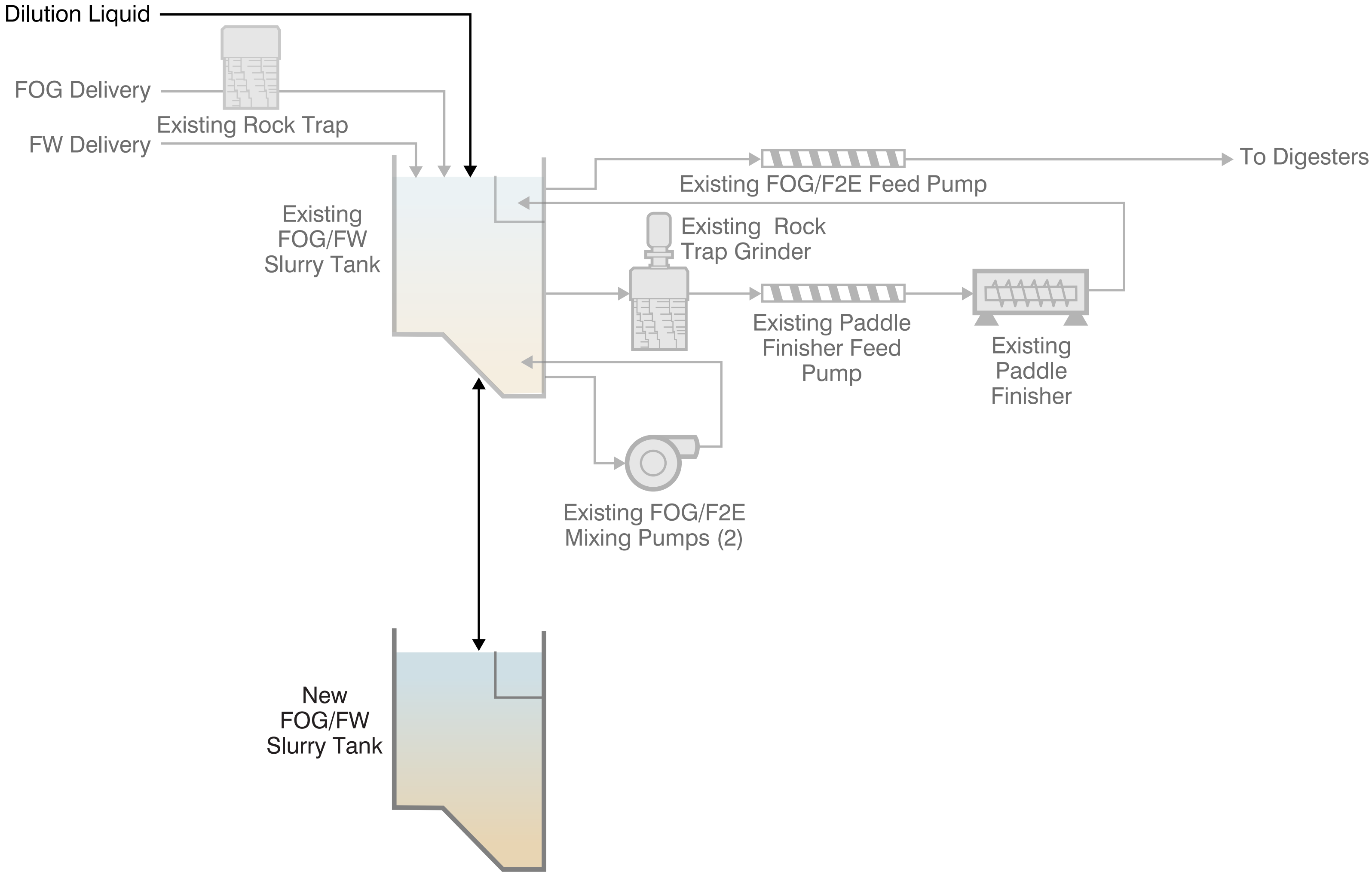
5.0 OWRF EXPANSION ALTERNATIVES

This section summarizes the evaluation of four organic waste receiving expansion alternatives.

5.1 Alternative 1: New Below-Grade Storage to Double Capacity

Alternative 1 was developed to double the storage volume of the existing OWRF to accommodate the increased FOG and FW flows to the digester. The preliminary layout of the new facility was assumed to be an identically sized below grade tank expansion located adjacent to the existing facility. It was also assumed this new tank would be an expansion to the existing facility and would thus not need a new set of pumps, grinders, etc. Figure 3.3 shows the preliminary process flow diagram for this alternative and Figure 3.4 depicts the Alternative 1 preliminary site plan. Preliminary design criteria are summarized in Table 3.3.

With this alternative, FOG and FW would continue to be stored in the same tank, so the FOG received provides some of the needed dilution for the thick FW slurry. Depending on the actual percent solids of the FW slurry received, an external dilution liquid volumetric flow of about 2,000 gpd in addition to the FOG received may be needed to keep the percent solids of the FOG/FW slurry below 6 percent. 6 percent solids was chosen based on Agency input, as the existing chopper pumps onsite appear to be able to pump this percent solids. However, typically chopper pumps are used to pump 2 to 3 percent solids (Pump Station Design, 3rd Edition). Prior to final pump selection during final design, the pump manufacturer should weigh in on the maximum pump-able slurry concentration. If the equipment supplier has concerns with pumping a 6 percent solution, alternative pumping should be evaluated. Because FOG is needed to dilute the FW before the mixture can be pumped, all daily FOG/FW deliveries need to occur before the slurry is mixed and fed to the digester. Thus, each day there will be a period of time when no high strength waste enters the digester. This variability in digester feedstock could impact digester stability and may



ALTERNATIVE 1
PRELIMINARY PROCESS FLOW DIAGRAM

FIGURE 3.3

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2017 FACILITIES MASTER PLAN

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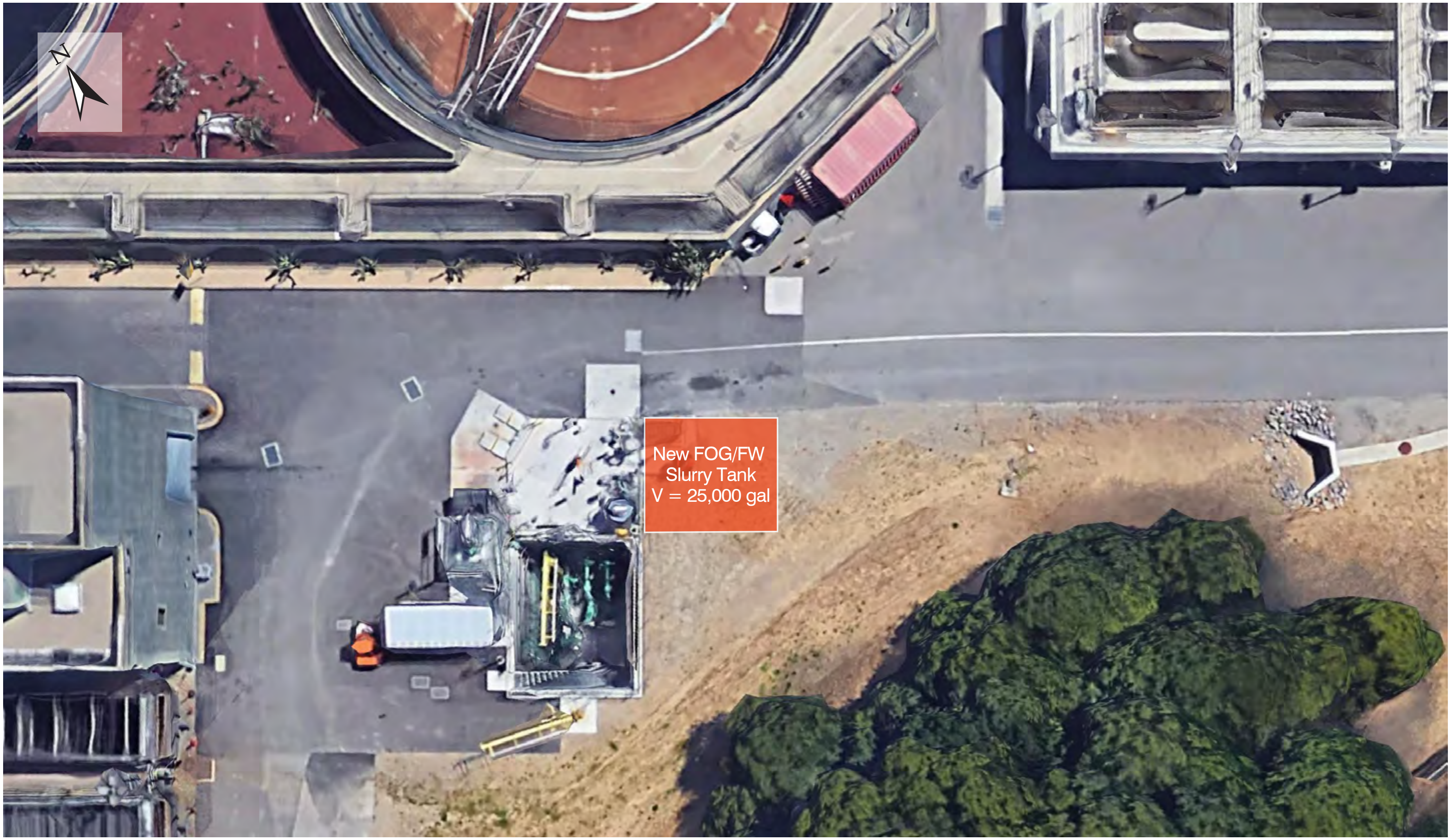

ALTERNATIVE 1
PRELIMINARY SITE PLAN

FIGURE 3.4

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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Table 3.3 Alternative 1 Preliminary Design Criteria 2017 Facilities Master Plan Central Marin Sanitation Agency			
	Existing	**New**	**Total**
Below-Grade Storage			
Service	FOG + FW	FOG + FW	FOG + FW
Number of Tanks	1	1	2 (1 new + 1 existing)
Capacity, total (gal)	25,000	25,000	50,000
HRT (days)	2.0	NA	1.5
External Dilution Required (gpd)	3,400(1)	NA	2,000(2)
Typical Percent Solids (%)	6.0	NA	6.0
Storage Tank Material	Concrete	Concrete	Concrete
Digester			
Digester HRT, days(3)	31.7	NA	24.5
Digester Loading, lb VS/cf/d(4)	0.083	NA	0.104

Notes:
(1) External dilution was assumed to keep the percent solids below 6 percent; however, current dilution amounts are not known at this time.
(2) External dilution liquid may be required to keep the FOG + FW slurry to a concentration below 6 percent solids. If used, it was assumed this dilution liquid would have a low solids concentration. 6 percent solids was chosen based on Agency input.
(3) Minimum HRT of 15 days is recommended.
(4) Maximum loading of 0.16 lb VS/cf/d is recommended.

result in diurnal fluctuation of digester gas production. Alternatively, the Agency could consider diluting with an additional external dilution source. This additional volume would decrease the HRT in the FOG/FW below grade storage facility.

With the increased FOG/FW flows and loads assumed with Scenario 2, the hydraulic residence time (HRT) of the expanded OWRF will change from its current value of 2.0 days. The new HRT with this alternative would be approximately 1.5 days. To operate at this HRT, Agency staff would need to coordinate FOG and FW deliveries to ensure they are regularly scheduled and occur at similar times each day. Staff would also need to remain cognizant of FOG/FW levels in the expanded OWRF holding tank. Additionally, to maximize the amount of energy produced in the cogeneration facility, FOG and FW deliveries would need to be made during the weekend. Currently FW and sometimes FOG are delivered on Saturday; however no deliveries are made on Sunday when maintenance work is done.

5.1.1 Electrical Requirements for Alternative 1

Table 3.4 summarizes the new estimated loads that would be required for Alternative 1. As shown in Table 3.4, it was assumed that only an additional odor scrubber would be needed for this tank expansion. The estimated new load of this odor scrubber is 14 amperage (A). This load, combined with the existing load, sums to a total of around 180 A/The existing OWRF has a 300 A feed from the Main Switchgear Building to supply power to MCC 21.1, which is dedicated for the existing OWRF equipment. Based on the preliminary load calculations shown in Table 3.4, this feeder appears to be large enough to accommodate both the existing and new loads. This should be reviewed further during preliminary design.

Table 3.4 Alternative 1 Preliminary Load List
2017 Facilities Master Plan
Central Marin Sanitation Agency

New Equipment	New Load (hp)	New FLA (amp)	Service
Odor Control Scrubber	7.5	11	Continuous
Total - New Equipment(1)		**14**	
Total (Including Existing Equipment)(2)		**179**	

Notes:
(1) Only "Intermittent" and "Continuous" loads were considered in calculation of total FLA. "Continuous" loads include a 25% safety factor.
(2) Existing power draw was assumed to be 165 amps.

5.2 Alternative 2: New Aboveground Storage to Double Capacity

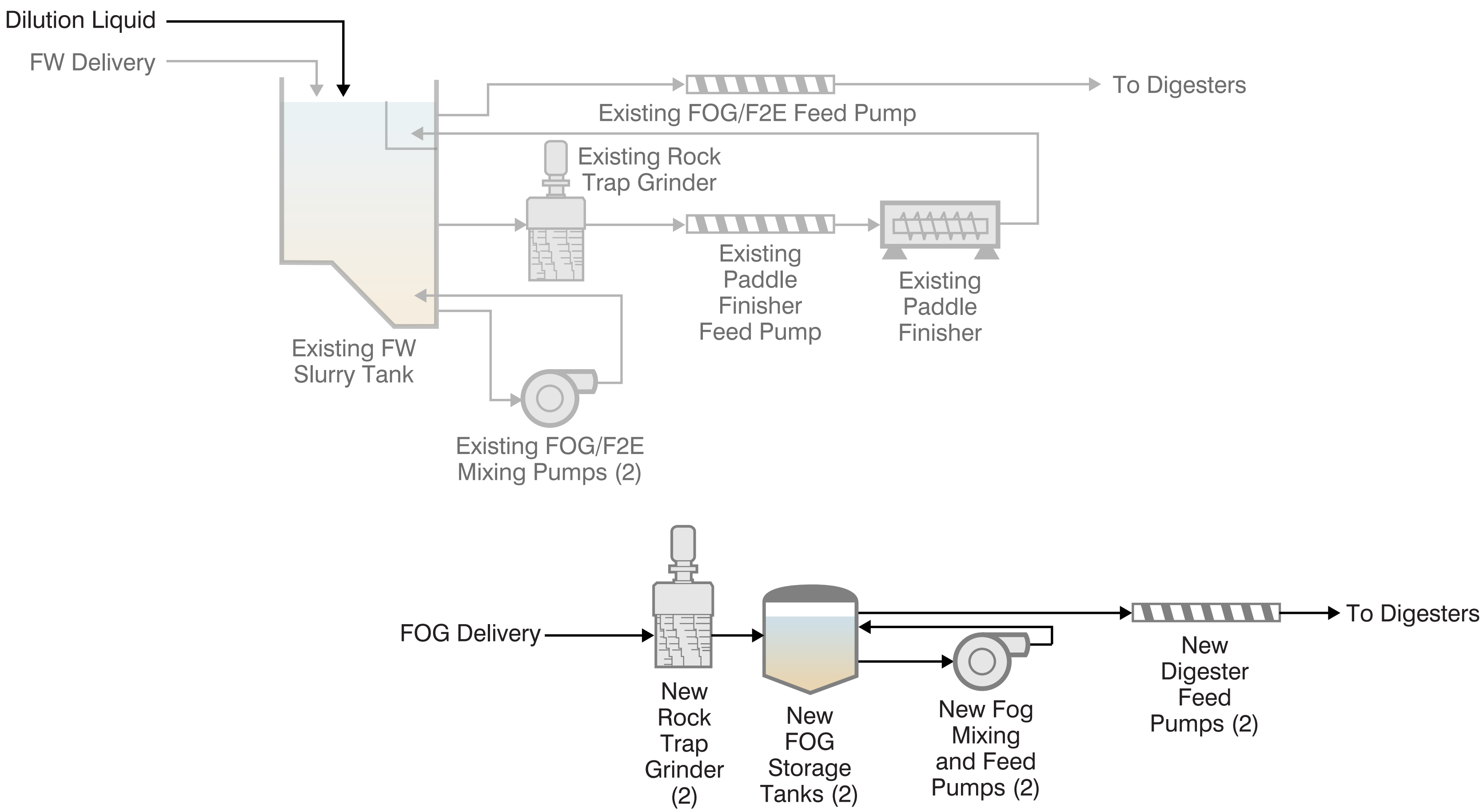
Alternative 2 was developed to provide a more consistent high strength waste feed to the digesters. With this alternative, the existing OWRF would be dedicated to FW receiving and two new aboveground 12,500 gallon tanks would be provided for dedicated FOG receiving. These aboveground tanks could be made of stainless steel, epoxy coated steel, or concrete. For planning purposes, epoxy coated steel was assumed. Figure 3.5 shows the preliminary process flow diagram for this alternative, Figure 3.6 shows a preliminary layout for this alternative, and Figure 3.7 depicts the Alternative 2 preliminary site plan. Preliminary design criteria are summarized in Table 3.5.

With this alternative, the FW may still be diluted with FOG, to the extent possible, depending on the actual percent solids of the FW received. However, an external liquid volumetric flow of approximately 9,500 gpd is needed to maintain a pump-able FW slurry concentration of 6 percent or less. Because a portion of the FOG is stored separately from the FW, high strength waste can be fed to the digester more regularly, as the Agency can pump FOG to the digesters before all the FW is received. This is an advantage over Alternative 1 as it maintains a consistent digester feed and makes it less likely that the digesters would become upset from feed fluctuations.

Table 3.5 Alternative 2 Preliminary Design Criteria 2017 Facilities Master Plan Central Marin Sanitation Agency			
	Existing	**New**	**Total**
Above Ground Storage			
Service	NA	FOG	FOG
Number of Tanks	NA	2	2
Capacity, total (gal)	NA	25,000	25,000
HRT (days)	NA	1.1	1.1
Typical Percent Solids (%)	NA	4.4	4.4
Storage Tank Material	NA	Epoxy Coated Steel	Epoxy Coated Steel
Below Ground Storage			
Service	FOG + FW	NA	FW
Number of Tanks	1	NA	1
Capacity, total (gal)	25,000	NA	25,000
HRT (days)	2.0	NA	1.4
External Dilution Required (gpd)	3,400(1)	NA	9,500(2)
Typical Percent Solids (%)	6.0	NA	5.5
Storage Tank Material	Concrete	NA	Concrete
Digester			
Digester HRT, days(3)	31.7	NA	22.4
Digester Loading, lb VS/cf/d(4)	0.083	NA	0.104

Notes:
(1) External dilution was assumed to keep the percent solids below 6 percent; however, current dilution amounts are not known at this time.
(2) External dilution liquid may be required to keep the FOG + FW slurry to a concentration below 6 percent solids. If used, it was assumed this dilution liquid would have a low solids concentration. 6 percent solids was chosen based on Agency input.
(3) Minimum HRT of 15 days is recommended.
(4) Maximum loading of 0.16 lb VS/cf/d is recommended.

However, like Alternative 1, the increased FOG/FW flows and loads assumed with Scenario 2, decreases the HRT of the expanded OWRF from its current value of 2.0 days. The new HRT with this alternative would be 1.1 days for FOG storage and 1.4 days for FW storage. Coordinating FOG/FW flows across these three tanks is more operationally challenging than in Alternative 1. To operate at this HRT, Agency staff would need to coordinate FOG and FW deliveries to ensure they are regularly scheduled and occur at similar times each day. Staff would also need to remain cognizant of FOG/FW levels in the



ALTERNATIVE 2
PRELIMINARY PROCESS FLOW DIAGRAM

FIGURE 3.5

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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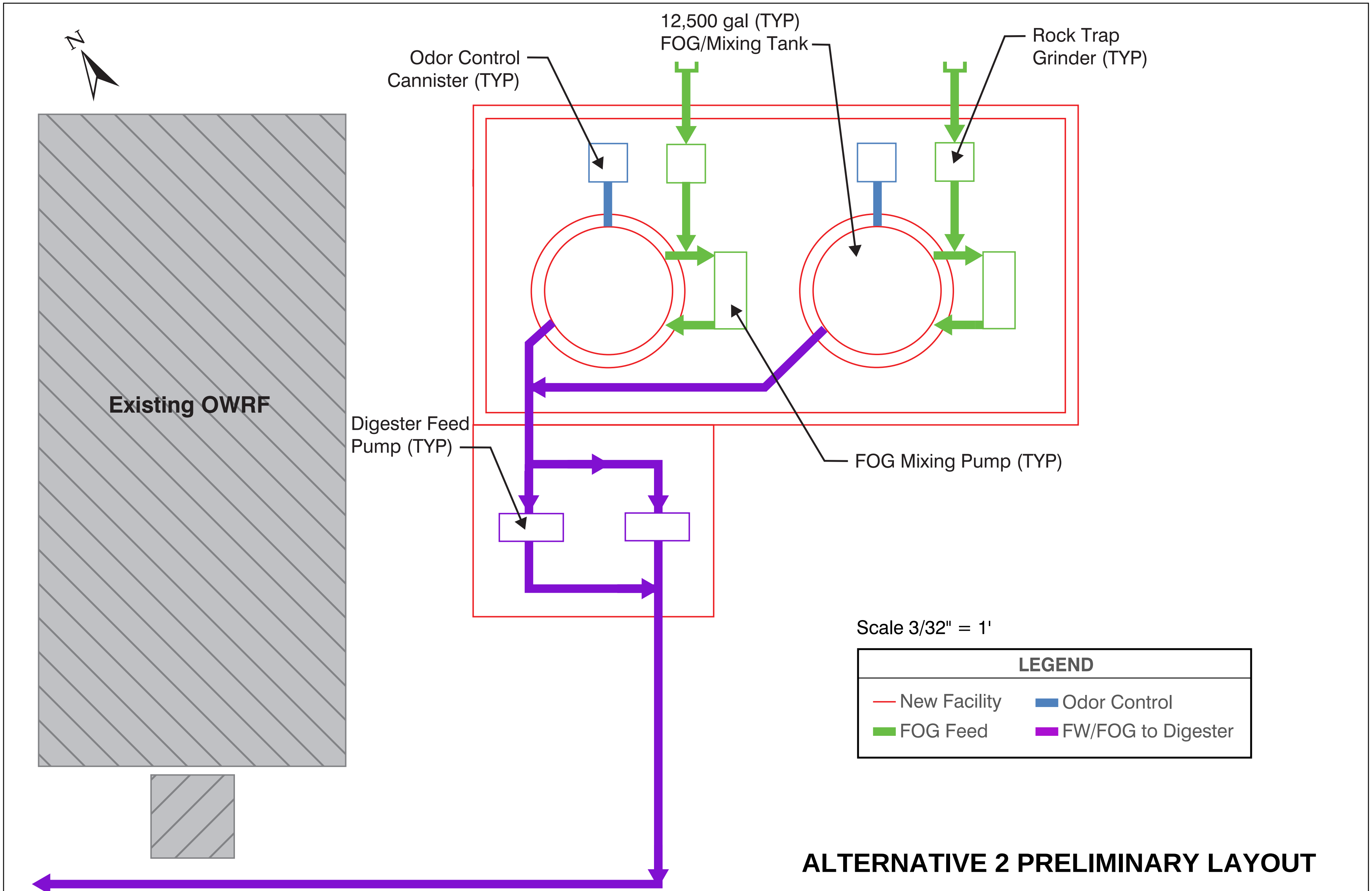

ALTERNATIVE 2 PRELIMINARY LAYOUT

FIGURE 3.6

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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ALTERNATIVE 2
PRELIMINARY SITE PLAN

FIGURE 3.7

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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OWRF holding tanks. Additionally, like Alternative 1, to maximize the amount of energy produced in the cogeneration facility, FOG and FW deliveries would need to be made during the weekend. This lower HRT may present operational challenges for staff and may sometimes mean turning away FOG/FW deliveries and operating the digesters with less than the designed FOG/FW loading. Alternatively, staff could accept all FOG/FW deliveries and feed the digester at a higher rate. However, these high digester loading rates may cause digester upsets.

5.2.1 Electrical Requirements for Alternative 2

Table 3.6 summarizes the estimated new loads that would be required for Alternative 2.

As shown in Table 3.6, the estimated new total load is 294 A. Based on the load calculations shown in Table 3.6, it appears that the existing 300 A feeder may be adequate to accommodate both the existing and new loads for Alternative 2. However, it appears there is insufficient space in MCC 21.1 to accommodate the starters for the new equipment and insufficient space to expand within the building. Thus, for the purpose of this analysis, it was assumed that a new 300 A feed from the existing Main Switchgear Building and a new MCC structure with a 600 A bus capacity would be required. This should be reviewed further during preliminary design.

Table 3.6 Alternative 2 Preliminary Load List
2017 Facilities Master Plan
Central Marin Sanitation Agency

New Equipment	New Load (hp)	New FLA (amp)	Service
FOG Delivery Valve 1	0.5	1.1	Intermittent
FOG Delivery Valve 2	0.5	1.1	Intermittent
Rock Trap Grinder 1	3	4.8	Intermittent
Rock Trap Grinder 2	10	14	Intermittent
FOG Mixing and Feed Pump 1	30	40	Intermittent
FOG Mixing and Feed Pump 2	30	40	Intermittent
Odor Control Scrubber 1	7.5	11	Continuous
Odor Control Scrubber 2	7.5	11	Continuous
Total - New Equipment(1)		**129**	
Total (Including Existing Equipment)(2)		**294**	

Notes:
(1) Only "Intermittent" and "Continuous" loads were considered in calculation of total FLA. "Continuous" loads include a 25% safety factor.
(2) Existing load list is identical to the new equipment shown in Table 3.4 for Alternative 1.

5.3 Alternative 3: New Below-Grade Storage for 1 Day HRT

Alternative 3 was developed as a smaller, lower volume alternative to Alternative 1. Instead of doubling the existing below-grade storage, Alternative 3 looks at expanding the existing below-grade storage to provide sufficient storage capacity for a 1 day HRT. To achieve this an additional 10,000 gallons of storage is needed. Like Alternative 1, it was assumed that this additional capacity would be added as an expansion to the existing tank and thus not require separate pumps, grinders, etc. Figure 3.8 shows the preliminary process flow diagram for this alternative and Figure 3.9 depicts the Alternative 3 preliminary site plan. Preliminary design criteria are summarized in Table 3.7.

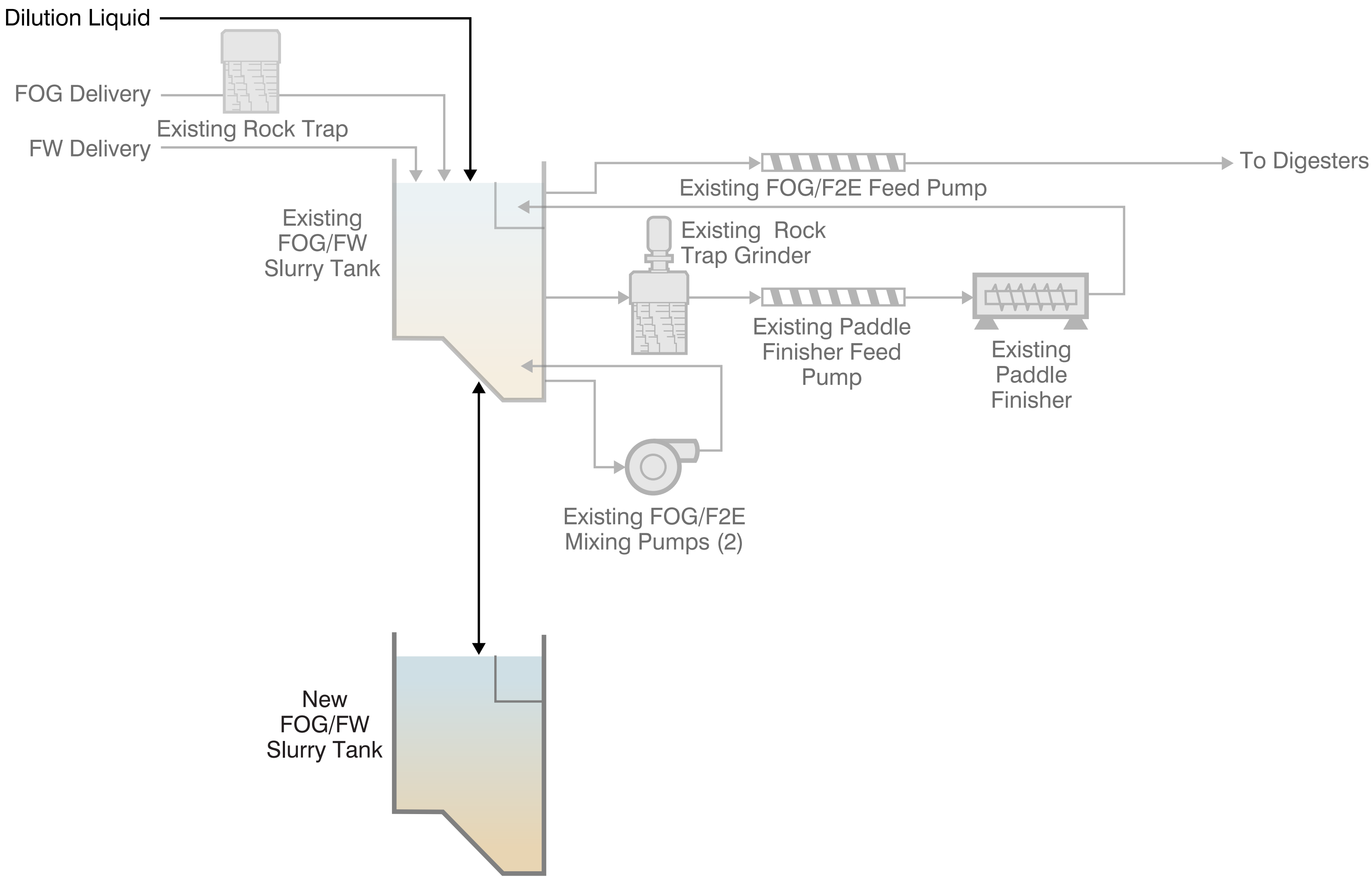
With this alternative, FOG and FW would continue to be stored in the same tank, so the FOG received provides some of the needed dilution for the thick FW slurry. Depending on the actual percent solids of FW received, an external dilution liquid volumetric flow of about 2,000 gpd in addition to the FOG received may be needed to keep the percent solids of the FOG/FW slurry below 6 percent. Again, like Alternative 1, because FOG is needed to dilute the FW before the mixture can be pumped, all daily FOG/FW deliveries need to occur before the slurry is mixed and fed to the digester. Thus, each day there will be a period of time when no high strength waste enters the digester. This variability in digester feedstock could impact digester stability and may result in diurnal fluctuation of digester gas production. Alternatively, the Agency could consider diluting with an additional external dilution source. This additional volume would decrease the HRT in the FOG/FW below grade storage facility to below 1 day.

To operate at a 1 day HRT, Agency staff would need to coordinate FOG and FW deliveries to ensure they are regularly scheduled and occur at similar times each day. Staff would also need to remain cognizant of FOG/FW levels in the OWRF holding tanks. This would be more challenging than for Alternative 1, as the FOG/FW tank would need to be emptied each day regardless of when FOG and FW deliveries occur. Additionally, to maximize the amount of energy produced in the cogeneration facility, FOG and FW deliveries would need to be made during the weekend. This limits when maintenance to the system can occur.

5.3.1 Electrical Requirements for Alternative 3

Table 3.8 summarizes the new estimated loads that would be required for Alternative 3.

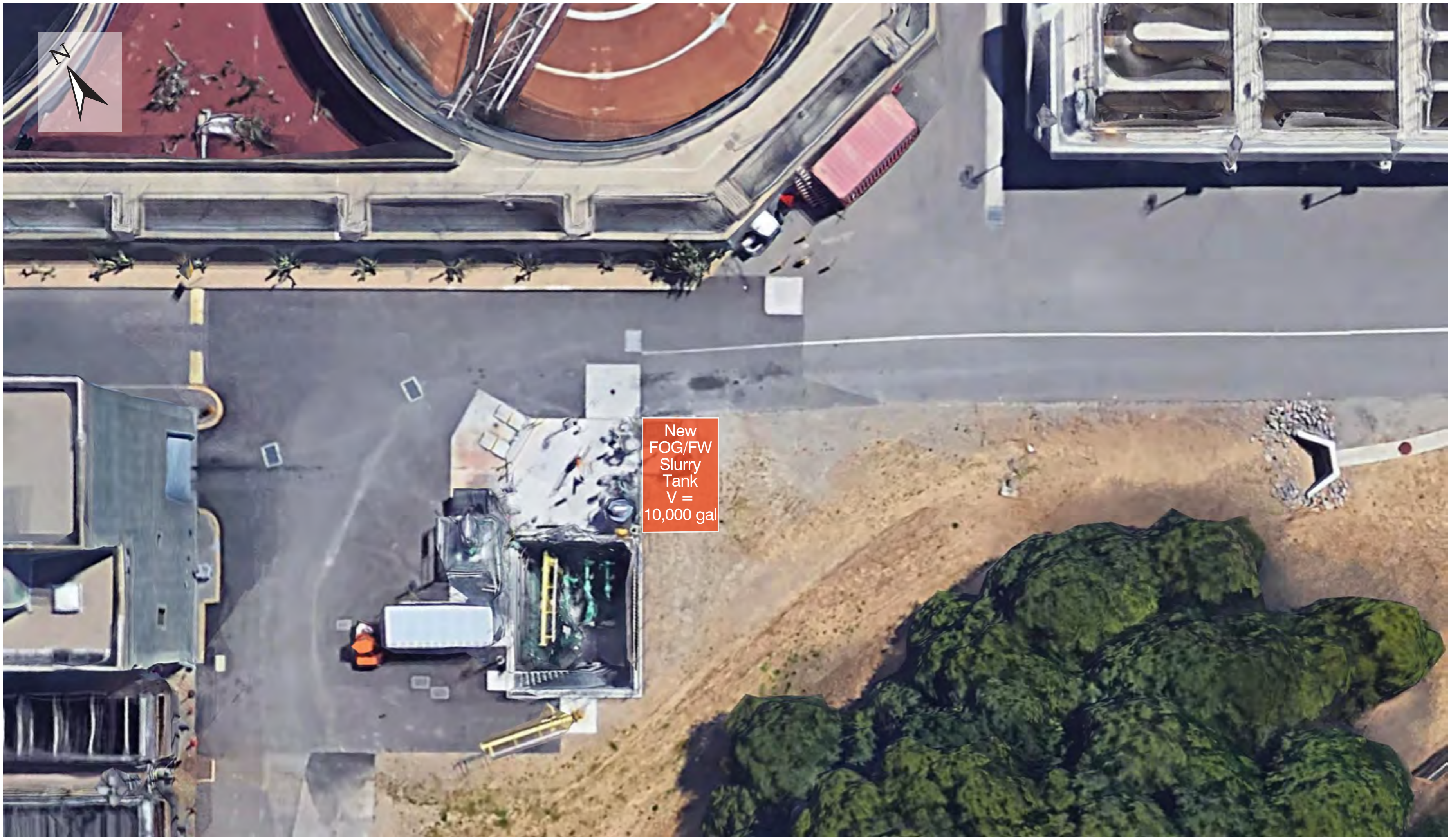
As shown in Table 3.8, it was assumed that only an additional odor scrubber would be needed for this tank expansion. The estimated new load of this odor scrubber is 14 A. The existing OWRF has a 300 A feed from the Main Switchgear Building to supply power to MCC 21.1, which is dedicated for the existing OWRF equipment. Based on the preliminary load calculations shown in Table 3.8, this feeder appears to be large enough to accommodate both the existing and new loads. This should be reviewed further during preliminary design.



ALTERNATIVE 3
PRELIMINARY PROCESS FLOW DIAGRAM

FIGURE 3.8

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN



ALTERNATIVE 3
PRELIMINARY SITE PLAN

FIGURE 3.9

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

Table 3.7 Alternative 3 Preliminary Design Criteria
2017 Facilities Master Plan
Central Marin Sanitation Agency

	Existing	New	Total
Below-Grade Storage			
Service	FOG + FW	FOG + FW	FOG + FW
Number of Tanks	1	1	2 (1 new + 1 existing)
Capacity, total (gal)	25,000	10,000	35,000
HRT (days)	2.0	NA	1.0
External Dilution Required (gpd)	3,400(1)	NA	2,000(2)
Typical Percent Solids (%)	6.0	NA	6.0
Storage Tank Material	Concrete	Concrete	Concrete
Digester			
Digester HRT, days(3)	31.7	NA	24.5
Digester Loading, lb VS/cf/d(4)	0.083	NA	0.104

Notes:
(1) External dilution was assumed to keep the percent solids below 6 percent; however, current dilution amounts are not known at this time.
(2) External dilution liquid may be required to keep the FOG + FW slurry to a concentration below 6 percent solids. If used, it was assumed this dilution liquid would have a low solids concentration. 6 percent solids was chosen based on Agency input.
(3) Minimum HRT of 15 days is recommended.
(4) Maximum loading of 0.16 lb VS/cf/d is recommended.

Table 3.8 Alternative 3 Preliminary Load List
2017 Facilities Master Plan
Central Marin Sanitation Agency

New Equipment	New Load (hp)	New FLA (amp)	Service
Odor Control Scrubber	7.5	11	Continuous
Total - New Equipment(1)		**14**	
Total (Including Existing Equipment)(2)		**179**	

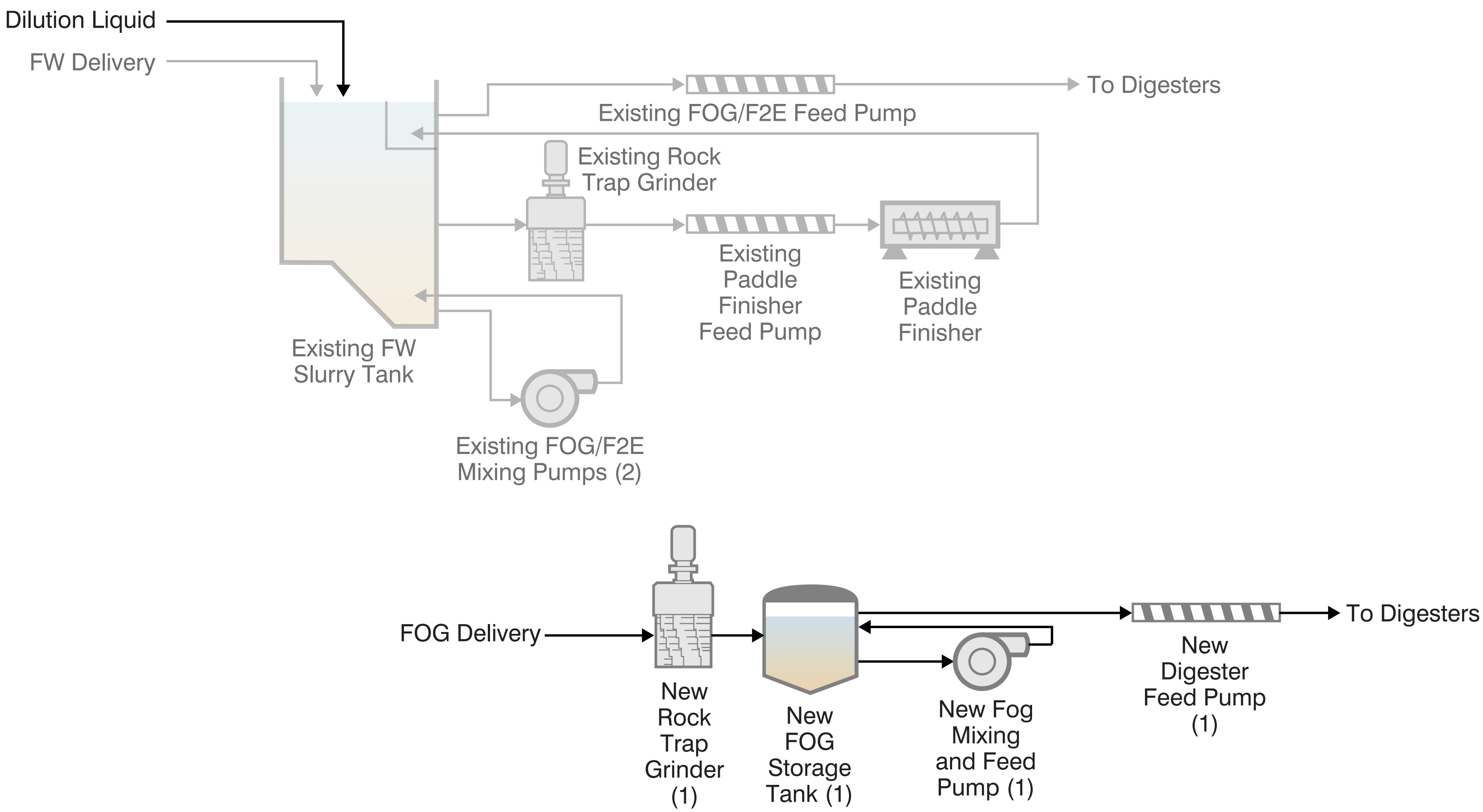
Notes:
(1) Only "Intermittent" and "Continuous" loads were considered in calculation of total FLA. "Continuous" loads include a 25% safety factor.
(2) Existing power draw was assumed to be 165 amps.

5.4 Alternative 4: New Aboveground Storage for 1 Day HRT

Alternative 4 was developed as a smaller, lower volume alternative to Alternative 2. Instead of adding two 12,500 gallon above-grade tanks to double capacity, Alternative 4 looks at adding just one 12,500 gallon above-grade tank to provide for a 1 day HRT. This aboveground tank could be made of stainless steel, epoxy coated steel, or concrete. For planning purposes, epoxy coated steel was assumed. Figure 3.10 shows the preliminary process flow diagram for this alternative, Figure 3.11 shows a preliminary layout for this alternative, and Figure 3.12 depicts the Alternative 4 preliminary site plan. Preliminary design criteria are summarized in Table 3.9.

Like Alternative 2, with this alternative, the FW would still be diluted with FOG, to the extent possible. However, an external liquid volumetric flow of approximately 4,500 gpd may also be needed to maintain a pump-able FW slurry concentration of 6 percent or less depending on the actual percent solids of FW received. Because a portion of the FOG is stored separately from the FW, high strength waste can be fed to the digester more regularly, as the Agency can pump FOG to the digesters before all the FW is received. This is an advantage over Alternative 1 and 3 as it maintains a more consistent digester feed and makes it less likely that the digesters would become upset from feed fluctuations.

However, like Alternative 3, the Agency will need to operate with a 1 day HRT. Unlike Alternative 3, the Agency will have to coordinate FOG/FW flows across two tanks which is more operationally challenging than in Alternative 3. To operate at a 1 day HRT, Agency staff would need to coordinate FOG and FW deliveries to ensure they are regularly scheduled and occur at similar times each day. Staff would also need to remain cognizant of FOG/FW levels in the OWRF holding tanks. This would be more challenging than for Alternative 2, as the FOG/FW tank would need to be emptied each day regardless of when FOG and FW deliveries occur. Additionally, to maximize the amount of energy produced in the cogeneration facility, FOG and FW deliveries would need to be made during the weekend. This lower HRT may present operational challenges for staff and may sometimes mean turning away FOG/FW deliveries and operating the digesters with less than the designed FOG/FW loading. Alternatively, staff could accept all FOG/FW deliveries and feed the digester at a higher rate. However, these high digester loading rates may cause digester upsets.



ALTERNATIVE 4
PRELIMINARY PROCESS FLOW DIAGRAM

FIGURE 3.10

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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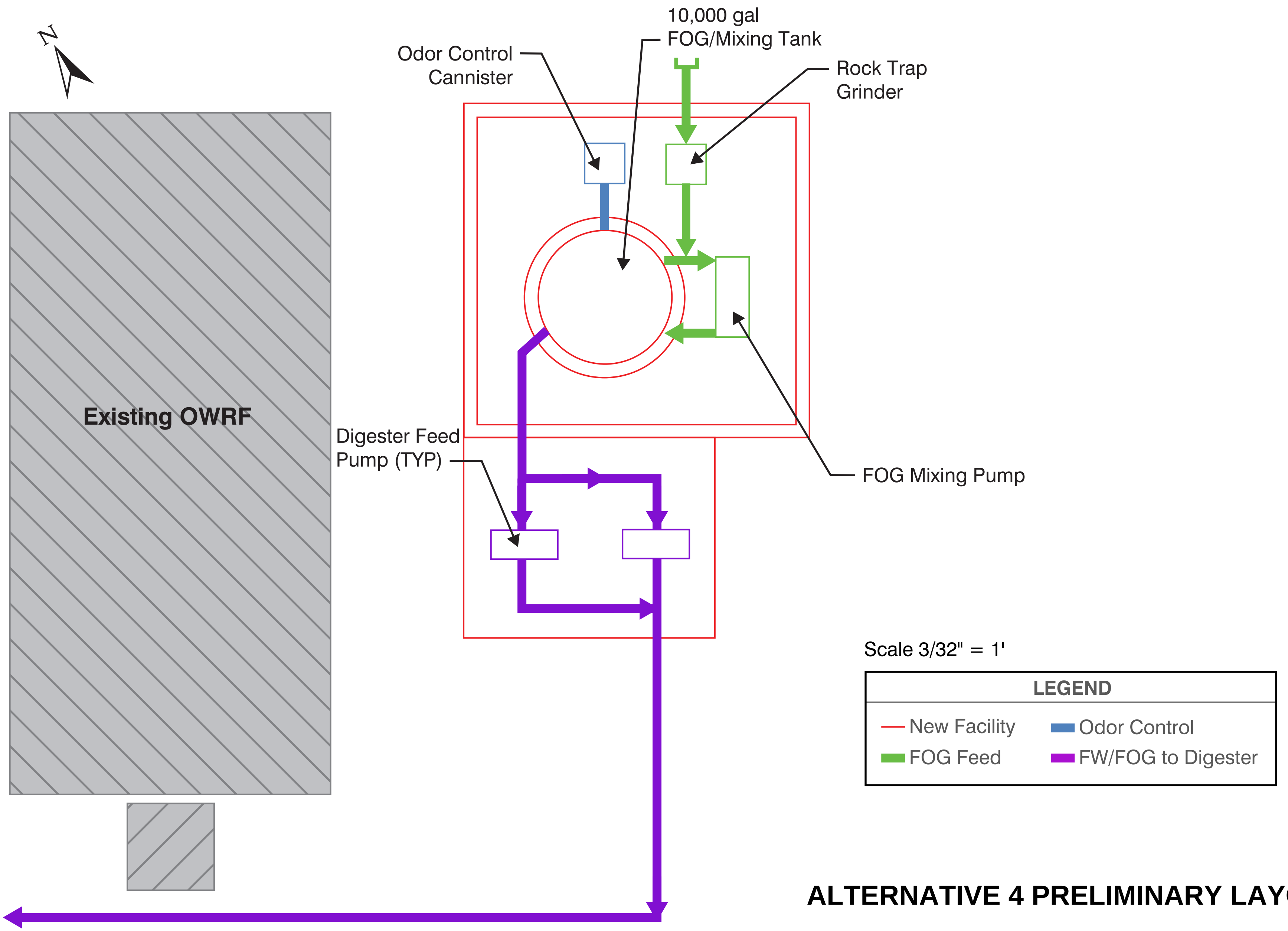

ALTERNATIVE 4 PRELIMINARY LAYOUT

FIGURE 3.11

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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ALTERNATIVE 4
PRELIMINARY SITE PLAN

FIGURE 3.12

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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Table 3.9 Alternative 4 Preliminary Design Criteria 2017 Facilities Master Plan Central Marin Sanitation Agency			
	Existing	**New**	**Total**
Above Ground Storage			
Service	NA	FOG	FOG
Number of Tanks	NA	1	1
Capacity, total (gal)	NA	10,000	10,000
HRT (days)	NA	1.0	1.0
Typical Percent Solids (%)	NA	4.4	4.4
Storage Tank Material	NA	Epoxy Coated Steel	Epoxy Coated Steel
Below Ground Storage			
Service	FOG + FW	NA	FW + FOG
Number of Tanks	1	NA	1
Capacity, total (gal)	25,000	NA	25,000
HRT (days)	2.0	NA	1.0
External Dilution Required (gpd)	3,400(1)	NA	4,500(2)
Typical Percent Solids (%)	6.0	NA	6.0
Storage Tank Material	Concrete	NA	Concrete
Digester			
Digester HRT, days(3)	31.7	NA	23.8
Digester Loading, lb VS/cf/d(4)	0.083	NA	0.104

Notes:
(1) External dilution was assumed to keep the percent solids below 6 percent; however, current dilution amounts are not known at this time.
(2) External dilution liquid may be required to keep the FOG + FW slurry to a concentration below 6 percent solids. If used, it was assumed this dilution liquid would have a low solids concentration. 6 percent solids was chosen based on Agency input.
(3) Minimum HRT of 15 days is recommended.
(4) Maximum loading of 0.16 lb VS/cf/d is recommended.

5.4.1 Electrical Requirements for Alternative 4

Table 3.10 summarizes the estimated new loads that would be required for Alternative 4.

As shown in Table 3.10, the estimated new total load is 294 A. Based on the load calculations shown in Table 3.10, it appears that the existing 300 A feeder may be adequate to accommodate both the existing and new loads for Alternative 4. However, it appears there is insufficient space in MCC 21.1 to accommodate the starters for the new equipment and insufficient space to expand within the building. Thus for the purpose of this analysis, it was assumed that a new 300 A feed from the existing Main Switchgear Building and a new MCC structure with a 600 A bus capacity would be required. This should be reviewed further during preliminary design.

Table 3.10 Alternative 4 Preliminary Load List
2017 Facilities Master Plan
Central Marin Sanitation Agency

New Equipment	New Load (hp)	New FLA (amp)	Service
FOG Delivery Valve 1	0.5	1.1	Intermittent
FOG Delivery Valve 2	0.5	1.1	Intermittent
Rock Trap Grinder 1	3	4.8	Intermittent
Rock Trap Grinder 2	10	14	Intermittent
FOG Mixing and Feed Pump 1	30	40	Intermittent
FOG Mixing and Feed Pump 2	30	40	Intermittent
Odor Control Scrubber 1	7.5	11	Continuous
Odor Control Scrubber 2	7.5	11	Continuous
Total - New Equipment(1)		**129**	
Total (Including Existing Equipment)(2)		**294**	

Notes:
(1) Only "Intermittent" and "Continuous" loads were considered in calculation of total FLA. "Continuous" loads include a 25% safety factor.
(2) Existing load list is identical to the new equipment shown in Table 3.4 for Alternative 1.

6.0 ALTERNATIVE COMPARISON

Alternatives 1, 2, 3 and 4 were compared on both economic and non-economic bases and the results of this comparison are found in this section.

6.1 Economic

Table 3.11 compares the life cycle costs for the four alternatives evaluated. The present worth analysis was based on a 15-year lifecycle cost and includes capital costs and annual O&M costs including power, maintenance, and labor costs. Capital costs reflect a December 2017 ENR of 10870 and are based on quantity takeoffs and similar facilities with allowances for mechanical, structural, and electrical improvements. Unit costs for estimating O&M are based on unit pricing provided by the Agency. Detailed capital and O&M costs are included in Appendix A.

Table 3.11 Present Worth Analysis of OWRF Alternatives 2017 Facilities Master Plan Central Marin Sanitation Agency				
	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
Project Cost[(1)]	$1,590,000	$2,330,000	$1,220,000	$1,440,000
Annual O&M Cost in 15 years[(2)]	$467,000	$503,000	$467,000	$486,000
Power Cost	$70,000	$81,000	$70,000	$77,000
Labor Cost	$353,000	$353,000	$353,000	$353,000
Maintenance Cost	$44,000	$69,000	$44,000	$56,000
Present Worth of O&M Costs[(3)]	$6,310,000	$6,880,000	$6,290,000	$6,597,000
Present Worth[(3)]	**$7,900,000**	**$9,210,000**	**$7,510,000**	**$8,037,000**

Notes:

(1) Project costs for new units are based on December 2017 ENR of 10870.
(2) O&M costs include power ($0.17/kWh), labor (based on $157,000/year including benefits and 1.6 FTE), and maintenance (intermittent maintenance based on 15% of direct cost and ongoing maintenance based on 7.5% of equipment costs).
(3) Present Worth is total project cost plus present worth of annual O&M costs. Annual O&M costs were converted to present worth based on 3 percent inflation rate, 6 percent discount rate, and 15-year analysis period.

6.2 Non-Economic

The non-economic evaluation is based on several criteria summarized in Table 3.12. For each criterion, a numeric score of 1, 2, or 3 is given to each alternative, which reflects how well an alternative is aligned with that specific criteria. The score for each criterion is multiplied by a weighting factor, and the sum total is provided on the bottom. The higher the overall score, the better it is aligned with the non-economic criteria shown.

7.0 RECOMMENDATIONS

Based on both the economic and non-economic comparisons, Alternative 3 has the lowest life-cycle cost and has the best non-economic score. It is anticipated that this alternative will have a capital cost of $1,220,000 and a life-cycle cost of $7,510,000. Prior to implementing this alternative, the Agency should conduct a study to confirm that the digesters can handle the proposed increase in FOG and FW loading above FY 16/17 levels.

Table 3.12 Evaluation Summary of Receiving Alternatives
2017 Facilities Master Plan
Central Marin Sanitation Agency

Non-Economic Evaluation Criteria	Weight	Alt 1	Alt 2	Alt 3	Alt 4	Comments
Consistent feed to digesters	20%	1	2	1	2	Separate storage allows more constant digester feed with Alternatives 2 and 4, while dilution with FOG in Alternatives 1 and 3 limit times when digesters can be fed FOG/FW.
Ease of maintenance	30%	2	1	2	1	There will be more equipment to maintain with Alternatives 2 and 4. However, the Alternatives 1 and 3 equipment is below grade, which is harder to maintain.
Ease of construction	20%	1	2	1	3	Below grade concrete tank construction is needed for Alternatives 1 and 3, while prefabricated slab-on grade SST tanks is needed for Alternatives 2 and 4.
Staff familiarity	20%	3	1	3	1	Alternatives 1 and 3 are extensions of the existing OWRF system, while Alternatives 2 and 4 require new FOG/FW management system.
Onsite footprint	10%	2	1	3	1	Onsite footprint requirement is much smaller for Alternatives 1 and 3 than Alternatives 2 and 4. In addition, Alternatives 2 and 4 require more substantial re-grading of existing site.
Total Score (Higher is Better)	**100%**	**18**	**14**	**19**	**16**	

Notes:
(1) Legend: 1 Fair; 2 Good; 3 Best.

APPENDIX A – PROJECT COST ESTIMATES

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	3 - ORGANIC WASTE RECEIVING FACILITY		
JOB # :	10405A.00	**LOCATION FACTOR :**	1.24
LOCATION :	San Rafael, CA	**SF ENR OCTOBER 2017:**	12015
		COST ESTIMATE PREPARATION DATE :	3/19/2018
TITLE:	Alternative 1	**BY :**	EAC
	Combined FOG and FW Storage - Double Capacity	**REVIEWED BY:**	CEG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**FOG/FW Slurry Tank**					
	Sitework and Miscellaneous Concrete	1	LS	$34,000	$34,000	
	Shoring	1	LS	$51,000	$51,000	
	Odor Control System	1	EA	$20,000	$20,000	
	Below Grade Concrete 25,000 gal Tank	1	EA	$301,000	$301,000	
						$406,000
2	**Existing OWRF Modifications**					
	Concrete Wall Demolition	40	SF	$23	$932	
	FW Dilution Pump	2	EA	$18,000	$36,000	
	Misc Piping, Valves, etc. to Connect to Existing System	1	LS	$55,000	$55,000	
						$92,000
	SUBTOTAL					**$498,000**
3	**Allowances**					
	Misc Piping Allowance	1	LS	$150,000	$150,000	
	EI&C Allowance (% of subtotal plus piping allowance)	20	%		$130,000	
	Total					$280,000
	SUBTOTAL					**$778,000**
	Estimating Contingency	30	%			$234,000
	SUBTOTAL					**$1,012,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$47,000
	SUBTOTAL					**$1,059,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$265,000
	CONSTRUCTION COST SUBTOTAL					**$1,324,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$265,000
	PROJECT COST					**$1,590,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	3 - ORGANIC WASTE RECEIVING FACILITY		
JOB # :	10405A.00	**LOCATION FACTOR :**	1.24
LOCATION :	San Rafael, CA	**SF ENR OCTOBER 2017:**	12015
		COST ESTIMATE PREPARATION DATE :	3/19/2018
TITLE:	Alternative 2	**BY :**	EAC
	Dedicated FOG and Dedicated FW Storage - Double Capacity	**REVIEWED BY:**	CEG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**FOG Tank**					
	Sitework and Miscellaneous Concrete	1	LS	$150,000	$150,000	
	Equipment per Tank	2	EA	$89,000	$178,000	
	Above Grade 12,500 gal Tank (Epoxy Coated Steel)	2	EA	$93,000	$186,000	
						$514,000
2	**External Feedstock Feed**					
	Pump	2	EA	$20,000	$40,000	
						$40,000
3	**Existing OWRF Modifications**					
	Centrate FW Dilution Pump	2	EA	$18,000	$36,000	
	Centrate Piping	1	LS	$5,000	$5,000	
						$41,000
	SUBTOTAL					**$595,000**
4	**Allowances**					
	Piping and Miscellaneous Metals Allowance	1	LS	$315,000	$315,000	
	EI&C Allowance (% of subtotal plus piping allowance)	25	%		$228,000	
	Total					$543,000
	SUBTOTAL					**$1,138,000**
	Estimating Contingency	30	%			$342,000
	SUBTOTAL					**$1,480,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$69,000
	SUBTOTAL					**$1,549,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$388,000
	CONSTRUCTION COST SUBTOTAL					**$1,937,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$388,000
	PROJECT COST					**$2,330,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	3 - ORGANIC WASTE RECEIVING FACILITY		
JOB # :	10405A.00	**LOCATION FACTOR :**	1.24
LOCATION :	San Rafael, CA	**SF ENR OCTOBER 2017:**	12015
		COST ESTIMATE PREPARATION DATE :	3/19/2018
TITLE:	Alternative 3	**BY :**	EAC
	Combined FOG and FW Storage - 1 Day SRT	**REVIEWED BY:**	CEG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**FOG/FW Slurry Tank**					
	Sitework and Miscellaneous Concrete	1	LS	$26,000	$26,000	
	Shoring	1	LS	$39,000	$39,000	
	Odor Control System	1	EA	$20,000	$20,000	
	Below Grade Concrete 10,000 gal Tank	1	EA	$171,000	$171,000	
						$256,000
2	**Existing OWRF Modifications**					
	Concrete Wall Demolition	40	SF	$23	$932	
	FW Dilution Pump	2	EA	$18,000	$36,000	
	Misc Piping, Valves, etc. to Connect to Existing System	1	LS	$55,000	$55,000	
						$92,000
	SUBTOTAL					**$348,000**
3	**Allowances**					
	Misc Piping Allowance	1	LS	$150,000	$150,000	
	EI&C Allowance (% of subtotal plus piping allowance)	20	%		$100,000	
	Total					$250,000
	SUBTOTAL					**$598,000**
	Estimating Contingency	30	%			$180,000
	SUBTOTAL					**$778,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$36,000
	SUBTOTAL					**$814,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$204,000
	CONSTRUCTION COST SUBTOTAL					**$1,018,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$204,000
	PROJECT COST					**$1,220,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	3 - ORGANIC WASTE RECEIVING FACILITY		
JOB # :	10405A.00	**LOCATION FACTOR :**	1.24
LOCATION :	San Rafael, CA	**SF ENR OCTOBER 2017:**	12015
		COST ESTIMATE PREPARATION DATE :	3/19/2018
TITLE:	Alternative 4	**BY :**	EAC
	Dedicated FOG and Dedicated FW Storage - 1 Day SRT	**REVIEWED BY:**	CEG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**FOG Tank**					
	Sitework and Miscellaneous Concrete	1	LS	$60,000	$60,000	
	Equipment per Tank	1	EA	$71,000	$71,000	
	Above Grade 10,000 gal Tank (Epoxy Coated Steel)	1	EA	$74,000	$74,000	
						$205,000
2	**External Feedstock Feed**					
	Pump	1	EA	$20,000	$20,000	
						$20,000
3	**Existing OWRF Modifications**					
	Centrate FW Dilution Pump	1	EA	$18,000	$18,000	
	Centrate Piping	1	LS	$5,000	$5,000	
						$23,000
	SUBTOTAL					**$248,000**
4	**Allowances**					
	Piping and Miscellaneous Metals Allowance	1	LS	$315,000	$315,000	
	EI&C Allowance (% of subtotal plus piping allowance)	25	%		$141,000	
	Total					$456,000
	SUBTOTAL					**$704,000**
	Estimating Contingency	30	%			$212,000
	SUBTOTAL					**$916,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$43,000
	SUBTOTAL					**$959,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$240,000
	CONSTRUCTION COST SUBTOTAL					**$1,199,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$240,000
	PROJECT COST					**$1,440,000**

Present Worth Cost Analysis

Year of analysis	**2017**	Period	**15**	yrs	**2032**	
Escalation rate	**3.00%**			Power Cost	**$0.17**	/kWh
Discount rate	**6.00%**			Labor Cost	**$157,000**	/year/person (1.6 FTE assumed)
				Intermittent Maintencence Cost	**10%**	direct capital cost
				Ongoing Maintenance Cost	**5%**	equipment cost

Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Project Cost																
Alt 1	**$1,590,000**															
Alt 2	**$2,330,000**															
Alt 3	**$1,220,000**															
Alt 4	**$1,440,000**															
Power Cost																
Alt 1	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000
Alt 2	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000	$81,000
Alt 3	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000
Alt 4	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000
Labor Cost																
Alt 1	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000
Alt 2	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000
Alt 3	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000
Alt 4	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000	$353,000
Intermittent Maintenance Cost																
Alt 1			$53,000			$53,000			$53,000			$53,000			$53,000	
Alt 2			$83,000			$83,000			$83,000			$83,000			$83,000	
Alt 3			$53,000			$53,000			$53,000			$53,000			$53,000	
Alt 4			$68,000			$68,000			$68,000			$68,000			$68,000	
Ongoing Maintenance Cost																
Alt 1	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000
Alt 2	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000	$69,000
Alt 3	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000	$44,000
Alt 4	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000	$56,000
Annual Cost																
Alt 1	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000
Alt 2	$503,000	$503,000	$586,000	$503,000	$503,000	$586,000	$503,000	$503,000	$586,000	$503,000	$503,000	$586,000	$503,000	$503,000	$586,000	$503,000
Alt 3	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000
Alt 4	$486,000	$486,000	$554,000	$486,000	$486,000	$554,000	$486,000	$486,000	$554,000	$486,000	$486,000	$554,000	$486,000	$486,000	$554,000	$486,000
Total Cost																
Alt 1	$2,057,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000
Alt 2	$2,833,000	$503,000	$586,000	$503,000	$503,000	$586,000	$503,000	$503,000	$586,000	$503,000	$503,000	$586,000	$503,000	$503,000	$586,000	$503,000
Alt 3	$1,687,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000	$467,000	$520,000	$467,000
Alt 4	$1,926,000	$486,000	$554,000	$486,000	$486,000	$554,000	$486,000	$486,000	$554,000	$486,000	$486,000	$554,000	$486,000	$486,000	$554,000	$486,000
Total Cost Inflated																
Alt 1	$2,057,000	$481,010	$551,668	$510,304	$525,613	$602,823	$557,622	$574,351	$658,720	$609,329	$627,609	$719,802	$665,830	$685,805	$786,547	$727,571
Alt 2	$2,833,000	$518,090	$621,687	$549,642	$566,131	$679,335	$600,608	$618,627	$742,327	$656,301	$675,990	$811,161	$717,158	$738,672	$886,378	$783,658
Alt 3	$1,687,000	$481,010	$551,668	$510,304	$525,613	$602,823	$557,622	$574,351	$658,720	$609,329	$627,609	$719,802	$665,830	$685,805	$786,547	$727,571
Alt 4	$1,926,000	$500,580	$587,739	$531,065	$546,997	$642,238	$580,309	$597,719	$701,791	$634,120	$653,143	$766,866	$692,920	$713,707	$837,975	$757,172
Present Value																
Alt 1	$2,057,000	$453,783	$490,983	$428,461	$416,334	$450,464	$393,102	$381,976	$413,289	$360,661	$350,454	$379,183	$330,897	$321,532	$347,890	$303,590
Alt 2	$2,833,000	$488,764	$553,300	$461,490	$448,429	$507,638	$423,405	$411,422	$465,745	$388,464	$377,469	$427,310	$356,405	$346,318	$392,046	$326,993
Alt 3	$1,687,000	$453,783	$490,983	$428,461	$416,334	$450,464	$393,102	$381,976	$413,289	$360,661	$350,454	$379,183	$330,897	$321,532	$347,890	$303,590
Alt 4	$1,926,000	$472,245	$523,085	$445,893	$433,273	$479,917	$409,095	$397,517	$440,312	$375,335	$364,712	$403,975	$344,360	$334,614	$370,637	$315,941
Net Present Value																
Alt 1	$7,900,000															
Alt 2	$9,210,000															
Alt 3	$7,509,599															
Alt 4	$8,036,912															
Net Present Value of O&M Costs																
Alt 1	$6,310,000															
Alt 2	$6,880,000															
Alt 3	$6,289,599															
Alt 4	$6,596,912															

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM NO. 4
NUTRIENT REMOVAL

FINAL
October 2018

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CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM
NO. 4
NUTRIENT REMOVAL

TABLE OF CONTENTS

Page No.

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

This technical memorandum summarizes an evaluation for a range of options to meet potential final effluent nitrogen and phosphorus discharge limits at the Central Marin Sanitation Agency (Agency) Wastewater Treatment Plant (WWTP). These options include modifications to the existing trickling filter/activated sludge (TF/AS) secondary treatment process, parallel secondary treatment processes handling some portion of the primary effluent, and sidestream treatment processes to treat the centrate from mechanical dewatering of anaerobically co-digested conventional wastewater solids (thickened primary sludge and thickened waste activated sludge), imported fats, oils, and grease (FOG), and food waste. Candidate options are evaluated individually and the most cost-effective options are combined into four (4) nutrient removal alternatives.

2.0 SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

The key findings of this evaluation are:

- There are a number of feasible sidestream treatment options, mainstream treatment options (based on the existing secondary treatment facilities), and parallel mainstream treatment options to meet potential Level 2 nutrient discharge limits as defined by the Bay Area Clean Water Agencies (BACWA). The mainstream treatment options include the modified Ludzak-Ettinger (MLE) process, ballasted sedimentation process (BioMag™), and integrated fixed film/activated sludge (IFAS) process. The parallel mainstream treatment options include the membrane bioreactor (MBR) process and the aerobic granular sludge (AGS) process.
- The peak wet weather treatment capacity of the combined mainstream and parallel treatment options would be 30 mgd to match the capacity of the existing trickling filter/activated sludge treatment process. Primary effluent flows greater than 30 mgd would be treated as they are currently.
- The anaerobic ammonia oxidation treatment option reduces process oxygen demands by approximately four (4) percent; however, sidestream treatment does not reduce the secondary treatment organic load and so the mainstream and mainstream parallel secondary treatment project costs would not change.
- The parallel mainstream MBR treatment option could be further modified to meet potential Level 3 nutrient discharge limits.
- Additional studies are recommended to demonstrate whether chemical addition to the aerobic granular sludge (AGS) system (e.g., supplemental carbon, metal salts) is

sufficient to meet Level 3 nutrient discharge limits or whether additional unit processes are needed (e.g., effluent filtration).

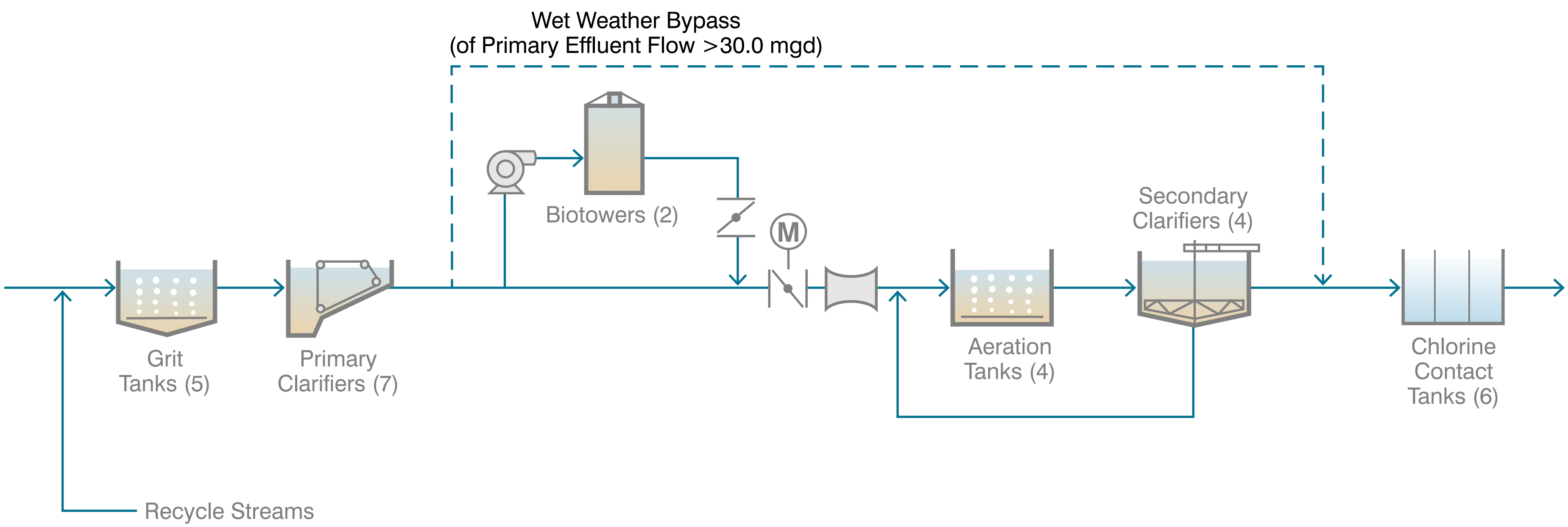
Additional monitoring is recommended to validate assumptions made in this study about plant influent and solids handling recycle characteristics. Periodic plant influent samples should be analyzed for ammonia, nitrite, nitrate, total Kjeldahl nitrogen, total phosphorus, and orthophosphorus to develop data on plant influent and centrate nitrogen and phosphorus fractions and peak loading factors. Plant influent soluble biochemical oxygen demand (BOD) analyses are recommended to determine the readily biodegradable soluble organics load, as this is the BOD fraction necessary for effective biological nitrogen and/or phosphorus removal.

3.0 BACKGROUND

The existing Agency's WWTP liquid treatment processes consist of raw sewage screens for debris removal, five aerated grit tanks, seven rectangular primary sedimentation tanks, two biotowers, four aeration tanks, four circular secondary clarifiers, and six chlorine contact tanks. These facilities are currently permitted for 10 million gallons per day (mgd) on an average dry weather flow rate (ADWF) basis. Corresponding wet weather flows up to 30 mgd receive primary and secondary treatment. Wet weather flows above 30 mgd receive primary treatment and are blended with secondary effluent upstream of final effluent chlorine disinfection. A schematic of the existing WWTP liquid treatment processes is shown in Figure 4.1.

Primary sludge (PS) is thickened in the sedimentation tanks before it is pumped to the two anaerobic digesters. Waste activated sludge (WAS) is thickened using rotary drum thickeners and the thickened waste activated sludge (TWAS) is pumped to the anaerobic digesters. An organic waste receiving facility (OWRF) at the WWTP receives, processes, and feeds imported FOG and food waste to the anaerobic digesters to generate additional methane to increase energy recovery through cogeneration.

Digested sludge is dewatered using centrifuges and the dewatered sludge is hauled off-site. Filtrate and washwater from the rotary drum thickeners and centrate from the centrifuges are collected in the basement of the Solids Handling Building. Solids handling recycles can be pumped to the influent channel upstream of the screens, to any grit tank, or to the primary sedimentation tank influent channel. Typical practice is to pump the solids handling recycles to the influent channel upstream of the screens.



**EXISTING CMSA WWTP
PROCESS FLOW SCHEMATIC**

FIGURE 4.1

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

cmsa0818rf1-10405.ai

3.1 Regional Watershed Permit

The Agency's WWTP and other publically owned treatment works (POTWs) discharging into San Francisco Bay are operating under a 2014 supplemental basin-wide discharge permit, which required final effluent nitrogen and phosphorus monitoring to provide data on current basin-wide nitrogen and phosphorus mass discharges into various areas of the Bay (e.g., Suisun Bay, North Bay, Central Bay, and South Bay). Ecological studies were conducted in parallel with the basin-wide effluent monitoring efforts to determine appropriate nitrogen and/or phosphorus discharge limits to prevent impairment of the Bay.

At this time, the ecological studies have been inconclusive with respect to establishing specific nitrogen and/or phosphorus discharge limits. It is anticipated that the 2019 renewal

of the basin-wide discharge permit will continue the final effluent nutrient monitoring in parallel with continued ecological studies.

It is anticipated that specific numeric limits would not be issued until the 2024 permit renewal at the earliest. It is anticipated that these specific limits would range from a no-net loading increase to a combined ammonia limit of 2.0 mgN/L, total nitrogen (TN) limit of 15 mgN/L, and total phosphorus (TP) limit of 1.0 mgP/L. This combined limit corresponds to "Level 2" as defined by the Bay Area Clean Water Agencies (BACWA) for ongoing planning studies, which is the less restrictive of two tiers of potential numeric discharge limits as shown in Table 4.1.

Table 4.1 Seasonal Nutrient Removal Targets in BACWA Scoping Plan
2017 Facilities Master Plan
Central Marin Sanitation Agency

Level	Ammonia	Total Nitrogen	Total Phosphorus	Comments
1 - Optimization	Variable	Variable	Variable	Plant specific
2 - Upgrade	2 mg N/L	15 mg N/L	1 mg P/L	No effluent filters or supplemental carbon required
3 - Upgrade	2 mg N/L	6 mg N/L	0.3 mg P/L	Typically requires effluent filters and supplemental carbon

Ecological studies to date have not indicated whether these numeric discharge limits should be enforced as an annual average concentration, monthly average dry-weather (i.e., May through September) concentration, or monthly average wet-weather (i.e., October through April) concentration.

Another factor to consider in evaluating treatment options to meet the potential Level 2 nutrient discharge limits is even lower future discharge limits. Potential "Level 3" nutrient discharge limits for ammonia are 2.0 mgN/L, TN limit of 6 mgN/L, and TP limit of 0.3 mgP/L, as shown in Table 4.1. Ideally, any treatment option selected to meet Level 2 discharge limits could be modified in a cost-effective manner to meet the more stringent Level 3 limits.

3.2 February 2018 BACWA Nutrient Reduction Study

A nutrient reduction study was completed for the Agency's WWTP in February 2018 as part of the BACWA study comprising all Bay Area POTWs included in the basin-wide permit. However, the study did not include the effluent flow rate correction discussed in the following section nor did it include the impact of recycled stream nutrient recycles from organic waste imported for co-digestion.

3.3 Planning Basis

Historical flow rates, influent total suspended solids (TSS) and biochemical oxygen demand (BOD) concentrations; effluent total Kjeldahl nitrogen (TKN), ammonia, and total phosphorus concentrations; and effluent temperature from July 2011 through June 2017 were analyzed to develop planning-level influent conditions for this study.

The planning-level flow rates were developed by analyzing historical effluent flow rates, which were adjusted based on the results of the September 2017 Flow Measurement Analysis. The analysis found that the effluent flow rate was being under-reported, so a correlation was developed to adjust the effluent flow rate based on detailed flow measurements made in 2016 using temporary flow meters. The adjustment was greater at lower effluent flow rates and decreased at higher effluent flow rates.

This analysis showed that the current ADWF is approximately 6.5 mgd, as estimated by the minimum 90-day running average flow rate in each fiscal year. As a check, the corresponding per capita wastewater flow rate was calculated as 62 gal/capita-d based on the combined population of San Rafael, Larkspur, Fairfax, San Anselmo, Ross, Kentfield, and Greenbrae.

An analysis of the influent TSS and BOD loads showed that the current average dry weather loads are approximately 21.0 thousand pounds per day (klb/d). This corresponds to a per capita load of approximately 0.20 lb/capita-d for both TSS and BOD.

Average day maximum month (ADMM) influent flow rate and load peaking factors were determined by analyzing the variability of the recent historical data. This analysis indicates that the ADMM TSS and BOD load peaking factor is approximately 1.4 and the ADMM flow rate peaking factor is approximately 1.2. Accordingly the ADMM TSS and BOD concentration peaking factor is approximately 1.17 (i.e., 1.4/1.2).

Planning-level influent flows and loads were estimated assuming a 1.0 percent annual growth rate over the next 25 years. The estimated planning-level ADWF is 8.34 mgd and average dry weather TSS and BOD loads are 27.0 klb/d. Corresponding influent TKN, ammonia, and TP loads were estimated based on typical TKN:BOD, ammonia:TKN, and TP:BOD ratios for typical North American wastewaters.

4.0 NUTRIENT REMOVAL OPTIONS

Three treatment options – sidestream treatment, modification of existing secondary treatment facilities, and parallel secondary treatment – were developed to provide nutrient removal to comply with potential numeric discharge limits of 2.0 mgN/L ammonia, 15.0 mgN/L total nitrogen, and 1.0 mgP/L total phosphorus as defined by BACWA.

4.1 Sidestream Treatment Options

Centrate from dewatering of anaerobically-digested primary sludge and thickened waste activated sludge (WAS) and high-strength organic waste (FOG and food waste) represents a significant nutrient recycle to the mainstream treatment processes. Sidestream treatment processes leverage the higher solids handling recycle temperature and nutrient concentrations in the centrate for nitrogen removal.

Both options described below use the higher recycle temperature to oxidize ammonia to nitrite, rather than all the way to nitrate, to reduce aeration costs. In the anaerobic ammonia oxidation process, approximately half the ammonia is oxidized to nitrite under aerobic conditions by ammonia oxidizing bacteria (AOB). The nitrite and remaining ammonia are then used for growth of a specialized group of bacteria, anaerobic ammonia oxidizers, under unaerated conditions.

In the nitration process, the ammonia is oxidized to nitrate under aerobic conditions.

Sidestream treatment alone, however, cannot meet potential effluent nutrient discharge limits. Additional nutrient removal must be provided by modification of existing secondary treatment facilities and/or addition of parallel secondary treatment processes as described in subsequent sections.

4.1.1 Anaerobic Ammonia Oxidation (Anammox)

Anaerobic ammonia oxidation (anammox) can be incorporated into suspended growth, sludge blanket, or fixed film sidestream treatment reactors. Sequential aerated and unaerated periods promote ammonia oxidation to nitrite (nitritation) during the aerobic cycle and anaerobic ammonia oxidation during the anoxic cycle. An anammox treatment system typically includes aeration air diffusers to maintain aerobic conditions, mechanical mixers to keep the suspended solids and/or plastic media in suspension during anoxic periods, and in-line sensors (e.g., dissolved oxygen, pH) for process control.

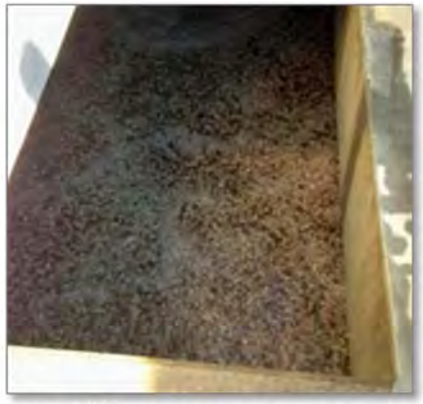
Figure 4.2 shows the process components for the ANITA™MOX anaerobic sidestream treatment configuration. The inset photo of the plastic media is from an ANITA™MOX pilot study at the Union Sanitary District Alvarado WWTP. The red color of the biomass indicates the presence of anammox bacteria.

Anaerobic ammonia oxidation (anammox) sidestream treatment would be provided at the WWTP by modifying Grit Tank 3 as shown in Figure 4.3. A dedicated centrate line would be routed from the Solids Handling Building basement to Grit Tank 3. ANITA™MOX, a fixed film configuration with suspended plastic media, is used as a representative anammox process for this nutrient removal study. Treated centrate would flow from the anammox reactor to the primary influent channel. ANITA™MOX has three full-scale installations in the U.S.: James River WWTP (Newport News, VA), South Durham WWTP (Chapel Hill, NC), and Egan WWTP (Chicago, IL).

Key elements of this treatment option include:

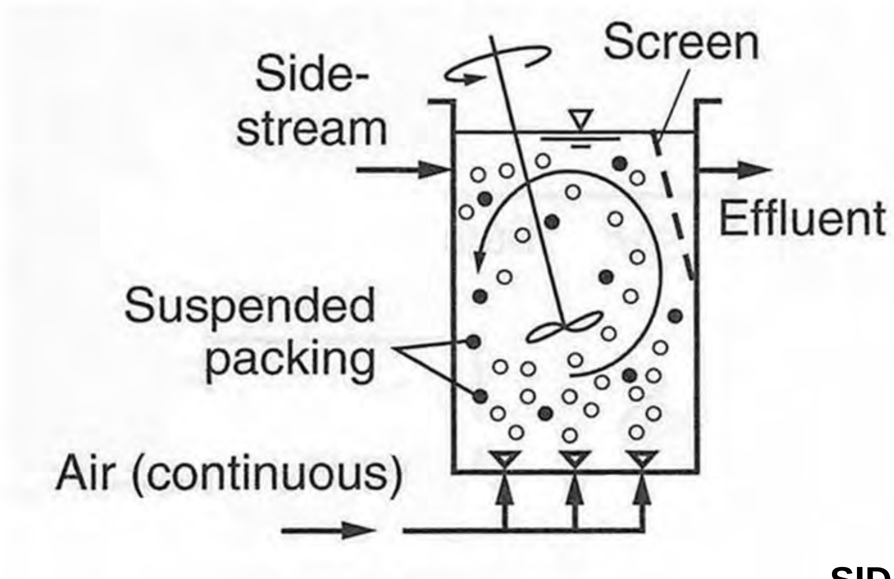
- Demolition of existing grit tank air diffusers, air piping, and other internals.
- Centrate line from Solids Handling Building to Grit Tank 3.
- Leveling grit tank floor to EL 110.50.
- ANITA™MOX equipment package.

Plastic biofilm carrier



ANITA™MOX reactor showing suspended biofilm carriers

Media retention screen



SIDESTREAM ANAEROBIC AMMONIA OXIDATION PROCESS COMPONENTS

FIGURE 4.2

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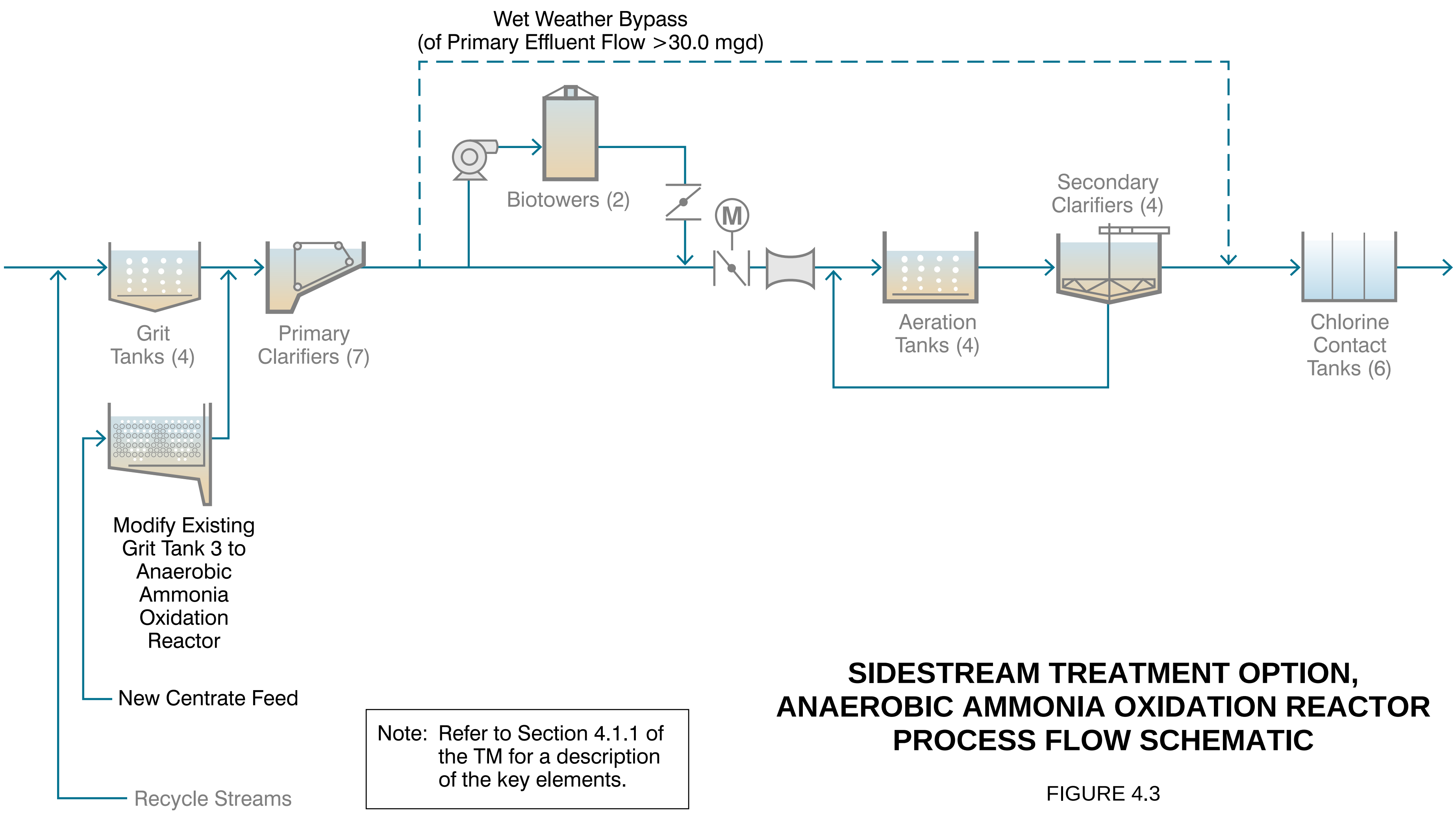

Note: Refer to Section 4.1.1 of the TM for a description of the key elements.

SIDESTREAM TREATMENT OPTION, ANAEROBIC AMMONIA OXIDATION REACTOR PROCESS FLOW SCHEMATIC

FIGURE 4.3

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4.1.2 Nitritation/Recycle

Sidestream nitritation uses ammonia oxidizing bacteria (AOB) only to oxidize ammonia to nitrite.

Nitritation sidestream treatment would be provided at the WWTP by modifying one of the existing grit tanks as shown in Figure 4.4. A dedicated centrate line would be routed from the Solids Handling Building to Grit Tank 3. The modified grit tank would function as a suspended growth reactor to oxidize ammonia to nitrite. The reactor effluent would flow into the primary clarifier influent channel, where readily biodegradable soluble organics in the influent wastewater would be used by heterotrophic bacteria to reduce nitrite to dissolved nitrogen gas. This process is similar to the first half of the SHARON process, another sidestream treatment process, which is used at the Wards Island WWTP (New York, NY) and several other European treatment facilities.

Key elements of this treatment option include:

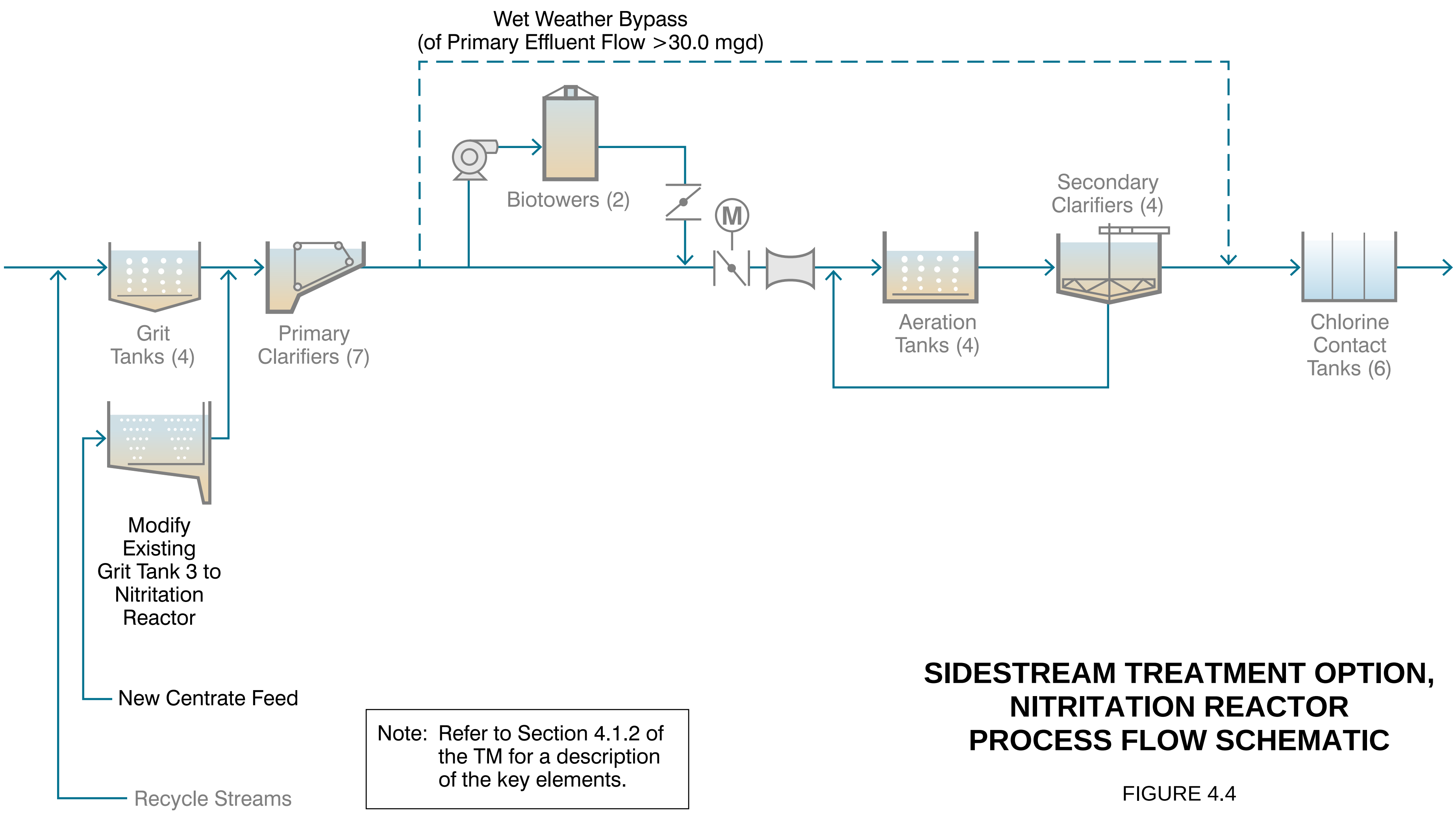
- Demolition of existing grit tank air diffusers, air piping, and other internals.
- Centrate line from Solids Handling Building to Grit Tank 3.
- Leveling grit tank floor to EL 110.50.
- Full-floor coverage fine-bubble diffusers.
- Aeration air control system using DO probe(s).

4.2 Mainstream Treatment Options

Mainstream treatment options are based on the current flow management strategy that all influent flow receives preliminary and primary treatment. Primary effluent flow up to 30 mgd receives full secondary treatment, and primary effluent flow above 30 mgd is blended with secondary effluent upstream of final effluent disinfection.

4.2.1 Existing Secondary Treatment Modifications

Trickling filter/activated sludge (TF/AS) modification options were developed to achieve reliable nitrification/denitrification. Integrated denitrification may require the biotowers be taken off-line, as the biotowers remove the readily biodegradable soluble organics necessary for nitrogen removal through denitrification. Post-denitrification could be considered for nitrogen removal (e.g., denitrifying granular media filter), but would require continuous supplemental carbon addition (e.g., methanol). However, denitrifying filters have the benefit that the filter effluent, with subsequent disinfection, would meet the requirements for Title 22 disinfected tertiary recycled water.



Note: Refer to Section 4.1.2 of the TM for a description of the key elements.

SIDESTREAM TREATMENT OPTION, NITRITATION REACTOR PROCESS FLOW SCHEMATIC

FIGURE 4.4

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4.2.1.1 Modified Ludzak-Ettinger Process

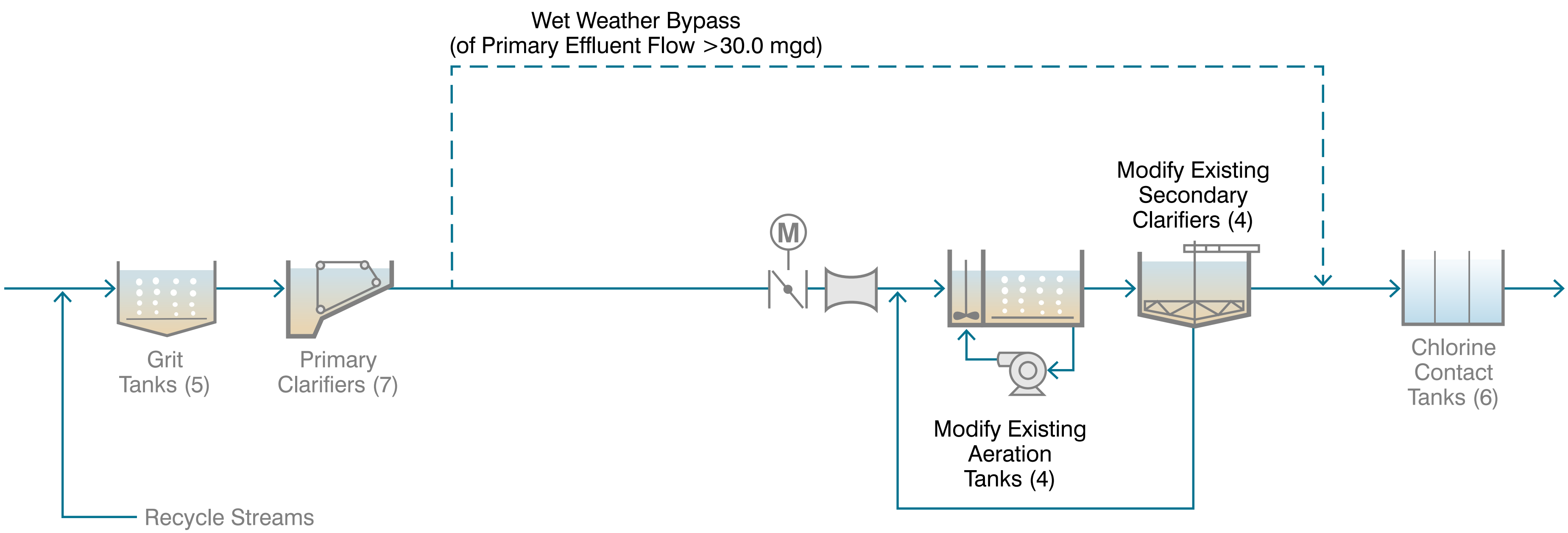
Modifications of the existing TF/AS treatment facilities to the modified Ludzak-Ettinger (MLE) process are shown Figure 4.5. This approach is based on abandoning the existing biotowers to provide soluble BOD (i.e., readily biodegradable soluble COD) for nitrogen removal through denitrification. Currently, the biotowers remove soluble BOD. The modifications include converting the existing aeration tanks to three-pass plug flow basins with a variable speed submersible mixed liquor recycle pump in each tank to recirculate nitrified mixed liquor from the end of the aeration tank to the beginning. The first portion of each aeration tank would be unaerated, but mixed, to provide denitrification. The MLE process is widely used throughout the U.S.

The mixed liquor suspended solids concentration would be higher with this option compared to current plant operation, because of the longer aerobic solids residence time (SRT) needed for effective nitrification. The higher mixed liquor suspended solids concentration would increase the clarifier solids loading rate (SLR) during wet weather conditions, so the modifications would include provisions for a sludge reaeration configuration during wet weather events to maximize overall treatment capacity. The sludge reaeration configuration consists of pumping returned activated sludge (RAS) to the downstream end of Aeration Tanks 1 and 4, which would be operated as sludge reaeration tanks. The RAS would flow in the reverse direction so it exits the sludge reaeration tank into the aeration tank inlet channel. The RAS would mix with the primary effluent and be fed to Aeration Tanks 2 and 3, which would be operated as solids contact tanks.

Because of the limited volume of the existing activated sludge aeration tanks, the process capacity when converted to an MLE configuration would be only 4.0 mgd on an average dry weather flow basis. The modifications would allow for maintenance of the aeration basins and secondary clarifiers during the dry weather season so they all may be available during the wet weather season. The modifications would also include sludge reaeration as an alternate configuration during wet weather periods to provide secondary treatment for primary effluent flow up to 30 mgd; primary effluent flows greater than 30 mgd would be bypassed to the chlorine contact tanks as they are now.

Key elements of this treatment option include:

- Abandon existing trickling filters in place.
- Demolition of existing aeration tank aeration air diffusers.
- Three full-height longitudinal concrete baffles and two submerged perpendicular concrete baffles per tank.
- Two submerged mechanical mixers per tank.
- 3.0-mgd variable-speed submersible mixed liquor recycle (MLR) pump per tank.



Note: Refer to Section 4.2.1.1 of the TM for a description of the key elements.

MAINSTREAM TREATMENT OPTION, MODIFIED LUDZAK-ETTINGER PROCESS FLOW SCHEMATIC

FIGURE 4.5

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- 12-inch MLR line within each tank.
- Full-floor coverage fine-bubble diffusers in the aerobic zone of each tank with aeration air control system using DO probes.
- 18-inch RAS line from existing 24-inch RAS line (in tunnel) to aeration tank 4 effluent ML channel and from existing 24-inch RAS line (in tunnel) to aeration tank 1 effluent ML channel.
- Energy dissipating inlet, flocculation well, and suction arm mechanism per clarifier.

4.2.1.2 BioMag™

BioMag™ is a proprietary ballasted clarification process that increases the maximum allowable mixed liquor suspended solids (MLSS) concentration of an activated sludge system by increasing the maximum allowable clarifier solids loading rate. Magnetite is added to the mixed liquor to approximately triple the clarifier solids loading rate compared to conventional activated sludge. This enables the BioMag™ system to handle a greater solids load and/or operate at a longer solids residence time – for more effective nitrification – compared to conventional activated sludge. BioMag™ is used at eight treatment facilities in New England and Mid-Atlantic.

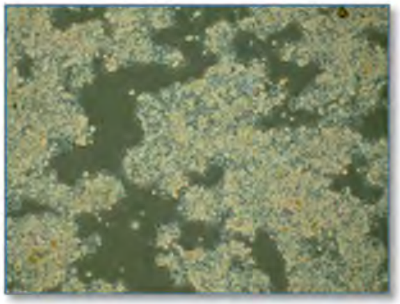
Figure 4.6 shows the process components for the BioMag™ ballasted clarification treatment configuration. The inset photomicrographs show a typical activated sludge floc and activated sludge from a BioMag™ ballasted clarification process, with magnetite particles enmeshed within the floc.

Unique BioMag™ system components include an in-line grinder to separate the magnetite from the WAS stream and a magnetic recovery system to recover the magnetite from the WAS stream and recycle it back to the aeration tank. Magnetite storage and feed facilities are included to make up for any magnetite lost in the WAS and/or secondary effluent.

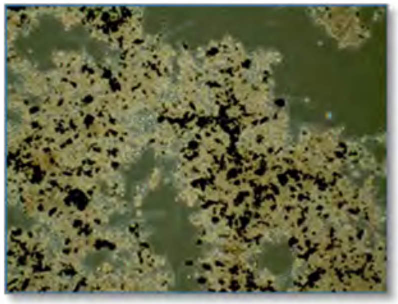
Modifications to the existing secondary treatment facilities for ballasted sedimentation using magnetite (BioMag™) are shown in Figure 4.7. The BioMag™ system would provide nitrification only, so denitrification filters would be needed downstream of the secondary clarifier to provide nitrogen removal. The granular media denitrification filters would be located north of the chlorine contact tanks.

Key elements of this treatment option include:

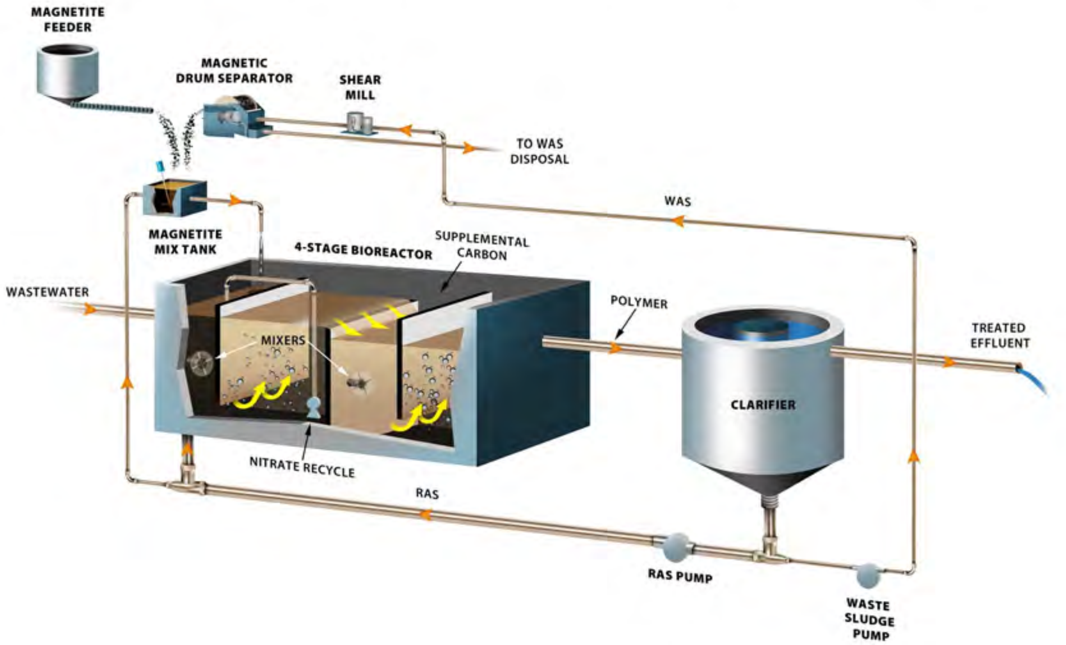
- Demolition of existing aeration tank aeration air diffusers.
- Three full-height longitudinal concrete baffles and two submerged perpendicular concrete baffles per tank.
- Two submerged mechanical mixers per tank.



Photomicrograph of typical activated sludge floc



Photomicrograph of activated sludge floc with enmeshed magnetite



BALLASTED ACTIVATED SLUDGE PROCESS COMPONENTS

FIGURE 4.6

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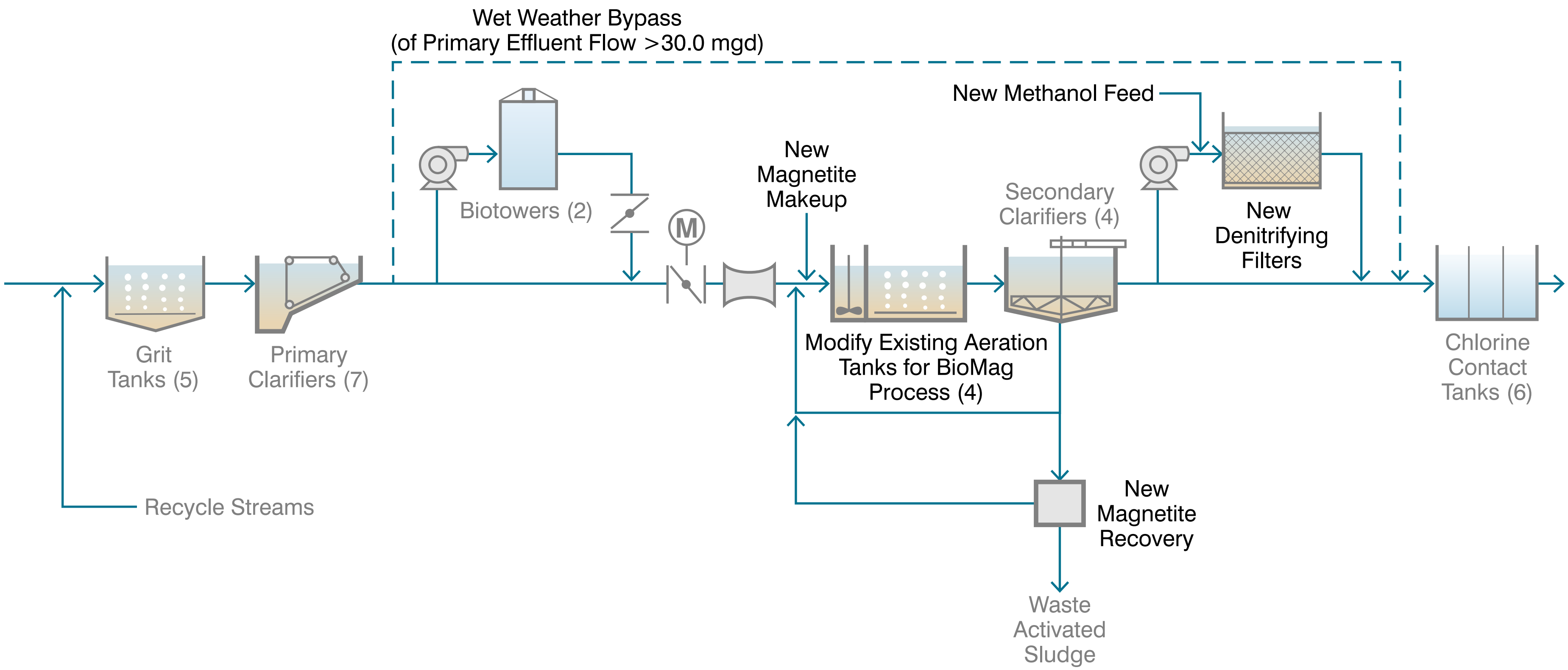

Note: Refer to Section 4.2.1.2 of the TM for a description of the key elements.

MAINSTREAM TREATMENT OPTION, BALLASTED ACTIVATED SLUDGE PROCESS FLOW SCHEMATIC

FIGURE 4.7

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- Full-floor coverage fine-bubble diffusers in the aerobic zone of each tank with aeration air control system using DO probes.
- BioMag™ equipment package (magnetite recovery equipment).
- 8.25 mgd denitrification granular media filters.
- Denitrification filter feed pumps.
- Methanol storage and feed system.

4.2.1.3 Integrated Fixed Film/Activated Sludge

The integrated fixed film/activated sludge (IFAS) system includes plastic media installed in a portion of the aeration tank to provide an environment to retain nitrifying bacteria at a lower solids residence time than comparably sized conventional activated sludge systems.

Figure 4.8 shows the process components for an integrated fixed film/activated sludge treatment configuration. The inset photograph on the right shows a piece of media from an IFAS system; note the biomass color difference compared to anammox biomass shown in Figure 4.2. The other inset photograph shows an internal baffle wall and multiple media retention screens that are used to keep the free-floating media within the aeration tank.

However, the additional headloss from the media retention screens limits peak wet weather flows with an IFAS system. IFAS has typically been used to improve nitrification at plants in colder climates (e.g., Broomfield, CO), but there is one facility in California at the Yucaipa WWTP.

Modifications to the existing secondary treatment facilities for IFAS are shown in Figure 4.9.

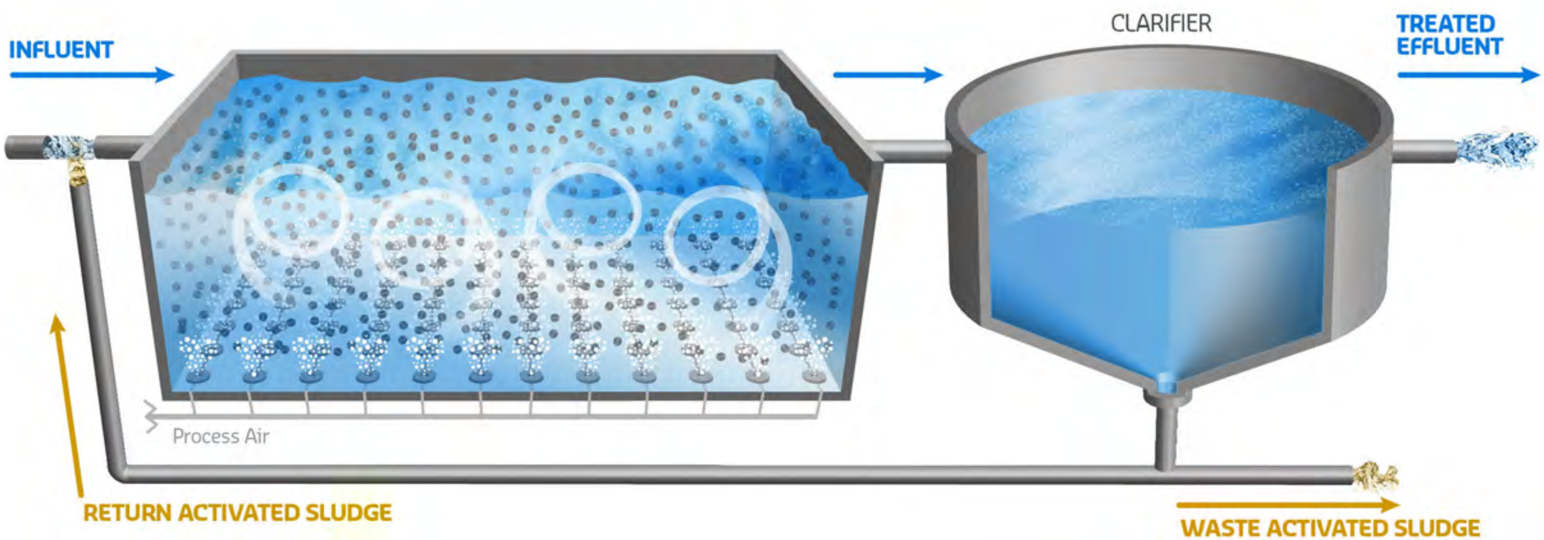
The IFAS system would provide nitrification only, so denitrification filters would be needed downstream to provide nitrogen removal. The granular media denitrification filters would be located north of the chlorine contact tanks.

Key elements of this treatment option include:

- Demolition of existing aeration tank aeration air diffusers.
- Three full-height longitudinal concrete baffles and two submerged perpendicular concrete baffles per tank.
- One full-height perpendicular concrete baffle with media retention screens.
- Two submerged mechanical mixers per tank.
- Full-floor coverage fine-bubble diffusers in the aerobic zone of each tank with aeration air control system using DO probes.

Plastic biofilm carrier

Baffle wall with media retention screens



**INTEGRATED FIXED FILM/
ACTIVATED SLUDGE PROCESS COMPONENTS**

FIGURE 4.8

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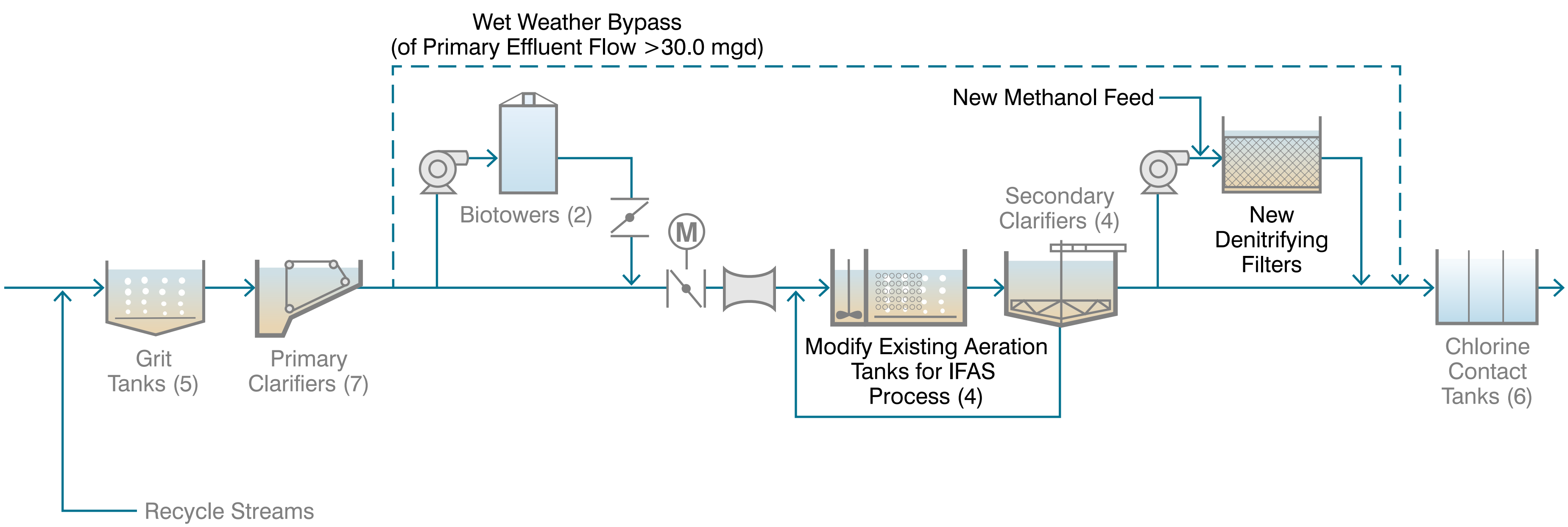

Note: Refer to Section 4.2.1.3 of the TM for a description of the key elements.

MAINSTREAM TREATMENT OPTION, INTEGRATED FIXED FILM/ACTIVATED SLUDGE PROCESS FLOW SCHEMATIC

FIGURE 4.9

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- IFAS equipment package (plastic media, media retention screens).
- 8.25 mgd denitrification granular media filters.
- Denitrification filter feed pumps.
- Methanol storage and feed system.

4.2.2 Parallel Secondary Treatment Options

These secondary treatment options would provide sufficient additional process capacity to handle the projected planning condition of 8.34 mgd ADWF, and associated peak month flows and loads, in parallel with modified secondary treatment facilities.

4.2.2.1 Membrane bioreactor (MBR)

An MBR is similar to a suspended growth activated sludge process, except that membranes are used for solid/liquid separation instead of gravity clarifiers. This allows a higher aeration tank MLSS concentration compared to a conventional activated sludge system. An MBR system requires a relatively high return sludge flow rate to limit the membrane tank MLSS concentration, so the MBR system can provide nitrogen removal similar to the MLE treatment option described above. The peak flow capacity of the MBR system is approximately 1.6 times the average flow rate.

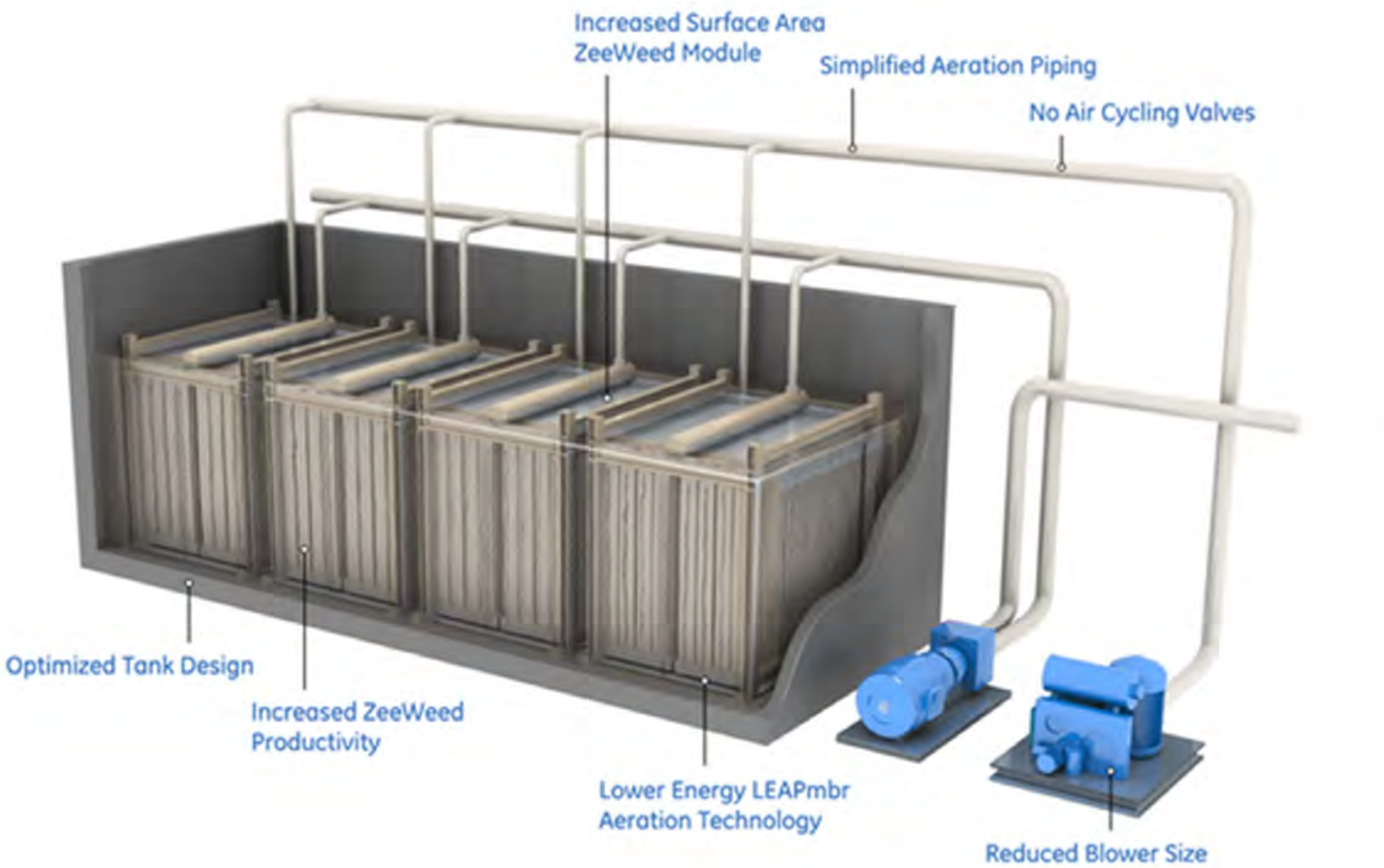
Figure 4.10 shows the process components for a membrane bioreactor treatment configuration.

The MBR parallel secondary treatment option is shown in Figure 4.11. A portion of the primary effluent would be diverted to the MBR aeration tanks and treated permeate from the membrane tanks would be conveyed to the chlorine contact tank inlet. The MBR aeration tanks would be operated in a MLE configuration, as described above, to provide nitrogen removal through denitrification. Examples of where MBR treatment is used for nitrogen removal include Modesto and Riverside in California.

One advantage of the MBR treatment process is that the MBR effluent (permeate) could be used for Title 22 disinfected tertiary recycled water with subsequent disinfection.

Key elements of this treatment option include:

- 18-inch PE line w/flow meter and flow control valve from existing 48-inch PE line (in tunnel) to new MBR aeration tanks.
- Four 80 feet x 20 feet x 15 feet SWD aeration tanks with two submerged transverse concrete baffles each.
- Two submerged mechanical mixers per tank.



MBR membrane tank showing agitation air blower used to minimize membrane fouling and permeate (effluent) pump. Concentrated mixed liquor (return sludge) from the membrane tank is recycled to the aeration tank upstream (not shown).

MEMBRANE BIOREACTOR PROCESS COMPONENTS

FIGURE 4.10

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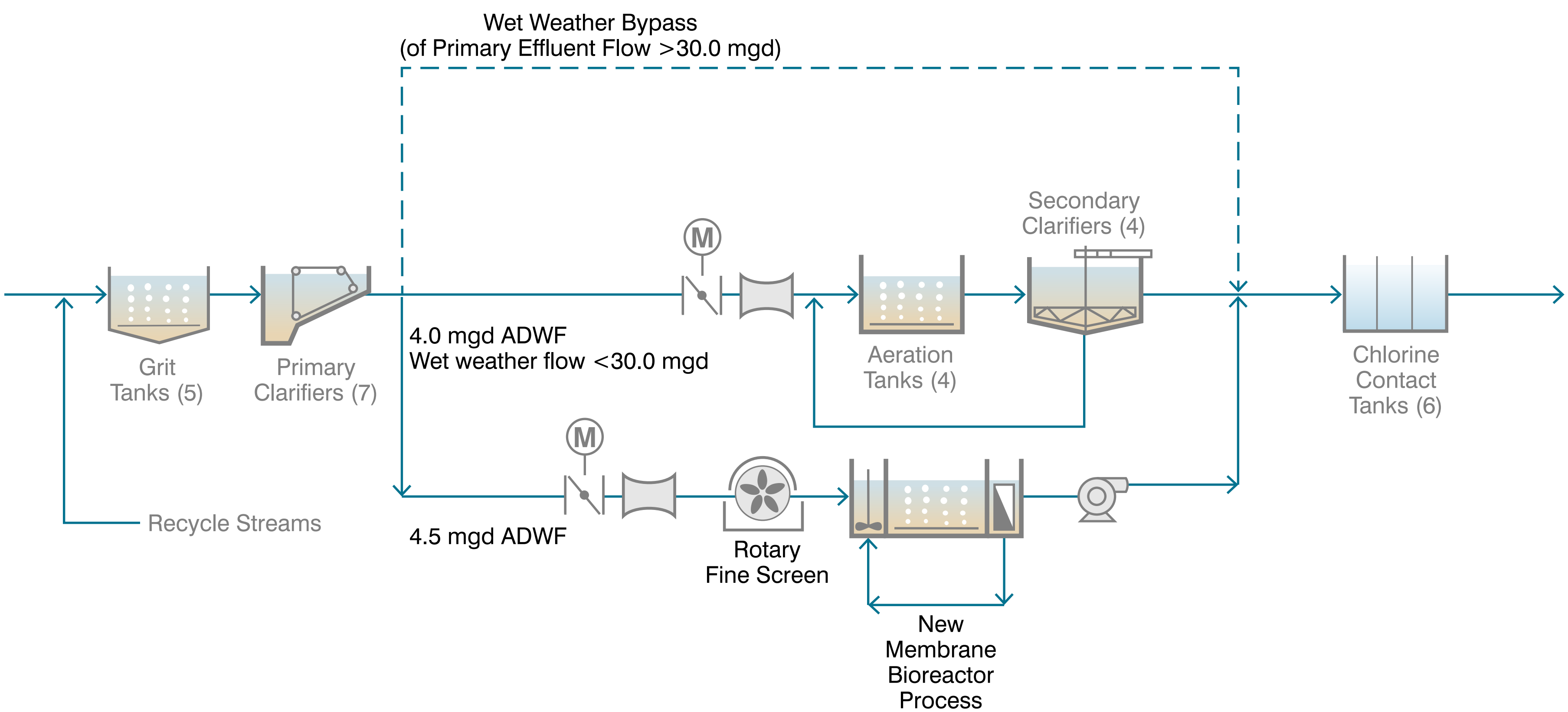

Note: Refer to Section 4.2.2.1 of the TM for a description of the key elements.

PARALLEL TREATMENT OPTION, MEMBRANE BIOREACTOR PROCESS FLOW SCHEMATIC

FIGURE 4.11

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- Full-floor coverage fine-bubble diffusers, 80 percent of tank area.
- Four 50 feet x 9 feet x 10 feet SWD membrane tanks.
- One 30 feet x 20 feet x 15 feet SWD deoxygenation tank.
- Three 6.75 mgd variable-speed return sludge pumps, low head.
- Two variable-speed waste sludge pumps.
- MBR equipment package (membrane modules/cassettes, membrane tank blowers, permeate pumps).
- 18-inch SE line from MBR permeate pumps to chlorine contact tank inlet structure.
- 6-inch WAS line from MBR waste sludge pumps to existing 6-inch WAS line (in RAS/WAS pumping station).

4.2.2.2 Aerobic granular sludge reactor

Aerobic granular sludge (AGS) has been developed over the past decade as a nutrient removal alternative with a relatively small footprint. AGS incorporates the same types of bacteria found in conventional suspended growth BNR systems (e.g., heterotrophs, AOB, nitrite oxidizing bacteria (NOB), and phosphorus accumulating organisms (PAOs)), except the biomass grows as heterogeneous granules rather than as individual flocs. The AGS reactors operate similar to a sequencing batch reactor, except the treated wastewater is not decanted from the reactor but is displaced by the influent wastewater during the fill phase.

Figure 4.12 shows the process components for an aerobic granular sludge treatment configuration. The inset photograph in the middle compares the settleability of AGS granules and conventional activated sludge flocs after 5 minutes of settling. The larger diameter, denser granules settle rapidly, which enables a shorter settling period for AGS reactor operation. The two other inset photographs in the upper part of the figure show the various stages comprising a reactor operational cycle.

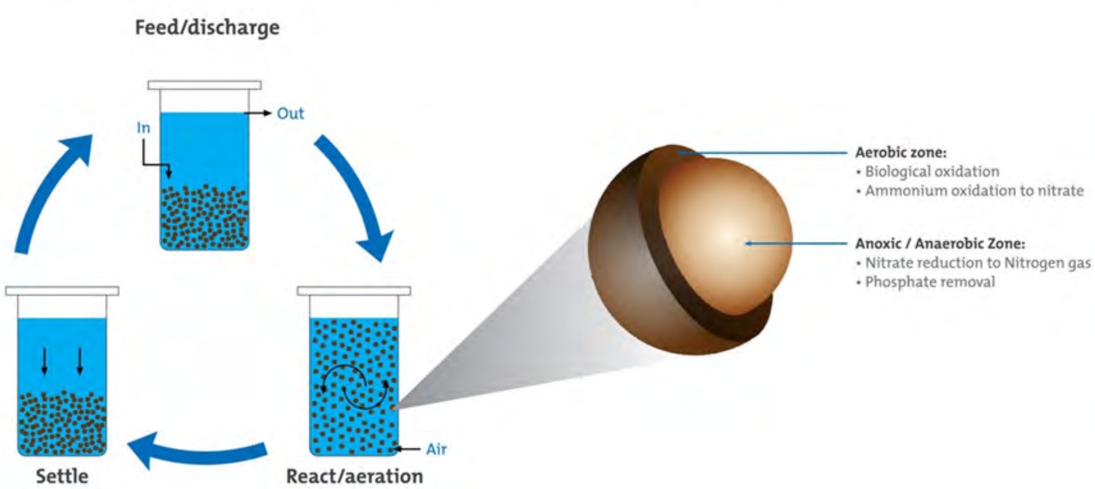
The sludge granules settle very rapidly, reducing the length of the settle phase relative to conventional SBRs. Process performance depends on plug-flow conditions to minimize effluent TN concentrations, so the influent wastewater is distributed through a grid of inlet ports across the tank bottom.

This process was developed the Netherlands and has several installations in Europe, Asia, and South America. The U.S. provider of this technology, Aqua Aerobics, has constructed a 200,000 gpd system at the Rock River WWTP (Rockford, IL) for demonstration purposes and to provide seed granules for future U.S. systems.

AGS reactors in react/aeration mode (top) and settle mode (bottom)

Comparative settleability of AGS granules (left) and activated sludge (right) after 5 minutes

AGS reactor in feed/discharge mode



AGS granules

AEROBIC GRANULAR SLUDGE PROCESS COMPONENTS

FIGURE 4.12

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The aerobic granular sludge (AGS) parallel secondary treatment option is shown in Figure 4.13. A portion of the primary effluent would be diverted to the AGS tanks and treated effluent would be conveyed to the chlorine contact tank inlet. The granular sludge settles much better than conventional suspended growth activated sludge, so the AGS would be operated as a sequencing batch reactor where the granular sludge is retained in the reactor during the “settle” phase.

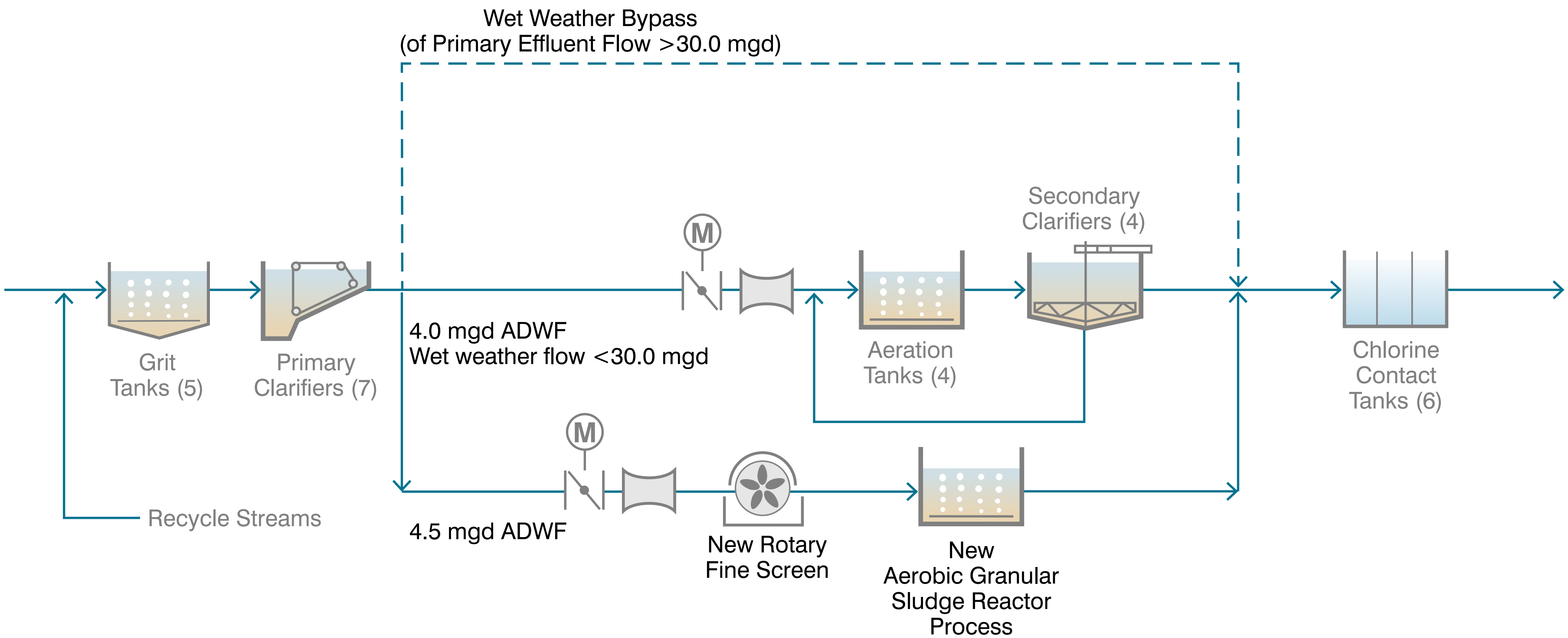
Key elements of this treatment option include:

- 18-inch PE line w/flow meter and flow control valve from existing 48-inch PE line (in tunnel) to new AGS reactors.
- Two 80 feet diameter x 26 feet high steel tanks (at grade).
- Two variable-speed waste sludge pumps.
- AGS equipment package (feed pumps, inlet nozzles, diffusers, mechanical mixers, blowers).
- 18-inch SE line from AGS tanks to chlorine contact tank inlet structure.
- 6-inch WAS line from AGS waste sludge pumps to existing 6-inch WAS line (in RAS/WAS pumping station).

5.0 ALTERNATIVES TO MEET POTENTIAL EFFLUENT NUTRIENT DISCHARGE LIMITS

This section describes four nutrient removal alternatives to meet Level 2 nutrient discharge limits and possible further modifications to meet more stringent Level 3 nutrient limits in the future. Two of the four alternatives combine the lowest cost secondary treatment modification option with the parallel MBR treatment option or the parallel AGS treatment option. The other two alternatives evaluate the benefit of combining the lowest cost sidestream treatment option and the lowest cost secondary treatment modifications option with the parallel MBR treatment option or the parallel AGS treatment option.

Tables 4.2 and 4.3 summarize the present worth cost of the sidestream treatment options and the secondary treatment modifications options, respectively. Detailed project cost estimates are included in Appendix A and Appendix B, respectively. The nitritation sidestream treatment option, with subsequent denitritation in the primary clarifiers, has a lower project cost than the anaerobic ammonia oxidation option. However, the nitritation option has not been proven in full-scale application, so the anaerobic ammonia oxidation option is recommended for process alternatives that include sidestream treatment. Conventional activated sludge (MLE with wet weather sludge reaeration) is the lowest cost mainstream treatment option.



Note: Refer to Section 4.2.2.2 of the TM for a description of the key elements.

PARALLEL TREATMENT OPTION, AEROBIC GRANULAR SLUDGE PROCESS FLOW SCHEMATIC

FIGURE 4.13

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2017 FACILITIES MASTER PLAN

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Table 4.2 Summary of Sidestream Treatment Alternatives
2017 Facilities Master Plan
Central Marin Sanitation Agency

	Anaerobic Ammonia Oxidation (ANITA™Mox)	Nitritation
Location	Located in aerated grit tank 3	Located in aerated grit tank 3
Nitrogen removal	Removes approximately 15 percent of secondary influent ammonia load Does not require organic carbon for nitrogen removal	Removes approximately 15percent of secondary influent ammonia load Uses raw influent soluble BOD for nitrogen removal
Phosphorus removal	--	--
Project cost	**$3,690,000**	**$552,000**
Annual operations cost(1)	$20,000	$43,000
Present worth of operations cost(1)	$263,000	$574,000
Present worth(2)	**$3,953,000**	**$1,126,000**

Note:
(1) Operations cost includes electric power and chemicals (e.g., sodium hydroxide).
(2) Present worth is total project cost plus present worth of annual O&M costs. Annual O&M costs were converted to present worth based on 3 percent inflation rate, 6 percent discount rate, and 15-year analysis period

Table 4.3 Summary of Mainstream Treatment Alternatives
2017 Facilities Master Plan
Central Marin Sanitation Agency

	Modified Ludzak-Ettinger	Ballasted Sedimentation (BioMag™)	Integrated Fixed Film/ Activated Sludge (IFAS)
Location	Located in modified aeration tanks	Located in modified activated sludge system	Located in modified aeration tanks
Nitrogen removal	Pre-anoxic zone and mixed liquor recycle pumps required for nitrogen removal	Denitrification filters required for nitrogen removal	Denitrification filters required for nitrogen removal
	Uses secondary influent soluble BOD for nitrogen removal	Uses supplemental carbon addition (methanol) for nitrogen removal	Uses supplemental carbon addition (methanol) for nitrogen removal
Phosphorus removal	Alum or ferric added to mixed liquor for phosphorus removal	Alum or ferric added to secondary effluent for phosphorus removal	Alum or ferric added to secondary effluent for phosphorus removal
Project cost	**$13,074,000**	**$27,695,000**	**$29,044,000**
Annual operations cost(1)	$19,000	$1,160,000	$752,000
Present worth of operations cost(1)	$245,000	$12,909,000	$10,153,000
Present worth(2)	**$13,319,000**	**$40,604,000**	**$39,197,000**

Note:
(1) Operations cost includes electric power and chemicals (e.g., methanol, sodium hydroxide, polymer, magnatite).
(2) Present worth is total project cost plus present worth of annual O&M costs. Annual O&M costs were converted to present worth based on 3 percent inflation rate, 6 percent discount rate, and 15-year analysis period.

Table 4.4 summarizes the project cost and present worth of the two parallel mainstream treatment options included in this study, MBR treatment and AGS treatment. Detailed project cost estimates for the two parallel treatment options are included in Appendix C.

Table 4.4 Summary of Parallel Treatment Alternatives
2017 Facilities Master Plan
Central Marin Sanitation Agency

	Membrane Bioreactor	**Aerobic Granular Sludge**
Location	Located east of existing maintenance building	Located east of existing maintenance building
Nitrogen removal	Uses return sludge pumps and pre-anoxic zone for nitrogen removal Uses secondary influent soluble BOD for nitrogen removal	Denitrification occurs during batch operating cycle Uses secondary influent soluble BOD for nitrogen removal
Phosphorus removal	Alum or ferric added to mixed liquor for phosphorus removal	Concurrent biological phosphorus removal
Project cost	**$21,107,000**	**$39,262,000**
Annual operations cost(1)	$29,000	$29,000
Present worth of operations cost(1)	$391,000	$391,000
Present worth(2)	**$21,498,000**	**$39,653,000**

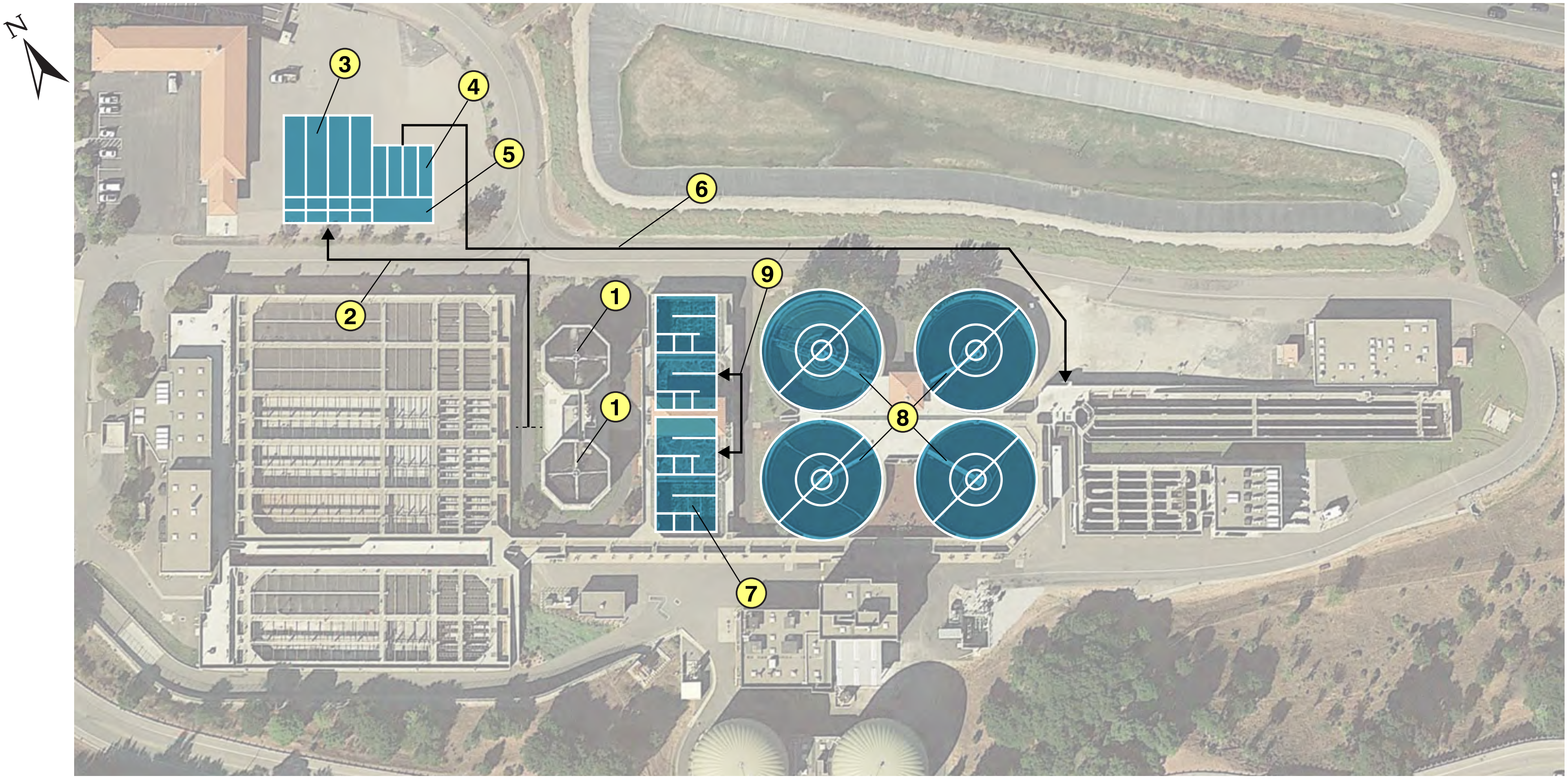
Notes:
(1) Operations cost includes electric power and chemicals (e.g., methanol, sodium hydroxide, polymer, magnatite).
(2) Present worth is total project cost plus present worth of annual O&M costs. Annual O&M costs were converted to present worth based on 3 percent inflation rate, 6 percent discount rate, and 15-year analysis period

5.1 Alternative 1

Alternative 1 consists of conventional activated sludge (MLE with wet weather sludge reaeration) and parallel MBR treatment to meet potential Level 2 nutrient discharge limits. Figure 4.14 shows the modifications to existing facilities and proposed location of new parallel treatment facilities for this alternative.

The facilities included in Alternative 1 could be modified in the future to meet Level 3 nutrient discharge limits by adding a post-anoxic zone, with supplemental carbon addition, between the MBR aeration tanks and membrane tanks for enhanced nitrogen removal.

Enhanced phosphorus removal could be achieved by adding metal salts (e.g., alum, ferric chloride) to the MBR mixed liquor to precipitate and/or adsorb dissolved phosphorus.



LEGEND

1. Existing Biotower (Abandoned in Place)
2. New Primary Effluent Pipe
3. New MBR Aeration Tanks with Preanoxic Zones
4. New Membrane Tanks
5. New Deoxygenation Tanks
6. New Secondary Effluent Pipe
7. Retrofit Existing Aeration Tanks to Modified Ludzak-Ettinger Configuration
8. Retrofit Existing Secondary Clarifiers with New Energy Dissipating Inlets, Flocculation Baffles, and Mechanisms
9. New Returned Activated Sludge Pipes for Sludge Reaeration Configuration during Peak Flow Periods

NUTRIENT REMOVAL ALTERNATIVE 1

FIGURE 4.14

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5.2 Alternative 2

Alternative 2 consists of anaerobic ammonia oxidation sidestream treatment, conventional activated sludge (MLE with wet weather sludge reaeration), and parallel MBR treatment to meet potential Level 2 nutrient discharge limits. Figure 4.15 shows the modifications to existing facilities and proposed location of new parallel treatment facilities for this alternative.

The benefit of sidestream treatment followed by mainstream and parallel secondary treatment would be to reduce secondary treatment aeration air demands by approximately 4 percent. Sidestream treatment would provide no reduction in sizing of the mainstream secondary treatment option nor the new parallel mainstream MBR treatment option, as sidestream treatment does not affect the secondary treatment organic load, which governs secondary treatment capacity.

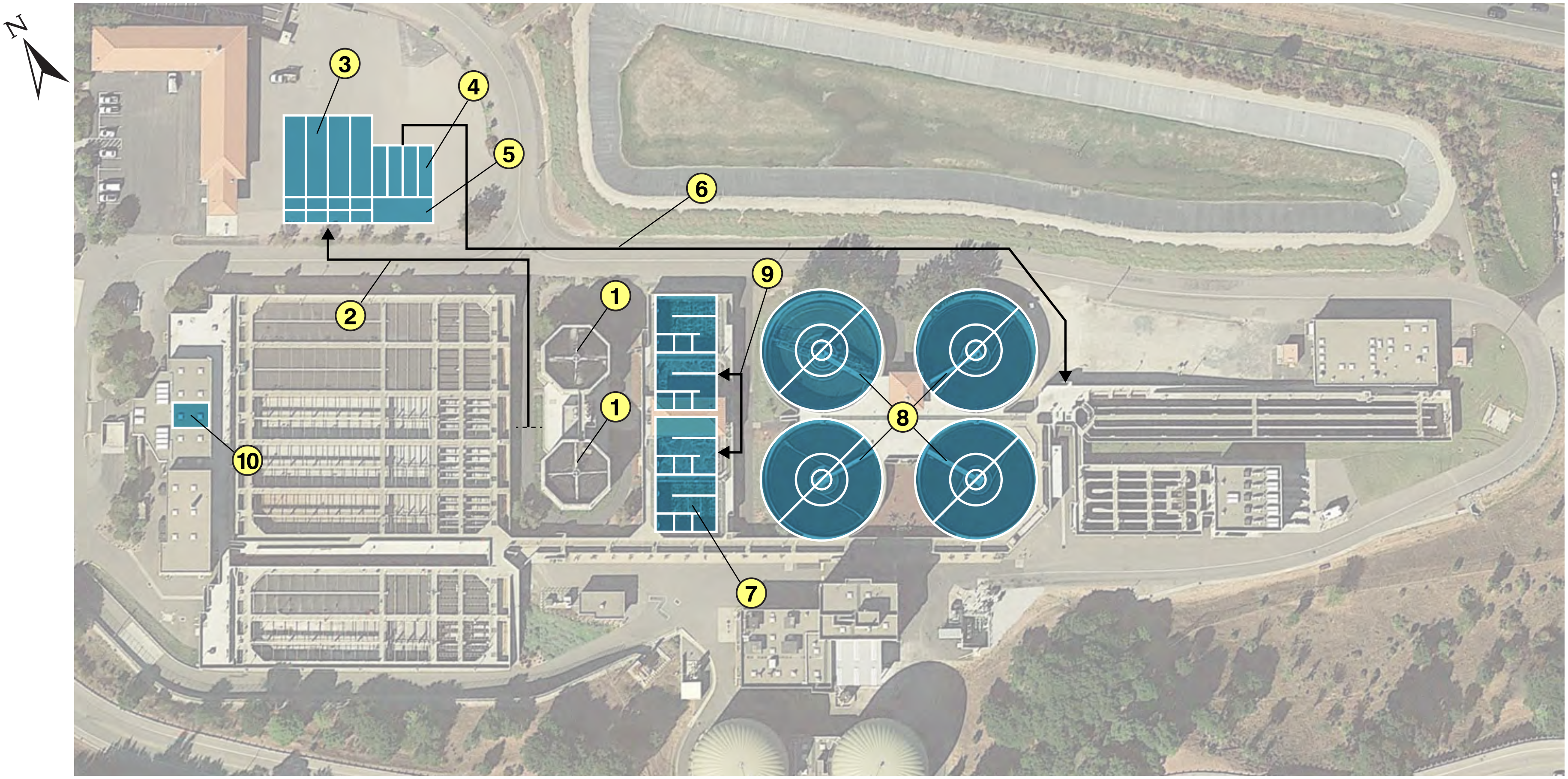
The facilities included in Alternative 2 could be modified in the future to meet Level 3 nutrient discharge limits by adding a post-anoxic zone, with supplemental carbon addition, between the MBR aeration tanks and membrane tanks for enhanced nitrogen removal. Enhanced phosphorus removal could be achieved by adding metal salts (e.g., alum, ferric chloride) to the MBR mixed liquor to precipitate and/or adsorb dissolved phosphorus.

5.3 Alternative 3

Alternative 3 consists of conventional activated sludge (MLE with wet weather sludge reaeration) and parallel AGS treatment to meet potential Level 2 nutrient discharge limits. Figure 4.16 shows the modifications to existing facilities and proposed location of new parallel treatment facilities for this alternative.

Aerobic granular sludge (AGS) modifications to meet Level 3 discharge limits have not been tested at this time. Ideally, supplemental carbon addition at specific point(s) in the operating cycle could be a modification to improve denitrification within the AGS reactor. Depending on the AGS effluent volatile suspended solids concentration, particulate nitrogen removal could be achieved through filtration. Additional studies are recommended, as described below, to demonstrate whether AGS with supplemental carbon addition could meet a TN discharge limit of 6.0 mgN/L.

Likewise, additional studies are recommended to demonstrate whether metal salt addition directly to the AGS reactor for precipitation and/or adsorption of dissolved phosphorus is feasible, as the precipitated aluminum- or iron-phosphorus solids may not settle well within the AGS reactor. Moreover, metal salt addition may have a negative impact on granule settling and/or physical characteristics. Metal salts could be added to the AGS effluent, with filtration for subsequent particulate removal.



LEGEND

1. Existing Biotower (Abandoned in Place)
2. New Primary Effluent Pipe
3. New MBR Aeration Tanks with Preanoxic Zones
4. New Membrane Tanks
5. New Deoxygenation Tanks
6. New Secondary Effluent Pipe
7. Retrofit Existing Aeration Tanks to Modified Ludzak-Ettinger Configuration
8. Retrofit Existing Secondary Clarifiers with New Energy Dissipating Inlets, Flocculation Baffles, and Mechanisms
9. New Returned Activated Sludge Pipes for Sludge Reaeration Configuration during Peak Flow Periods
10. Ananmox Sidestream Treatment

NUTRIENT REMOVAL ALTERNATIVE 2

FIGURE 4.15

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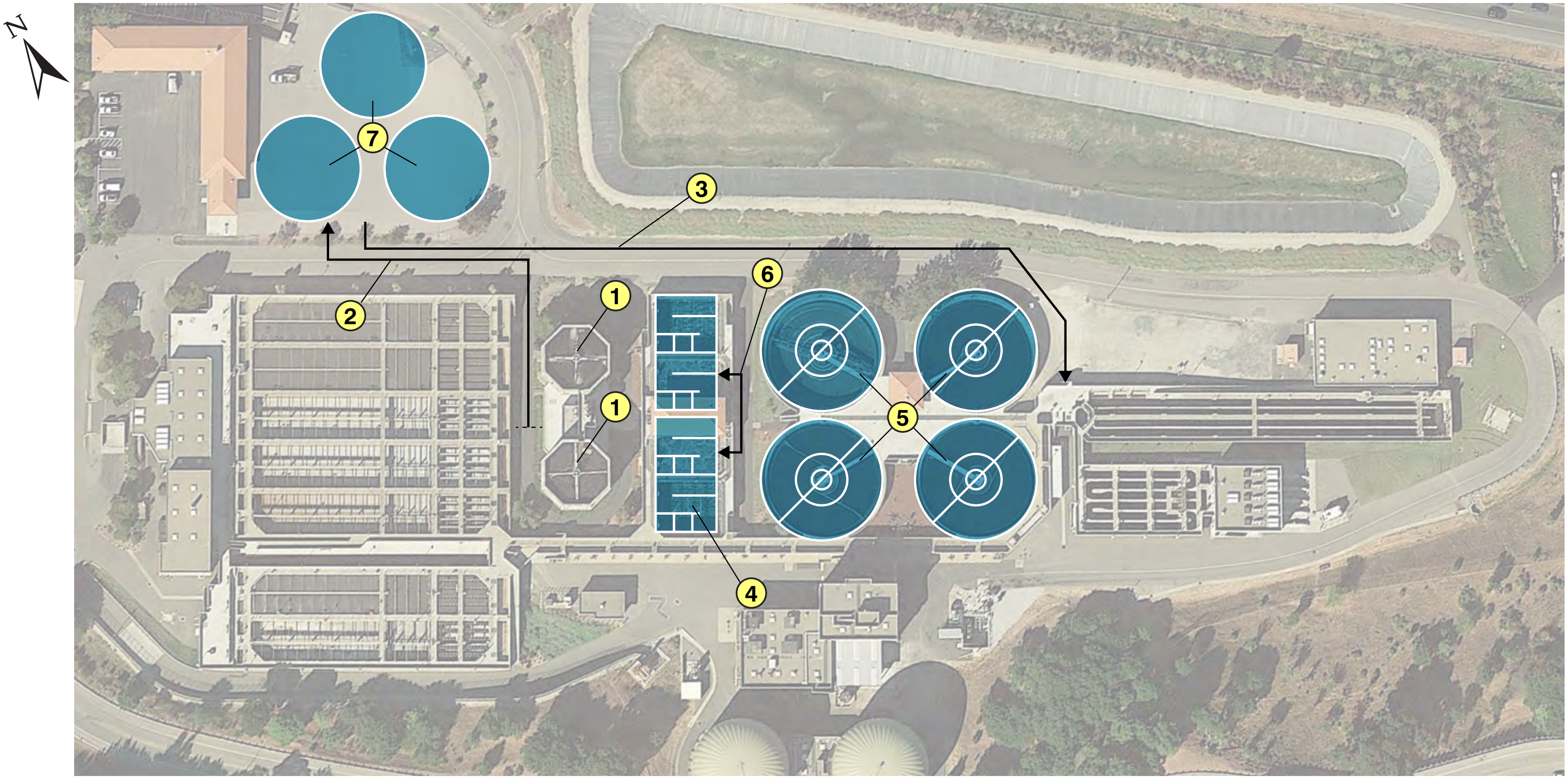

LEGEND

1. Existing Biotower (Abandoned in Place)
2. New Primary Effluent Pipe
3. New Secondary Effluent Pipe
4. Retrofit Existing Aeration Tanks to Modified Ludzak-Ettinger Configuration
5. Retrofit Existing Secondary Clarifiers with New Energy Dissipating Inlets, Flocculation Baffles, and Mechanisms
6. New Returned Activated Sludge Pipes for Sludge Reaeration Configuration during Peak Flow Periods
7. Aerobic Grandular Sludge (AGS) Reactors

NUTRIENT REMOVAL ALTERNATIVE 3

FIGURE 4.16

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5.4 Alternative 4

Alternative 4 consists of anaerobic ammonia oxidation sidestream treatment, conventional activated sludge (MLE with wet weather sludge reaeration), and parallel AGS treatment to meet potential Level 2 nutrient discharge limits. Figure 4.17 shows the modifications to existing facilities and proposed location of new parallel treatment facilities for this alternative.

The benefit of sidestream treatment followed by mainstream and parallel secondary treatment would be to reduce secondary treatment aeration air demands by approximately 4 percent. Sidestream treatment would provide no reduction in sizing of the mainstream secondary treatment option nor the new parallel mainstream AGS treatment option, as sidestream treatment does not affect the secondary treatment organic load, which governs secondary treatment capacity.

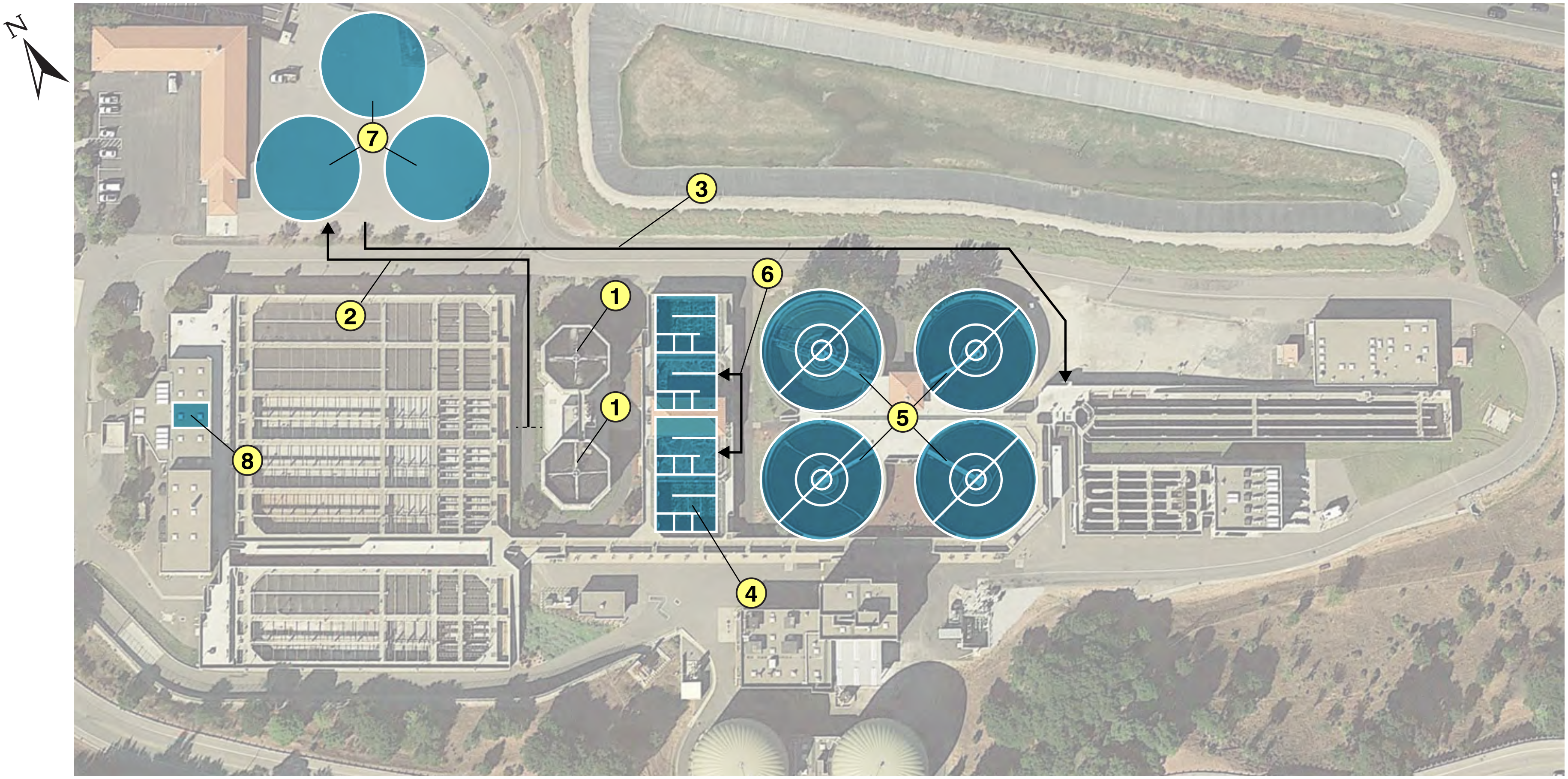
Additional studies are recommended, as described above, to demonstrate whether chemical addition to the AGS system (e.g., supplemental carbon, metal salts) is sufficient to meet Level 3 nitrogen and phosphorus discharge limits or whether additional unit processes are needed (e.g., effluent filtration).

5.5 Treatment Alternative Costs

The estimated project costs for the four treatment alternatives described above are summarized in Table 4.5. As described above, inclusion of sidestream treatment in Alternative 2 and 3 reduces the overall aeration air demands slightly, but does not reduce the project cost of the mainstream nor parallel mainstream treatment options.

6.0 FOLLOW-UP STUDIES

Additional monitoring is recommended to validate assumptions made in this study about plant influent and solids handling recycle characteristics. Periodic effluent samples have been analyzed for ammonia, nitrite, nitrate, total Kjeldahl nitrogen, total phosphorus, and orthophosphorus as required by the watershed nutrient permit. However, similar analyses of plant influent and centrate should be run to develop data on plant influent and centrate nitrogen and phosphorus fractions and peak loading factors. Plant influent soluble BOD analyses are recommended to determine the readily biodegradable soluble organics load, as this is the BOD fraction necessary for effective biological nitrogen and/or phosphorus removal.



LEGEND

1. Existing Biotower (Abandoned in Place)
2. New Primary Effluent Pipe
3. New Secondary Effluent Pipe
4. Retrofit Existing Aeration Tanks to Modified Ludzak-Ettinger Configuration
5. Retrofit Existing Secondary Clarifiers with New Energy Dissipating Inlets, Flocculation Baffles, and Mechanisms
6. New Returned Activated Sludge Pipes for Sludge Reaeration Configuration during Peak Flow Periods
7. Aerobic Grandular Sludge (AGS) Reactors
8. Ananmox Sidestream Treatment

NUTRIENT REMOVAL ALTERNATIVE 4

FIGURE 4.17

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2017 FACILITIES MASTER PLAN

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Table 4.5 Nutrient Removal Alternatives Costs 2017 Facilities Master Plan Central Marin Sanitation Agency				
	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
	Mainstream Modified Ludzak-Ettinger/ Membrane Bioreactor	**Sidestream Anaerobic Ammonia Oxidation and Mainstream Modified Ludzak-Ettinger/ Membrane Bioreactor**	**Mainstream Modified Ludzak-Ettinger/ Aerobic Granular Sludge**	**Sidestream Anaerobic Ammonia Oxidation and Mainstream Modified Ludzak-Ettinger/ Aerobic Granular Sludge**
Project cost	**$34,181,000**	**$37,871,000**	**$52,336,000**	**$56,026,000**
Annual operations cost(1)	$48,000	$68,000	$48,000	$68,000
Present worth of operations cost(1)	$636,000	$899,000	$636,000	$899,000
Present worth(2)	**$34,817,000**	**$38,770,000**	**$52,972,000**	**$56,925,000**

Notes:
(1) Operations cost includes electric power and chemicals (e.g., methanol, sodium hydroxide, polymer, magnatite).
(2) Present Worth is total project cost plus present worth of annual O&M costs. Annual O&M costs were converted to present worth based on 3 percent inflation rate, 6 percent discount rate, and 15-year analysis period.

Pilot testing of the aerobic granular sludge (AGS) process should be considered in the future to demonstrate compliance with the existing final effluent suspended solids discharge limit and with anticipated Level 2 nitrogen and phosphorus discharge limits. Pilot testing can also demonstrate whether chemical addition to the AGS system (e.g., supplemental carbon, metal salts) is sufficient to meet Level 3 nutrient discharge limits or whether additional unit processes are needed (e.g., effluent filtration).

APPENDIX A – SIDESTREAM TREATMENT OPTION COSTS

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/25/2018
ALT. # :	S1	**PREPARED BY :**	RA
ALT. :	Sidestream Treatment with Anaerobic Ammonia Oxidation Reactor Process	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Grit Tank 3 Modifications**					
	Demolish Air Piping, Air Diffusers, and Other Internals	1	LS	$20,000	$20,000	
	Add 6" Centrate Pipe from Solids Handling Building to Grit Tank 3	1	LS	$96,000	$96,000	
	Level Grit Tank 3 Floor to EL 110.50	1	LS	$10,000	$10,000	
	8" Aeration Pipe to Grit Tank 3	1	LS	$15,000	$15,000	
	Total					$141,000
2	**AnitaMox Process**					
	AnitaMox Equipment Package	1	LS	$1,201,200	$1,201,200	
	Total					$1,201,000
	SUBTOTAL					**$1,342,000**
3	**Allowances**					
	Process Mechanical Allowance	5	%		$67,000	
	Yard Piping & Site Civil Allowance	5	%		$67,000	
	EIC Allowance	20	%		$268,000	
	Coating/Painting Allowance	5	%		$67,000	
	Total					$469,000
	SUBTOTAL					**$1,811,000**
	Estimating Contingency	30	%			$543,000
	SUBTOTAL					**$2,354,000**
	Sales Tax on 50% of Subtotal Above	9.00	%			$106,000
	SUBTOTAL					**$2,460,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$615,000
	CONSTRUCTION COST SUBTOTAL					**$3,075,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$615,000
	PROJECT COST					**$3,690,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/25/2018
ALT. # :	S2	**PREPARED BY :**	RA
ALT. :	Sidestream Treatment with Nitritation Reactor Process	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Grit Tank 3 Modifications**					
	Demolish Air Piping, Air Diffusers, and Other Internals	1	LS	$20,000	$20,000	
	Add 6" Centrate Pipe from Solids Handling Building to Grit Tank 3	1	LS	$96,000	$96,000	
	Level Grit Tank 3 Floor to EL 110.50	1	LS	$10,000	$10,000	
	Add Fine Bubble Diffusers in Grit Tank 3	1	LS	$50,000	$50,000	
	8" Aeration Pipe to Grit Tank 3	1	LS	$15,000	$15,000	
	Add DO Aeration Air Control System	1	LS	$10,000	$10,000	
	Total					$201,000
	SUBTOTAL					**$201,000**
2	**Allowances**					
	Process Mechanical Allowance	5	%		$10,000	
	Yard Piping & Site Civil Allowance	5	%		$10,000	
	EIC Allowance	20	%		$40,000	
	Coating/Painting Allowance	5	%		$10,000	
	Total					$70,000
	SUBTOTAL					**$271,000**
	Estimating Contingency	30	%			$81,000
	SUBTOTAL					**$352,000**
	Sales Tax on 50% of Subtotal Above	9.00	%			$16,000
	SUBTOTAL					**$368,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$92,000
	CONSTRUCTION COST SUBTOTAL					**$460,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$92,000
	PROJECT COST					**$552,000**

APPENDIX B – MAINSTREAM TREATMENT OPTION COSTS

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2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/25/2018
ALT. # :	M1	**PREPARED BY :**	RA
ALT. :	Mainstream Treatment with Modified Ludzak-Ettinger (MLE) Process	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Aeration Tank Modifications**					
	Demolish Existing Aeration Tank Aeration Air Diffusers	1	LS	$20,000	$20,000	
	Add Two (2) Full-Height Longitudinal Concrete Baffles Per Tank	1	LS	$182,000	$182,000	
	Add Two (2) Submerged Perpendicular Concrete Baffles Per Tank	1	LS	$66,920	$66,920	
	Add Submerged Mechanical Mixers Per Tank	8	EA	$35,000	$280,000	
	Add 3 MGD Variable-Speed Submersible Mixed Liquor Recycle (MLR) Pump Per Tank	4	EA	$30,000	$120,000	
	Add 12" MLR Pipe from NE Corner to SW Corner of Aeration Tanks 1 and 2 within Aeration Tank	1	LS	$18,000	$18,000	
	Add 12" MLR Pipe from NE Corner to SW Corner of Aeration Tanks 3 and 4 within Aeration Tank	1	LS	$18,000	$18,000	
	Add Fine-Bubble Diffusers, Full-Floor Coverage	1	LS	$190,000	$190,000	
	Total					$895,000
2	**RAS Piping Modifications**					
	Add 18" RAS Pipe from Existing 24" RAS Pipe (in tunnel) to Aeration Tank 1 Effluent ML Channel	1	LS	$31,500	$31,500	
	Add 18" RAS Pipe from Existing 24" RAS Pipe (in tunnel) to Aeration Tank 4 Effluent ML Channel	1	LS	$31,500	$31,500	
	Total					$63,000
3	**Secondary Clarifier Modifications**					
	Tow-Bro Clarifier Mechanisms, 100 ft. dia., 304SS	4	EA	$600,000	$2,400,000	
	Demolition	1	LS	$125,000	$125,000	
	Sheet Piling	4	EA	$150,000	$600,000	
	Center Column Foundation	4	EA	$125,000	$500,000	
	Total					$3,625,000
	SUBTOTAL					**$4,583,000**
4	**Allowances**					
	Process Mechanical Allowance	10	%		$458,000	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$917,000	
	Coating/Painting Allowance	10	%		$458,000	
	Total					$1,833,000

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/25/2018
ALT. # :	M1	**PREPARED BY :**	RA
ALT. :	Mainstream Treatment with Modified Ludzak-Ettinger (MLE) Process	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	SUBTOTAL					**$6,416,000**
	Estimating Contingency	30	%			$1,925,000
	SUBTOTAL					**$8,341,000**
	Sales Tax on 50% of Subtotal Above	9.00	%			$375,000
	SUBTOTAL					**$8,716,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$2,179,000
	CONSTRUCTION COST SUBTOTAL					**$10,895,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$2,179,000
	PROJECT COST					**$13,074,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/25/2018
ALT. # :	M2	**PREPARED BY :**	RA
ALT. :	Mainstream Treatment with Ballasted Activated Sludge Process (BioMag)	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Aeration Tank Modifications**					
	Demolish Existing Aeration Tank Aeration Air Diffusers	1	LS	$20,000	$20,000	
	Add Two (2) Full-Height Longitudinal Concrete Baffles Per Tank	1	LS	$182,000	$182,000	
	Add Two (2) Submerged Perpendicular Concrete Baffles Per Tank	1	LS	$66,920	$66,920	
	Add Submerged Mechanical Mixers Per Tank	8	EA	$35,000	$280,000	
	Add Fine-Bubble Diffusers, Full-Floor Coverage	1	LS	$190,000	$190,000	
	Total					$739,000
2	**BioMag Process**					
	BioMag Equipment Package (Magnetite Recovery Equipment)	1	LS	$2,244,000	$2,244,000	
	Total					$2,244,000
3	**Denitrification Filters**					
	Add 8.25 MGD Denitrification Granular Media Filters	1	LS	$6,246,000	$6,246,000	
	Concrete piles	1	LS	$238,897	$238,897	
	Add Denitrification Filter Feed Pumps	1	LS	$200,000	$200,000	
	Add Methanol Storage and Feed System	1	LS	$400,000	$400,000	
	Total					$7,085,000
	SUBTOTAL					**$10,068,000**
4	**Allowances**					
	Process Mechanical Allowance	5	%		$503,000	
	Yard Piping & Site Civil Allowance	5	%		$503,000	
	EIC Allowance	20	%		$2,014,000	
	Coating/Painting Allowance	5	%		$503,000	
	Total					$3,523,000
	SUBTOTAL					**$13,591,000**
	Estimating Contingency	30	%			$4,077,000
	SUBTOTAL					**$17,668,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/25/2018
ALT. # :	M2	**PREPARED BY :**	RA
ALT. :	Mainstream Treatment with Ballasted Activated Sludge Process (BioMag)	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	Sales Tax on 50% of Subtotal Above	9.00	%			$795,000
	SUBTOTAL					**$18,463,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$4,616,000
	CONSTRUCTION COST SUBTOTAL					**$23,079,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$4,616,000
	PROJECT COST					**$27,695,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/25/2018
ALT. # :	M3	**PREPARED BY :**	RA
ALT. :	Mainstream Treatment with Integrated Fixed Film/Activaged Sludge (IFAS) Process	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Aeration Tank Modifications**					
	Demolish Existing Aeration Tank Aeration Air Diffusers	1	LS	$20,000	$20,000	
	Add Two (2) Full-Height Longitudinal Concrete Baffles Per Tank	1	LS	$182,000	$182,000	
	Add Two (2) Submerged Perpendicular Concrete Baffles Per Tank	1	LS	$66,920	$66,920	
	Add One (1) Full-Height Perpendicular Concrete Baffle Per Tank with Media Retention Screen	1	LS	$40,145	$40,145	
	Add Submerged Mechanical Mixers Per Tank	8	EA	$35,000	$280,000	
	Add Fine-Bubble Diffusers, Full-Floor Coverage	1	LS	$190,000	$190,000	
	Total					$779,000
2	**IFAS Process**					
	IFAS Equipment Package (Plastic Media, Media Retention Screens)	1	LS	$2,692,800	$2,692,800	
	Total					$2,693,000
3	**Denitrification Filters**					
	Add 8.25 MGD Denitrification Granular Media Filters	1	LS	$6,246,000	$6,246,000	
	Concrete piles	1	LS	$238,897	$238,897	
	Add Denitrification Filter Feed Pumps	1	LS	$200,000	$200,000	
	Add Methanol Storage and Feed System	1	LS	$400,000	$400,000	
	Total					$7,085,000
	SUBTOTAL					**$10,557,000**
4	**Allowances**					
	Process Mechanical Allowance	5	%		$528,000	
	Yard Piping & Site Civil Allowance	5	%		$528,000	
	EIC Allowance	20	%		$2,111,000	
	Coating/Painting Allowance	5	%		$528,000	
	Total					$3,695,000
	SUBTOTAL					**$14,252,000**
	Estimating Contingency	30	%			$4,276,000

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/25/2018
ALT. # :	M3	**PREPARED BY :**	RA
ALT. :	Mainstream Treatment with Integrated Fixed Film/Activaged Sludge (IFAS) Process	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	SUBTOTAL					**$18,528,000**
	Sales Tax on 50% of Subtotal Above	9.00	%			$834,000
	SUBTOTAL					**$19,362,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$4,841,000
	CONSTRUCTION COST SUBTOTAL					**$24,203,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$4,841,000
	PROJECT COST					**$29,044,000**

APPENDIX C – PARALLEL MAINSTREAM ALTERNATIVE COSTS

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	LOCATION FACTOR :	1.24
JOB # :	10405A.00	SF ENR OCTOBER 2017:	12015
LOCATION :	San Rafael, CA	ESTIMATE PREPARATION DATE :	6/25/2018
ALT. # :	P1	PREPARED BY :	RA
ALT. :	Parallel Treatment with Membrane Bioreactor (MBR) Process	REVIEWED BY :	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**MBR Process**					
	Add 18" PE Pipe with Flow Meter and Flow Control Valve from Existing 48" PE Pipe (in tunnel) to New MBR Aeration Tanks	1	LS	$62,500	$62,500	
	Add Four (4) 80'x20'x15' SWD Aeration Tanks with Two (2) Submerged Transverse Concrete Baffles	1	LS	$864,054	$864,054	
	Add Submerged Mechanical Mixers per Aeration Tank	8	EA	$35,000	$280,000	
	Add Fine-Bubble Diffusers, 80% of Tank Area	1	LS	$146,000	$146,000	
	Add 8,100 SCFM Variable Output Aeration Air Blowers	3	EA	$40,000	$120,000	
	MBR Equipment Package (Membrane Modules/Cassettes, Membrane Tank Blowers, Permeate Pumps)	1	LS	$4,455,000	$4,455,000	
	Add Four (4) 50'x9'x10' SWD Membrane Tanks	1	LS	$365,082	$365,082	
	Add One (1) 30'x20'x15' SWD Deoxygenation Tank	1	LS	$115,275	$115,275	
	Concrete Piles	1	LS	$929,623	$929,623	
	Add 6.75 MGD Variable-Speed Return Sludge Pumps, Low-Head	3	EA	$50,000	$150,000	
	Add Variable-Speed Waste Sludge Pumps	2	EA	$50,000	$100,000	
	Add 18" SE Pipe from MBR Permeate Pumps to Chlorine Contact Tank Inlet Structure	1	LS	$42,000	$42,000	
	Add 6" WAS Pipe from MBR Waste Sludge Pumps to Existing 6" WAS Pipe (in RAS/WAS Pump Station)	1	LS	$42,000	$42,000	
	Total					$7,672,000
	SUBTOTAL					**$7,672,000**
2	**Allowances**					
	Process Mechanical Allowance	5	%		$384,000	
	Yard Piping & Site Civil Allowance	5	%		$384,000	
	EIC Allowance	20	%		$1,534,000	
	Coating/Painting Allowance	5	%		$384,000	
	Total					$2,686,000
	SUBTOTAL					**$10,358,000**
	Estimating Contingency	30	%			$3,107,000
	SUBTOTAL					**$13,465,000**
	Sales Tax on 50% of Subtotal Above	9.00	%			$606,000

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/25/2018
ALT. # :	P1	**PREPARED BY :**	RA
ALT. :	Parallel Treatment with Membrane Bioreactor (MBR) Process	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	SUBTOTAL					**$14,071,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$3,518,000
	CONSTRUCTION COST SUBTOTAL					**$17,589,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$3,518,000
	PROJECT COST					**$21,107,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	4 - NUTRIENT REMOVAL	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR OCTOBER 2017:**	12015
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	6/25/2018
ALT. # :	P2	**PREPARED BY :**	RA
ALT. :	Parallel Treatment with Aerobic Granular Sludge (AGS) Process	**REVIEWED BY :**	RC

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**AGS Process**					
	Add 18" PE Pipe with flow meter from Existing 48" PE Pipe (in tunnel) to New AGS Reactors	1	LS	$62,500	$62,500	
	Add 110' Diameter x 26' High Pre-Stressed Concrete Tank	2	EA	$1,750,000	$3,500,000	
	Concrete Piles	1	LS	$3,933,039	$3,933,039	
	AGS Equipment Package (Feed Pumps, Inlet Nozzles, Diffusers, Mechanical Mixers, Blowers)	1	EA	$6,670,320	$6,670,320	
	Add 18" SE Pipe from AGS Tanks to Chlorine Contact Tank Inlet Structure	1	LS	$52,500	$52,500	
	Add 6" WAS Pipe from AGS Waste Sludge Pumps to Existing 6" WAS Pipe (in RAS/WAS Pumping Station)	1	LS	$52,500	$52,500	
	Total					$14,271,000
	SUBTOTAL					**$14,271,000**
2	**Allowances**					
	Process Mechanical Allowance	5	%		$714,000	
	Yard Piping & Site Civil Allowance	5	%		$714,000	
	EIC Allowance	20	%		$2,854,000	
	Coating/Painting Allowance	5	%		$714,000	
	Total					$4,996,000
	SUBTOTAL					**$19,267,000**
	Estimating Contingency	30	%			$5,780,000
	SUBTOTAL					**$25,047,000**
	Sales Tax on 50% of Subtotal Above	9.00	%			$1,127,000
	SUBTOTAL					**$26,174,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$6,544,000
	CONSTRUCTION COST SUBTOTAL					**$32,718,000**
	Engineering, Const. Mgmt., Eng. Support During Const.	20	%			$6,544,000
	PROJECT COST					**$39,262,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM NO. 5
BIOSOLIDS MANAGEMENT ALTERNATIVES

FINAL
October 2018

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM
NO. 5
BIOSOLIDS MANAGEMENT ALTERNATIVES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DISCLOSURE STATEMENT

Funding for this document has been provided in full or in part through an agreement with the State Water Resources Control Board. California's Clean Water State Revolving Fund is capitalized through a variety of funding sources, including grants from the United States Environmental Protection Agency and state bond proceeds. The contents of this document do not necessarily reflect the views and policies of the foregoing, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

BIOSOLIDS MANAGEMENT ALTERNATIVES

1.0 INTRODUCTION

This technical memorandum (TM) summarizes the new regulatory requirements for organic diversion from landfills and discusses how these requirements impact Central Marin Sanitation Agency's (Agency) current biosolids management strategy. This TM also evaluates alternative biosolids end use strategies for the Agency's Wastewater Treatment Plant (WWTP).

2.0 SUMMARY OF KEY FINDINGS

The key findings are:

- Recently enacted regulations (including Senate Bill 1383, Assembly Bill 1594, and Assembly Bill 341) will make it harder for the Agency to continue sending biosolids to landfill for use as alternative daily cover. This places price and capacity pressures on existing biosolids markets, such as compost and land application, increasing competition among utilities for available biosolids outlets.

- Given current contracts, current biosolid management practices, potential future fats, oils, and grease (FOG) and food waste (FW) increases, and regulations, another biosolids end use will likely be needed for the Agency as soon as the winter of 2019.

- It is recommended that the Agency continue summer land applications, as available, and pursue winter biosolids end use options with Synagro in the near term (3 to 5 years). As the cost of land application increases to over $60 per wet ton, consider increasing the portion of biosolids sent to compost. As the cost of composting and land application increase to over $65 to $70 per wet ton, consider a future regional Bay Area Biosolids (BAB) Coalition facility.

3.0 BACKGROUND

3.1 Existing Biosolids Hauling and End Use Permits

3.1.1 <u>Hauling Permits</u>

The Agency has a biosolids hauling contract with Total Waste Systems, Inc. to transport biosolids to the Redwood Landfill in Novato, Synagro's Sonoma County land applications site, Synagro's Solano County land application site, and Synagro's Merced County Central Valley Compost (CVC) facility. The Agency also has an amendment to this contract for sending biosolids to the Lystek facility in Fairfield. This agreement was made in June 2015 and expired in June 2017 with one administrative extension available. The hauling rates are adjusted every 6 months. Hauling rates from the second half of 2017 CY are shown in Table 5.1. The full agreement and amendment can be found in Appendix A.

Table 5.1 Biosolids Hauling Fees
2017 Facilities Master Plan
Central Marin Sanitation Agency

End Use Location	Hauling Fee ($/ton)	Approximate Distance (miles)
Redwood Landfill (Novato, CA)	$7.89(1)	27
Synagro's Sonoma County Land Application Site (Sonoma County, CA)	$10.92(2)	18
Synagro's Solano County Land Application Site (Solano County, CA)	$24.41(1)	51
Synagro's Merced County CVC Facility (Dos Palos, CA)	$24.41(1)	148
Lystek (Fairfield, CA)	$22.34(1)	41

Notes:
(1) Hauling fee is adjusted every 6 months. Hauling fee from the second half of 2017 CY is shown.
(2) Hauling fee from the second half of 2017 CY was not available so the hauling fee from the second half of 2016 CY is shown.

3.1.2 End Use Permits

The Agency has three end use agreements: 1) Redwood Landfill, 2) Synagro, and 3) Lystek. Each agreement is described in further detail below and summarized in Table 5.2. The full agreements can be found in Appendix A.

The Agency has contracted with Redwood Landfill to send at least 2,500 wet tons per year (TPY) but no more than 7,500 wet TPY (maximum of 40 wet tons per day (TPD)) to Redwood Landfill. Redwood Landfill uses the Agency's biosolids as both alternative daily cover (ADC) and as co-compost. No seasonal restrictions are in place with this agreement. This agreement became effective in June 2009 and continued through June 30th, 2014. At that time this contract has been extended in one year increments. One year extensions of this contract can continue as long as both parties agree.

The Agency has also contracted with Synagro to land apply their biosolids in both Sonoma County and Solano County and compost one truckload per year at their CVC facility. The Agency agrees to send at least 80 percent by volume of the biosolids generated between April 16th and October 31st to Synagro's land application sites each year as long as these sites have capacity available. This agreement became effective in January 2015 and will continue through December 2019. After that time, if both parties agree, the contract can be extended. However, the Sonoma County site recently stopped allowing biosolids land application and Synagro does not foresee biosolids land application in Sonoma County in the near future.

Additionally, the Agency has contracted with Lystek to send between 1 and 6 truckloads per week to the Lystek facility in Fairfield. This facility produces a state certified biofertilizer and has a capacity to process 150,000 wet tons of biosolids per year. No seasonal restrictions are in place with this agreement. This agreement became effective in September 2016 and will continue through December 2020. No provisions for contract extension are discussed. Currently, the Agency and Lystek are in mutual agreement that the Agency will deliver biosolids twice weekly, usually on Tuesday and Wednesday.

Table 5.2 Biosolids End Use Fees
2017 Facilities Master Plan
Central Marin Sanitation Agency

End Use Location	End Use Fee ($/ton)	Restrictions	Agreement Term
Redwood Landfill (Novato, CA)	$37.88	Agency must provide between 2,500 wet TPY and 7,500 wet TPY or 40 wet TPD.	Jun. 2009 - Jun. 2014 + 1 year extensions
Synagro's Sonoma County Land Application Site (Sonoma County, CA)	$28.00	Agency must provide at least 80% of biosolids generated between April 16 and October 31 to these sites as long as capacity is available.	Jan. 2015 - Dec. 2019 + extensions
Synagro's Solano County Land Application Site (Solano County, CA)	$16.50		
Synagro's Merced County CVC Facility (Dos Palos, CA)	$0.00	1 truckload per year(1)	
Lystek (Fairfield, CA)	$70.37	1 to 6 truckloads per week(1)	Sept. 2016 - Dec. 2020

Note:
(1) A truckload is defined as 17.5 wet tons.

Combined, the cost of biosolids removal for the Agency costs from $24.41 to $92.71 per wet ton. The combined cost for each end use site is shown in Table 5.3.

Table 5.3 Biosolids Removal Total Costs
2017 Facilities Master Plan
Central Marin Sanitation Agency

End Use Location	Hauling Fee ($/ton)	End Use Fee ($/ton)	Total Cost ($/ton)
Redwood Landfill (Novato, CA)	$7.89[(1)]	$37.88	$45.77
Synagro's Sonoma County Land Application Site (Sonoma County, CA)	$10.92[(2)]	$28.00	$38.92
Synagro's Solano County Land Application Site (Solano County, CA)	$24.41[(1)]	$16.50	$40.91
Synagro's Merced County CVC Facility (Dos Palos, CA)	$24.41[(1)]	$0.00	$24.41
Lystek (Fairfield, CA)	$22.34[(1)]	$70.37	$92.71

Notes:

(1) Hauling fee is adjusted every 6 months. Hauling fee from the second half of 2017 CY is shown.
(2) Hauling fee from the second half of 2017 CY was not available so the hauling fee from the second half of 2016 CY is shown.

3.2 Historical Biosolids End Use

From FY14/15 to FY16/17, the Agency has produced on average 6,300 wet TPY of biosolids. These biosolids average around 26 percent solids. Historically, the agency has sent a third of these biosolids to land application sites and roughly two thirds of these biosolids to landfill. A breakdown of historical biosolids end use is shown in Table 5.4.

As land application is restricted in the winter months, biosolids end use varies greatly by month. Table 5.5 shows what percentage of the biosolids produced each month are sent to land application, compost, landfill, and Lystek from October 2016 to October 2017 when the Agency was delivering 2 loads per week to Lystek. As shown in the table, the Agency sends their biosolids to landfill during the winter and to land application in the summer. While this approach has been acceptable in the past, current and future regulations will make this approach less sustainable in the long term.

Table 5.4	Historical Biosolids End Use 2017 Facilities Master Plan Central Marin Sanitation Agency				
Fiscal Year	**Biosolids Land Application (TPY)**	**Biosolids Compost (TPY)**	**Biosolids Landfill (TPY)**	**Biosolids Lystek (TPY)**	**Total Biosolids (TPY)**
FY14/15	2,124	0	3,850	0	5,974
FY15/16	2,573	18	3,706	0	6,296
FY16/17	1,663	13	3,676	1,306	6,657

Table 5.5	Historical Monthly Percentages 2017 Facilities Master Plan Central Marin Sanitation Agency				
Month	**% Yearly Biosolids Produced Each Month(1)**	**% Monthly Biosolids Sent to Land Application(1)**	**% Monthly Biosolids Sent to Compost(1)**	**% Monthly Biosolids Sent to Landfill(1)**	**% Monthly Biosolids Sent to Lystek(1)**
Oct. 2016	8%	26%	2%	59%	12%
Nov. 2016	9%	0%	0%	71%	29%
Dec. 2016	10%	0%	0%	80%	20%
Jan. 2017	10%	0%	0%	75%	25%
Feb. 2017	8%	0%	0%	73%	27%
Mar. 2017	10%	0%	0%	75%	25%
Apr. 2017	8%	0%	0%	72%	28%
May 2017	8%	31%	0%	34%	35%
Jun. 2017	8%	46%	0%	25%	29%
Jul. 2017	7%	46%	0%	25%	30%
Aug. 2017	8%	45%	0%	19%	36%
Sept. 2017	7%	44%	0%	26%	30%

Note:

(1) As the Agency started sending biosolids to Lystek in October 2016, percentages from October 2016 through September 2017 were used for planning purposes.

4.0 REGULATIONS

Solids generated at a wastewater treatment facility typically comprise of screenings, grit, primary or raw sludge (PS), and secondary or waste activated sludge (WAS). The screenings and grit are typically dewatered and disposed in a landfill. The PS and WAS are described as sewage sludge or wastewater solids prior to stabilization.

Sludge generated by a wastewater treatment facility is defined as biosolids once beneficial use criteria, as determined by compliance with the EPA's Title 40 Code 503 regulations, have been achieved through stabilization processes. Stabilization processes are described as those that help reduce pathogens and reduce vector attraction. Biosolids are defined as treated organic solid residuals resulting from the treatment of municipal sewage at a wastewater treatment facility. Biosolids are a product with a high carbon content and other beneficial use properties.

Several federal, state, and local regulations are in place that influence whether biosolids from municipal WWTPs can be beneficially used or disposed. Increased concern and debate over biosolids use/disposal and its associated environmental impacts have led to more stringent amendments to regulations. Changes in regulations affecting biosolids management are expected and make a flexible management program essential.

4.1 Federal Regulations

Federal, state, and local agencies are responsible for regulating beneficial use/disposal of biosolids. The authority of each agency varies based on the beneficial use/disposal methods employed. However, key guidelines are established by the EPA. These guidelines are in turn implemented by state and local governments. Many state and local agencies in California have developed additional rules, guidelines, and criteria for biosolids management.

4.1.1 40 CFR 503 Regulations

In order to implement the long-term biosolids permitting program required by the Water Quality Act of 1987, the EPA initiated two rule makings. The first rule-making established requirements and procedures for including biosolids management in NPDES permits, procedures for granting state biosolids management programs primacy over federal programs, and federal programs to implement biosolids permits if a state so chooses.

The second rule-making to regulate and control biosolids permitting was 40 CFR Part 503 Standards for the Use and Disposal of Sewage Sludge ("40 CFR 503"). This rule addresses three general categories of beneficial use/disposal of biosolids including:

- Land application of sewage sludge for beneficial use of organic content.
- Surface disposal of biosolids in a monofill, surface impoundment, or other dedicated site.
- Incineration of sewage sludge with or without auxiliary fuel.

Biosolids are classified by the EPA's 40 CFR 503 regulations as Class B or Class A, according to the level of pathogen reduction. Biosolids must also meet vector attraction and metal concentration limits. All biosolids must meet the Ceiling Concentration Limits for pollutants. Land applied biosolids must also meet either the pollutant concentration limits, cumulative pollutant loading rate limits, or annual pollutant loading rate limits. Table 5.6 summarizes these limits required by 40 CFR 503 for land applied biosolids. Pathogen reduction requirements of 40 CFR 503 for land applied biosolids are summarized in Table 5.7.

Table 5.6 Pollutant Limits for Land Applied Biosolids
2017 Facilities Master Plan
Central Marin Sanitation Agency

Pollutant	EPA CCL, mg/kg dry weight basis	EPA PCL for EQ Biosolids, mg/kg dry weight basis	EPA CPLR Limits for Biosolids, kg per hectare	EPA APLR Limits for Biosolids, kg per hectare
Arsenic	75	41	41	2.0
Cadmium	85	39	39	1.9
Chromium	3,000	1,200	3,000	150
Copper	4,300	1,500	1,500	75
Lead	840	300	300	15
Mercury	57	17	17	0.85
Molybdenum	75	-	-	-
Nickel	420	420	420	21
Selenium	100	36	36	5
Zinc	7,500	2,800	2,800	140
Applies to:	All biosolids that are land applied	Bulk biosolids and bagged biosolids	Bulk biosolids	Bagged biosolids

Abbreviations:
CCL: Ceiling Concentration Limit
EQ: Exceptional Quality
PCL: Pollutant Concentration Limit
CPLR: Cumulative Pollutant Loading Rate
APLR: Annual Pollutant Loading Rate

As shown in the table, biosolids can be land applied in bulk or distributed in bags. Land application through bag distribution generally refers to biosolids that are marketed for use on smaller units of land, such as lawns or home gardens. In this case, tracking the amount of pollutants applied in biosolids is not feasible, thus lower annual pollutant loading rate limits are used instead of cumulative pollutant loading rate limits.

Table 5.7	40 CFR 503 Biosolids Regulations – Pathogen Reduction Requirements 2017 Facilities Master Plan Central Marin Sanitation Agency
Class A	**Class B**
• Either fecal coliform density is less than 1,000 MPN/gram of total dry solids, or the density of Salmonella species bacteria in the sludge is less than 3 MPN/4 grams of total dry solids. • Biosolids must be treated and/or meet one of the following alternatives before disposal. For more details on each treatment alternative, refer to 40 CFR 503.32(a): - Thermally treated. - High pH-high temperature treatment. - Treatment to reduce enteric virus to less than 1 PFU/4 grams of total dry solids) and viable helminth to less than 1/4 grams of total dry solids). - Treatment by composting, heat drying, heat treatment, thermophilic aerobic digestion, beta ray irradiation, gamma ray irradiation, or pasteurization process. Specific operating conditions for each process has been specified in 40 CFR 503.32(a). - Use of processes equivalent to the above (subject to authority approval).	• Comply with site restrictions of land application of Class B biosolids as specified in 40 CFR 503.32(b)(2), (b)(3), or (b)(4). In summary, these restrictions include harvesting of certain food crops, grazing of animals, turf harvesting, and public access to lands where Class B biosolids were applied. • Biosolids must be treated and/or meet one of the following alternatives before disposal. For more details on each treatment alternative, refer to 40 CFR 503.32(b): - Geometric mean of seven samples of treated biosolids collected at the time of disposal shall meet a fecal coliform density of 2 million CFU or MPN/gram of total dry solids. - Processes that significantly reduce pathogens which include aerobic digestion, air drying, anaerobic digestion, composting, or lime stabilization. Specific operating conditions for each process has been specified in 40 CFR 503.32(b). - Use of processes equivalent to the above (subject to authority approval).

Abbreviations:
CFU: Colony Forming Unit
PFU: Plaque Forming Unit
MPN: Most Probable Number
CFR: Code of Federal Regulations

In addition to reducing pollutant and pathogen levels, 40 CFR 503 requirements mandate that biosolids undergo treatment to reduce the risk of vectors such as flies, mosquitoes, fleas, rodents, and birds that are attracted to the biosolids. In order to prevent the spread of disease-laden pathogens, biosolids must be treated to reduce their attractiveness to these types of vectors. Alternatively, drying the biosolids to reduce the moisture content to 10 percent or lower also meets the requirement. Vector attraction reduction requirements are summarized in Table 5.8.

Table 5.8 40 CFR 503 Biosolids Regulations – Vector Attraction Reduction Requirements
2017 Facilities Master Plan
Central Marin Sanitation Agency

Alternative Number in 40 CFR 503.33(b)	Description
1	Mass of volatile solids shall be reduced by a minimum of 38 percent during biosolids treatment. [(1)]
2	If the above requirement cannot be met, vector attraction reduction can be demonstrated by reducing volatile solids by a minimum of 17 percent by digesting a portion of previously digested biosolids anaerobically in the laboratory in a bench-scale unit for 40 additional days at a temperature between 30 and 37 degrees C (86 and 98.6 degrees F).
3	If the above requirement cannot be met, vector attraction reduction can be demonstrated by reducing volatile solids by a minimum of 15 percent by digesting a portion of previously digested biosolids aerobically in the laboratory in a bench-scale unit for 30 additional days at a temperature of 20 degrees C (68 degrees F).
4	Specific oxygen uptake rate for biosolids treated in an aerobic process is less than or equal to 1.5 mg of oxygen per hour per gram of total dry solids at a temperature of 20 degrees C (68 degrees F).
5	Biosolids shall be treated in an aerobic process for 14 days or longer. During that time the temperature of biosolids shall be higher than 40 degrees C (104 degrees F), with an average of 45 degrees C (113 degrees F) or higher.
6	The pH of biosolids shall be raised to 12 or higher by alkali addition and, without the addition of more alkali, shall remain at 12 or higher for 2 hours, and then at 11.5 or higher for an additional 22 hours at 25 degrees C (77 degrees F).
7	The percent solids of material that does not contain unstabilized solids shall be equal to or greater than 75 percent based on moisture content and total solids prior to mixing with other materials.
8	The percent solids of material that contains unstabilized solids shall be equal to or greater than 90 percent based on moisture content and total solids prior to mixing with other materials.
9	Sewage sludge shall be injected below the surface of the land. No significant amount of the sewage sludge shall be present on the land surface within one hour after the sewage sludge is injected. When the sewage sludge that is injected below the surface of the land is Class A with respect to pathogens, the sewage sludge shall be injected below the land surface within eight hours after being discharged from the pathogen reduction process.
10	Sewage sludge applied to the land surface or placed on a surface disposal site shall be incorporated into the soil within six hours after application to or placement on the land. When sewage sludge that is incorporated into the soil is Class A with respect to pathogens, the sewage sludge shall be applied to or placed on the land within eight hours after being discharged from the pathogen treatment process.

Note:
(1) Applicable for the Agency.

4.1.1.1 Class B Biosolids

Class B biosolids can be produced through any of the defined Processes to Significantly Reduce Pathogens (PSRP). The quantity and quality of the processed sludge and biosolids produced must be monitored and recorded by each biosolids producer. Quality parameters include pathogen reduction, vector attraction reduction, and inorganic content (e.g., heavy metals). The PSRPs include mesophilic anaerobic digestion and static aerated pile composting. To meet Class B standards, the mesophilic anaerobic digestion process must be operated between 15 days at 35 to 55 degrees Celsius (95 to 131 degrees F) and 60 days at 20 degrees Celsius (68 degrees F). Composting operations are required to raise the temperature of biosolids to 40 degrees Celsius (104 degrees F) or higher for five days. The temperature in the compost pile must also exceed 55 degrees Celsius (131 degrees F) for four hours during the five-day period.

Land appliers must follow application restrictions and pollutant load restrictions for Class B biosolids at the time of application with regard to public contact, animal forage, and production of crops for human consumption. For example, Class B biosolids may only be applied at sites where there is no possibility of contact with the general public. These sites include certain types of agriculture, landfills, etc. Additional restrictions associated with Class B prevent crop harvesting, animal grazing, and public access for a defined period of time until environmental conditions have further reduced pathogens.

4.1.1.2 Class A Biosolids

Class A biosolids can be produced through any of the defined Processes to Further Reduce Pathogens (PFRP). Class A biosolids have more stringent treatment requirements than Class B biosolids for pathogen reduction and may be land applied where contact with the general public is possible (i.e., nurseries, gardens, golf courses, etc.).

The PFRPs include thermophilic anaerobic digestion, static aerated pile composting, heat drying, and pasteurization. To meet Class A standards, the thermophilic anaerobic digestion process must be operated at 50 degrees Celsius (122 degrees F) or higher for 30 minutes or longer. Composting operations are required to operate at 55 degrees Celsius (131 degrees F) or higher for three consecutive days. Heat drying must reduce the moisture content of the biosolids to 10 percent or lower. Pasteurization processes must maintain the temperature of the biosolids at 70 degrees Celsius (158 degrees F) for 30 minutes or longer.

4.1.1.3 Exceptional Quality Biosolids

Biosolids that meet the high quality pollutant concentrations limits of Table 5.6, one of the Class A pathogen reduction requirements of Table 5.7 and one of options 1 through 8 of the vector attraction reduction alternatives in Table 5.8, may be identified as exceptional quality (EQ) biosolids. EQ biosolids may be used and distributed in bulk or bag form and are not subject to general requirements and management practices other than monitoring, recordkeeping, and reporting to substantiate that the quality criteria have been met.

4.1.2 40 CFR 258 Regulations

In addition to the regulations set forth to govern biosolids permitting, 40 CFR 258 Solid Waste Disposal Facility Criteria was promulgated October 1991 to control the disposal of biosolids classified as solid wastes. Wastewater sludge is exempt from the definition of solid waste unless the sludge is co-disposed with household solid wastes. The regulations set forth criteria for landfills with respect to: location, design, operation, groundwater monitoring, and closure with the intent of protection of ground and surface water from contamination. The main requirement of co-disposed sludge is that it must meet the Paint Filter Liquids Test (EPA Method 9095A). This method determines the presence of free liquids in a sample. Well-dewatered sludge, such as in the case of WWTP's sludge, typically passes this test as it does not contain any free liquid.

4.2 State Regulations

State biosolids beneficial use/disposal is primarily regulated by California's State Water Resources Control Board (SWRCB), the Division of Drinking Water (DDW), and the nine Regional Water Boards. The Agency is regulated under the San Francisco Regional Water Board. As required under the Porter-Cologne Act, the SWRCB, along with its nine Regional Water Boards, is principally concerned with protecting existing and future beneficial uses of water.

The California Department of Resources Recycling and Recovery (CalRecycle) oversees and regulates California's solid waste disposal including co-disposal issues and biosolids use as a daily covering material. The main regulation dealing with land discharge of biosolids (and incineration ash) is the California Code of Regulations (CCR) Title 23, Division 3, Chapter 15. Other regulations and guidelines include Title 22, Division 4.5, Chapter 11; California Water Environment Association's (CWEA) Manual of Good Practice for Agricultural Land Application of Biosolids; and CEQA.

The SWRCB's General Waste Discharge Requirements (GWDRs) for the Discharge of Biosolids to Land for use as a Soil Amendment in Agriculture, Silviculture, Horticulture, and Land Reclamation Activities covers the discharge of sewage sludge as a soil amendment. In order for such a discharge to be allowed, the sludge must have been treated, tested, and shown to be capable of being used beneficially and legally as a soil amendment as specified under 40 CFR 503. This order is intended to help streamline the regulatory process for such discharges, but may not be appropriate for all sites using biosolids due to particular site-specific conditions or locations. Such sites are not precluded from being issued individual Waste Discharge Requirements (WDRs).

4.3 Local Agency Regulations

Many counties in California have developed, or are developing, ordinances for biosolids land application. The stringency of these county regulations ranges from requirements for relatively high minimum insurance to the banning of biosolids land application. Land application restrictions for biosolids are shown by county in Figure 5.1. Four counties ban all land application and an additional six counties ban Class B land application. Of the remaining counties, twenty seven require a conditional use permit from various offices, such as the Board of Supervisors, County Health Officer, Director of Health, etc. Additionally, some of these counties limit biosolids application to only biosolids produced in their county or place limits on where biosolids can be spread (e.g., 100 feet from surface waters, etc.) and require a corporate surety bond. Only five counties specifically allow Class B biosolids land application: Sonoma, Solano, Sacramento, Glen, and Sierra Counties.

For the Agency, several local agencies have regulatory input concerning sludge management. These agencies are:

- Association of Bay Area Governments (ABAG). ABAG is a nine-county agency that acts as the metropolitan clearinghouse for review of projects receiving federal assistance. ABAG's major role in any proposed project would be to ensure that land use is consistent with regional long-range goals and policies.
- Bay Area Air Quality Management District (BAAQMD). BAAQMD enforces local, state, and federal air quality standards and issues and enforces pollution control facility permits. The BAAQMD also monitors local air quality, which includes any nuisance odor conditions.

4.4 Future Regulatory Considerations

In effort to achieve post-2020 greenhouse gas (GHG) emissions reduction targets, Governor Brown introduced five key goals or "pillars" in 2015 under which various programs and regulations will be developed. These pillars are:

1. Reducing today's petroleum use in cars and trucks by 50 percent.
2. Increasing our electricity derived from renewable sources from 33 to 50 percent.
3. Doubling the energy efficiency of existing buildings and making heating fuels cleaner.
4. Reducing the release of methane, black carbon, and other short-lived climate pollutants.
5. Managing farm, rangelands, forests, and wetlands so they can store carbon (i.e., carbon sequestration).

County Ordinance Requirements and Biosolids Bans

LEGEND
Ban on All Land Application
Ban on Class B
Conditional Use Permit Required
Class B Land Application Allowed
No Regulations/Ordinances Enacted

This map was produced by CASA and is based on a search of online available Codes and may have missed County other requirements such as non-codified requirements or requirements of city or regional agencies. This map presents findings for individual county requirements and deals only with the unincorporated areas of the counties, all area in California are subject to California and Federal biosolids regulations.

BIOSOLIDS LAND APPLICATION IN CALIFORNIA AS OF 2016

FIGURE 5.1

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

carollo

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To enact these pillars, the Governor has recently signed legislation that either directly or indirectly impacts the disposal and/or use of WWTP biosolids at landfills, as well as the diversion of other organic waste streams to WWTPs. The good news is the regulatory agencies involved (i.e., ARB, CalRecycle, and SWRCB) consider WWTPs as part of the solution for diverting other organic waste streams from landfills (such as, FW and FOG), in effort to reduce methane production/emissions at landfills. However, legislation does not address how to handle the resulting biosolids/organic material and in fact requires diversion of biosolids from landfills by 2025. Table 5.9 summarizes this legislation. Termination of landfill ADC would place capacity and price pressure on existing biosolids markets, such as compost and land application, increasing competition among utilities for available biosolids outlets.

5.0 BIOSOLIDS PROJECTIONS

In order to develop appropriate biosolids management options given the regulatory constraints outlined above, biosolids produced at the Agency's WWTP were projected through the 2031/32 FY planning horizon. The following key assumptions were made in projecting Agency biosolids:

- It was assumed that the amount of primary sludge (PS) and thickened waste activated sludge (TWAS) contributions would remain at FY 16/17 levels and stay constant over the planning horizon.
- It was assumed that deliveries of FOG and FW would be capable of increasing above FY 16/17 levels to a projected maximum level to achieve a digester volatile solids loading fraction of approximately 42 percent. This increase would maximize the use of the existing cogeneration capacity. While this was assumed for planning purposes, a detailed assessment of any future additional organic loading to the digester would need to be completed prior to any increase in loading above FY 16/17 levels.
- The potential increase in FOG and FW loading at the WWTP was assumed to occur in FY 19/20. Prior to FY 19/20, FOG and FW loading was assumed to be consistent with past loading rates. Starting in FY 19/20 FOG and FW would increase linearly over a 5 year period to reach the projected maximum level. FY 19/20 was chosen for planning purposes assuming the successful completion of full-scale testing to increase digester organic loading above FY 16/17 levels.
- The percent of yearly biosolids produced each month will remain consistent with historical data. The percentages used are shown in column 2 of Table 5.5 and are October 2016 through September 2017 data.

Table 5.9 Adopted Legislation Impacting WWTP Biosolids Management Operations and/or Use
2017 Facilities Master Plan
Central Marin Sanitation Agency

Legislative Bill	Impact to WWTPs	Direct Impact to Agency?	Status
AB 876 (2015)	Requires a county or regional agency to track and annually report the amount of organic waste in cubic yards it will generate over the next 15 years, the additional organic waste recycling facility capacity that will be needed to process that waste, and identify new or expanded organic waste recycling facilities (such as WWTP anaerobic digesters) capable of reliably meeting that additional need.	May be identified as a recycling facility for accepting additional organic waste.	First report due: August 2017
AB 1826 (2014)	As of April 1, 2016, requires a business (commercial or public entity) or residential dwelling of 5 or more units, generating a certain amount (starts at 8 CY and over time decreased to 2 CY) of organic waste per week to arrange for recycling services. Phased implementation with lower volumes triggering action over time. This bill requires reduction of organic waste production and creates market certainty for the diversion of organic waste from businesses and multifamily dwellings to a recycling service (e.g., anaerobic digesters at WWTPs).	May experience more entities that produce organic waste seeking to send their organic waste to the Agency.	Phased Implementation 2016 - 2020
SB 1383 (2016)	Requires the reduction of short-lived climate pollutants (including methane) to achieve *statewide* GHG reduction targets by 2030. Requires a regulation be developed and adopted by end of 2018, to accomplish 50 percent diversion of organics (including WWTP solids and biosolids) from landfills by 2020 relative to 2014 levels and 75 percent diversion by 2025. May require WWTPs to identify new options for biosolids management where land application is not an option.	Will likely need to divert biosolids from Redwood Landfill to achieve 2025 statewide target. The amount of diversion required is unknown at this time.	Final regulation: End of 2018 50% statewide diversion: 2020 75% statewide diversion: 2025
AB 1594 (2014)	Requires green waste no longer qualify for diversion credit when used as ADC at a landfill. Green waste that is mixed with biosolids for use as ADC currently receives diversion credit under AB 939, but will no longer be able to do so for the green waste portion. It is expected that landfills will not accept biosolids (if not mixed with green waste) for ADC since they need the combination to achieve a workable moisture content.	Redwood Landfill will no longer receive diversion credit for use of green waste as ADC. Redwood Landfill may restrict the amount of ADC consisting of green waste and biosolids it accepts.	Effective: 2020
AB 341 (2011)	Sets a goal that 75 percent of solid waste generated (including organics) be source reduced, recycled, or composted by the year 2020. Provides a platform for state agencies to consider WWTPs as part of the solution to achieve this goal.	The Agency may be required to divert a portion of their biosolids from landfills by 2020. The regulation developed under SB 1383 (by end of 2018) will define how much.	Deadline: 2020

Table 5.9 Adopted Legislation Impacting WWTP Biosolids Management Operations and/or Use
2017 Facilities Master Plan
Central Marin Sanitation Agency

Legislative Bill	Impact to WWTPs	Direct Impact to Agency?	Status
SB 970 (2016)	Requires CalRecycle, when awarding a grant for organics composting or anaerobic digestion, to consider the amount of GHG emissions reductions that may result from the project and the amount of organic material that is diverted from landfills as a result of the project. This bill allows for larger grant awards to be given to large-scale regional integrated projects that provide cost-effective organic waste diversion and maximize environmental benefits.	More funding may be available for regional projects that provide cost-effective organic waste diversion that maximize environmental benefits.	Determined Per Project
AB 901 (2015)	Changes disposal and recycling reporting to CalRecycle. Waste, recycling (including WWTPs), and compost facilities, as well as exporters, brokers, and transporters of recyclables or compost will be required to submit information directly to CalRecycle on the types, quantities, and destinations of materials that are disposed of, sold, or transferred inside or outside of the state. CalRecycle is given enforcement authority to collect this information.	The Agency will be required to report the types, quantities, and destinations of their biosolids to CalRecycle starting in Q1 of 2019. The regulation will outline how to comply with the reporting requirement. Outreach and training will occur mid to late 2018.	Regulation Adoption: Spring 2017 First Reports: Q1 2019
Healthy Soils Initiative (2015)	Collaboration of state agencies and departments, led by CDFA, to promote the development of healthy soils on California's farm and ranchlands (e.g., through land application of biosolids) building adequate soil organic matter that can increase carbon sequestration and reduce overall GHG emissions.	The Agency may see additional incentive for land application of biosolids through the Healthy Soils Initiative.	Developing Key Actions

With these assumptions, biosolids were projected and are shown in Figure 5.**2**.

While the amount of biosolids generated will increase over time and will increase with the planned additions of FOG and FW, the current biosolids end uses are limited by existing contracts and by the regulatory pressures described in the sections above. For this TM it was assumed that land application will continue at the current rate, which means biosolids sent to land application were capped at 473 wet tons per month, the maximum monthly tonnage sent to land application from FY 14/15 through FY 16/17. Furthermore, as long as this tonnage cap was not exceeded, the historical average percent of monthly biosolids produced sent to land application would remain constant in the future. The percentages used are shown in column 3 of Table 5.5 and are October 2016 through September 2017 data.

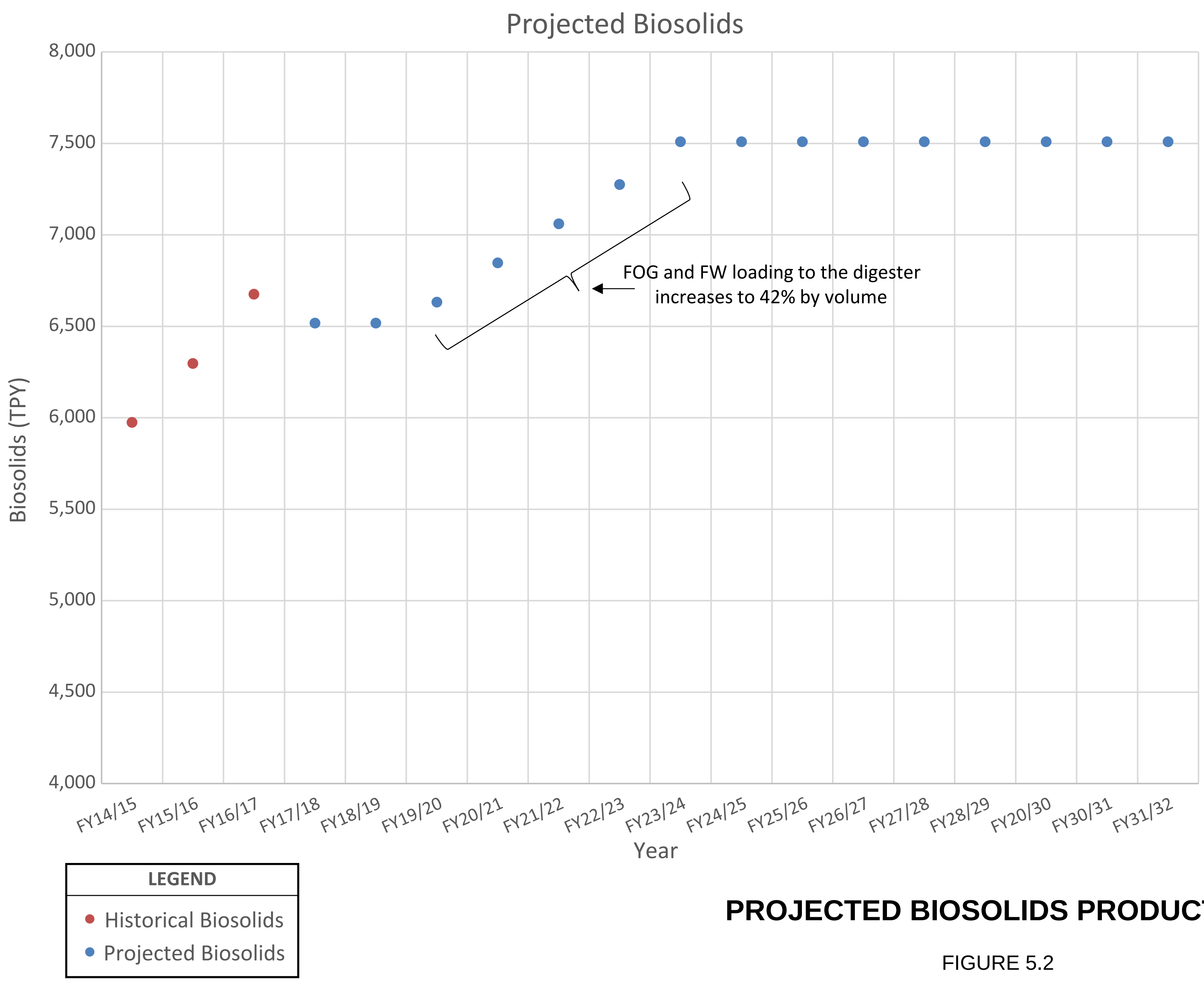
This TM also assumed that the amount of biosolids sent to landfills would linearly decrease from 100 percent of FY 14/15 levels in FY 17/18 to 50 percent of FY 14/15 levels in FY 20/21. From FY 20/21, the amount of biosolids sent to landfills would linearly decrease to 25 percent of FY 14/15 levels in FY 25/26. It was also assumed that the Agency would continue its current end use practice with Lystek, sending on average 155 wet tons per month, every month, to the Lystek facility. With these assumptions, and the biosolids projections in Figure 5.2, Figure 5.3 shows the end use distribution of biosolids generated through FY 31/32. The red portion of the biosolids generated represents the "remainder" of biosolids with no end use identified.

6.0 BIOSOLIDS END USE OPTIONS

This section presents biosolids end use options that address the increasing uncertainty surrounding the Agency's business-as-usual biosolids management practices to account for the projected biosolids "remainder" shown in Figure 5.4. Both Class A and Class B biosolids end use options are considered and described in further detail in the sections that follow.

6.1 Lystek International

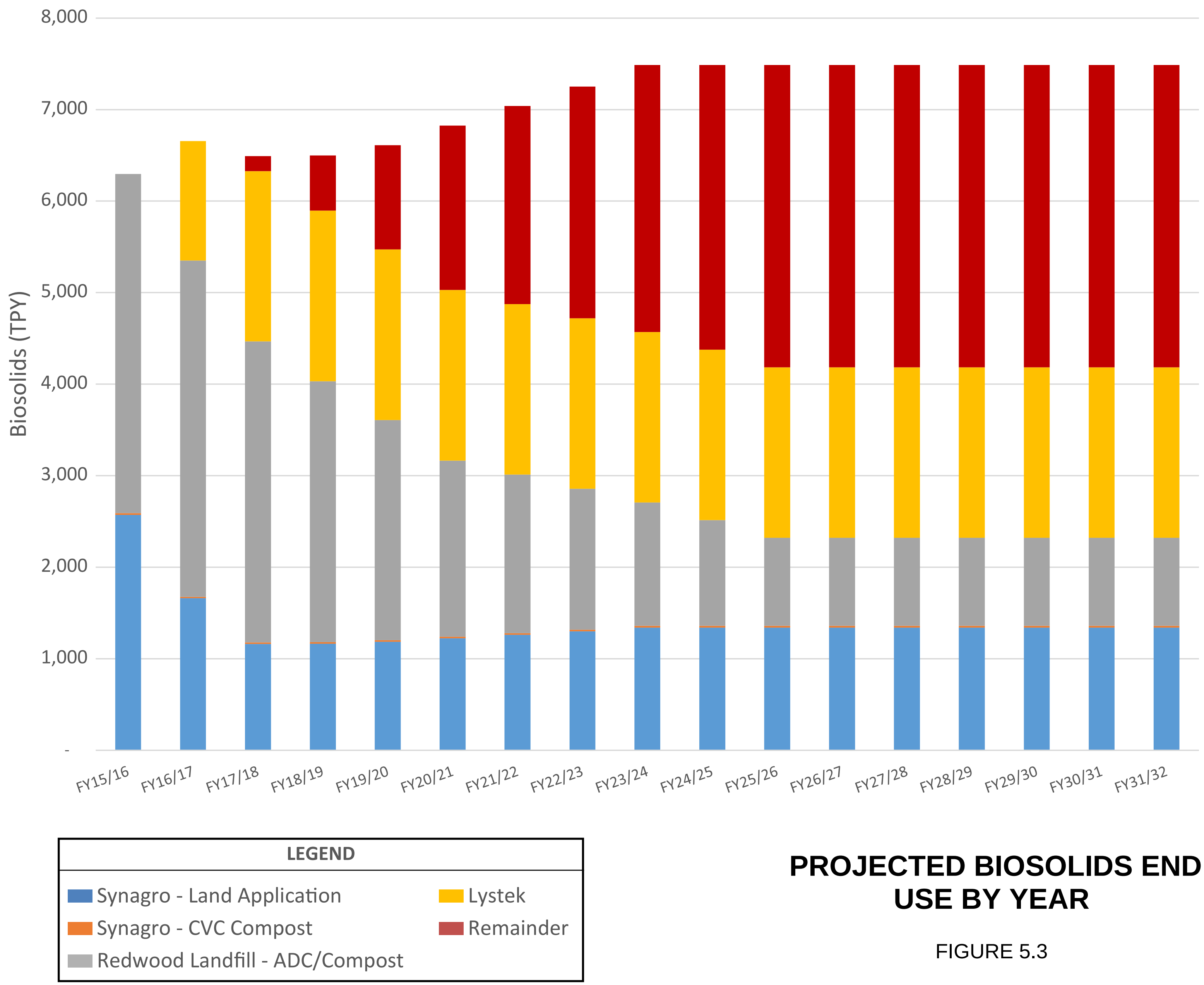
Lystek International (Lystek), in partnership with the Fairfield-Suisun Sewer District, has constructed a full-scale merchant project with a capacity to process 150,000 wet tons of biosolids per year. As of November 2017 the facility is processing around 40,000 wet TPY. The facility produces a state certified biofertilizer that can be used year-round. The facility began operation in August 2016.



PROJECTED BIOSOLIDS PRODUCTION

FIGURE 5.2

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN



PROJECTED BIOSOLIDS END USE BY YEAR

FIGURE 5.3

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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As described in the sections above, the Agency currently sends biosolids to Lystek twice weekly accounting for about 25 percent of the Agency's biosolids. The existing contract, which extends through December 2020, allows for up to 6 trucks per week, year-round. One option for the Agency is to increase the amount of biosolids sent to Lystek. Under the Agency's current contract, up to 5,460 wet TPY could be sent to Lystek. This accounts for 82 percent of the Agency's current biosolids and would account for 73 percent of the Agency's biosolids in FY 31/32. The Agency could also look at expanding their current contract to send more than 5,460 wet TPY to Lystek. The cost for biosolids end use at Lystek is currently $22.34 per wet ton for hauling and $70.37 per wet ton for tipping (combined fee of $92.71 per wet ton).

6.2 Synagro

Synagro is a nation-wide biosolids and residual management company that provides land application, composing, and other biosolids management services. Currently, Synagro has four land application sites around the Bay Area in Sonoma County, Solano County, Sacramento County, and Merced County. Synagro also operates the CVC facility located in Merced. The Solano land application site operates weekdays from April 16th through October 14th of each year. The Solano land application site also runs only in the summer. Solano County has an ordinance requiring biosolids generators to divert a portion of their biosolids to Class A facility. This is why the Agency sends one load of biosolids to Synagro's CVC Facility in Merced each year. It is expected that Synagro will continue to operate the biosolids land application site in Solano County in the next few years, and there are no anticipated changes or restrictions caused by the GHG bills, regulations, or Solano County ordinances. The owner at the Sonoma land application site recently stopped letting Synagro land apply biosolids at this location and Synagro does not foresee operating another land application site in Sonoma County in the future. The Sacramento land application site operates year-round, 7 days per week and has a 7 day storage facility onsite. The Merced land application site operates year-round but is subject to cropping patterns and weather. While the Merced site operates year-round, land application is only available when farmers are between crop cycles. At all four land application sites as well as the CVC facility, both Class A and Class B biosolids are accepted. There is no cost or timing benefit of producing Class A biosolids if the biosolids end use is with Synagro.

As described in the sections above, the Agency currently sends biosolids to Synagro's Sonoma and Solano County land application sites during the summer. The Agency also sends one truckload to the CVC facility per year. The Agency's contract with Synagro expires in December 2019, at which time one year extensions can be negotiated. In email communications in October 2017 with John Pugliaresi at Synagro, he indicated that Synagro has adequate capacity to service all of Agency's biosolids if desired, including transportation to Sacramento in the winter if necessary. Currently the cost to send biosolids to Synagro's land application sites in the summer ranges from $38.92 to $40.91 per wet ton for hauling and tipping. If winter land application in Sacramento were pursued with Synagro, the cost would likely range from $45 to $49 per wet ton.

6.3 Denali Water Solutions

Denali Water Solutions (Denali), like Synagro, is a nation-wide residuals management company that provides land application and composing services in the Bay Area. Currently, Denali has over 4,500 acres of land application permitted in Merced County for biosolids. Their sites generally operate between April 15 and November 15 every year. Both Class B and Class A biosolids are accepted and at this time there is no cost or timing benefit of producing Class A biosolids if the biosolids end use is with Denali.

The Agency is not currently contracted with Denali. However, in conversations with Chris Marks at Denali, the Merced land application sites do have capacity to accept the Agency's biosolids in the summer. It is likely that the cost for land application in Merced through Denali would range from $30 to $38 per wet ton for hauling and tipping.

6.4 Other Land Application Sites

In addition to contracting with Synagro or Denali for land application of biosolids, the Agency could also consider other potential future land application sites. One possible future site includes land owned by Ironhouse Sanitary District (ISD).

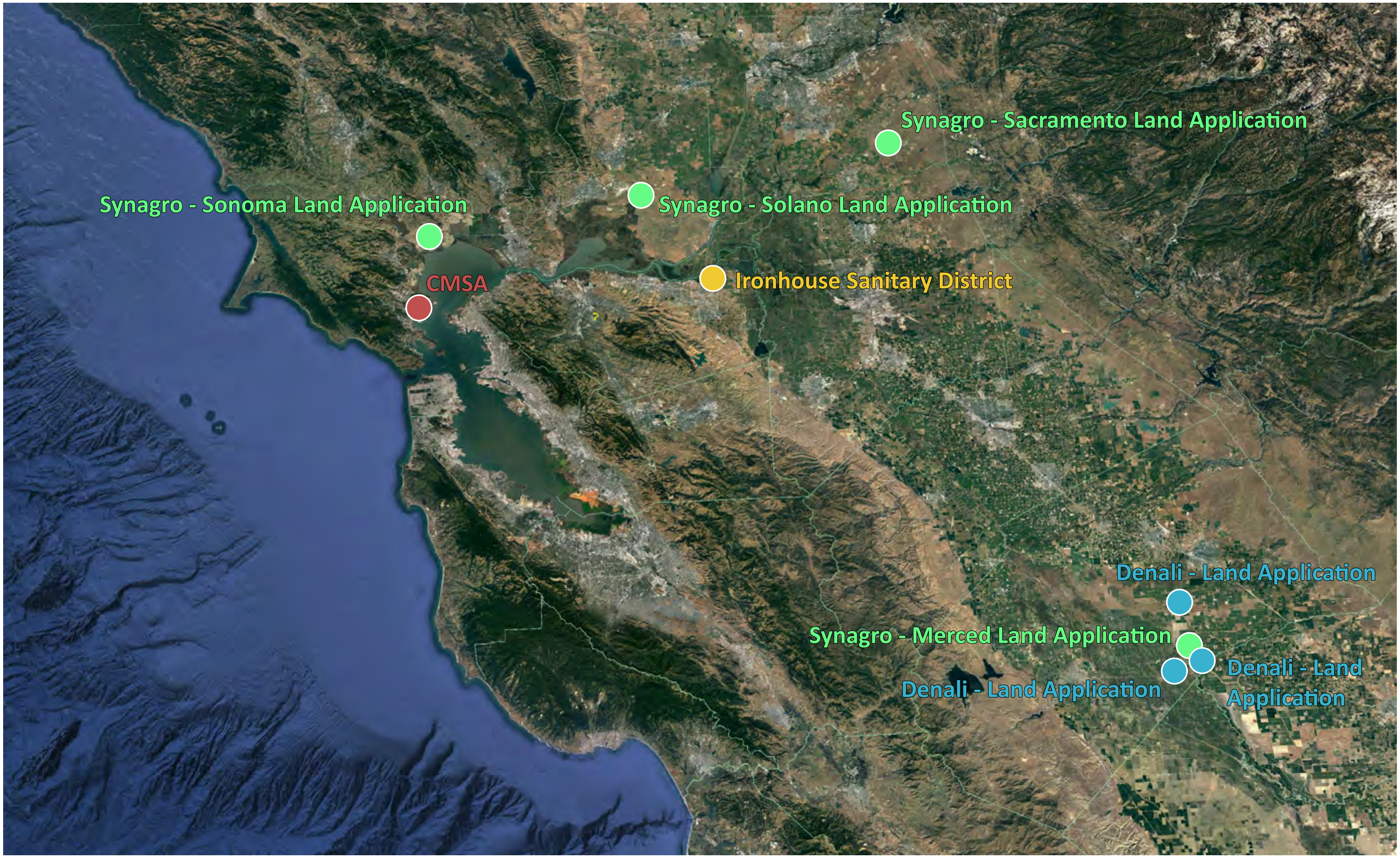
ISD currently has over 400 acres that are permitted for land application. Their land application permit allows them to apply around 2,500 dry TPY. Of this, they currently produce only 500 dry TPY. ISD is potentially interested in accepting additional biosolids to reach their land application limit. A price for land application at ISD has not yet been established.

Figure 5.4 shows the approximate locations of Synagro and Denali land application sites as well as the potential future ISD land application site.

6.5 Redwood Landfill

The Redwood Landfill has been in operation since the 1950s and owns 420 acres. Of this, 222.5 acres are used for landfill and the remaining acreage is used for composting, recycling, and operations.

As described above, the Agency is currently contracted with Redwood Landfill to send 2,500 to 7,500 wet TPY to Redwood Landfill where it is used as ADC. There are no seasonal restrictions with this contract; however, using the Agency's biosolids as ADC will become increasingly difficult given current regulations. It is unknown at this time whether Redwood Landfill would be amenable to continuing to accept the Agency's biosolids and if so, for what cost.



LEGEND	
CMSA	Ironhouse Sanitary District
Denali - Land Application	Synagro – Land Application

LAND APPLICATION SITES AROUND THE BAY AREA

FIGURE 5.4

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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6.6 Bay Area Biosolids Coalition

The Agency is a member of the BAB Coalition, which has identified critical challenges over the next five years for BAB management as legislation has been passed and regulations develop. The Coalition originally formed in 2004 when a group of agencies came together to evaluate the feasibility of a single regional biosolids management project to mitigate the threat of a potential ban on land application of biosolids. By 2008, the membership expanded and the group decided to name itself the Bay Area Biosolids to Energy Coalition to take advantage of opportunities anticipated to be developed under Assembly Bill 32 (AB 32, to achieve 1990 levels of GHG emissions by 2020). To achieve GHG reductions under AB 32, the state created numerous programs incentivizing renewable energy and low carbon fuel production. This legislation served as a driver to prioritize the conversion of biosolids to energy over other Class A or B options, which also satisfies the Solano County Code requirements for land application of biosolids (Chapter 25, Article IV, Sec. 25-400). However, in 2016 Senate Bill 32 was adopted seeking further reductions in GHG emissions of 40 percent below 1990 levels by 2030 by expanding beyond renewable energy/fuel programs and consider building healthy soils and sequestering carbon (e.g., through land application of biosolids) . The Coalition has changed its name to the BAB Coalition to reflect the expansion in scope of opportunities for biosolids management, looking beyond biosolids to energy options.

With this goal in mind, two facilities were constructed at BAB member agencies:

- BioForceTech Corporation partnered with Silicon Valley Clean Water (SVCW) to construct a facility that has capacity to take a portion of SVCW's biosolids. BioForceTech's technology includes an innovative BioDryer™ followed by pyrolysis. The byproducts of the process are syngas and biochar, both products with high reuse value. The full facility began operation in September 2017. Given the limited capacity of this facility, it is not an option for the Agency.

- Lystek partnered with Fairfield Suisun Sewer District to create a regional facility to produce a licensed liquid fertilizer. Further details regarding this facility and its availability to the Agency are discussed in the previous sections.

Most of the member agencies use a combination of hauling biosolids for land application and/or ADC at landfills and would like to see these beneficial uses preserved. However, increasingly restrictive regulations may require that biosolids no longer be accepted at landfills within the next 5 to 10 years. These increasingly restrictive regulations are driving the need for long term sustainable disposal/beneficial use alternatives. As a result, the Coalition is performing an evaluation of biosolids management options to identify those that are viable at a regional or subregional scale, generate a product or products that can be beneficially used all year long, are implementable in the next two to three years (or may be viable in the next five years with Coalition support), and comply with the regulation being developed under SB 1383 (see Table 5.9). Table 5.10 summarizes a subset of the options considered who have provided planning level costs. This information is available to the Agency because they are a member agency of the BAB Coalition.

As shown in the table, many of these options are more expensive than current land application and landfill rates. However, as land application and landfill rates increase due to decreasing availability, some of these solutions may become more favorable. It is recommended that the Agency continue participating in the Coalition to have access to the latest status and availability of capacity at existing options as well as emerging options, and consider participation in regional opportunities.

Table 5.10 Planning Level Costs for Potential BAB Coalition Options(1)
2017 Facilities Master Plan
Central Marin Sanitation Agency

Technology Provider	Regional Facility		Unspecified or Onsite Facility		
	Tipping Fee ($/wet ton)(2)	Cost Basis (dry TPD)	Capital and O&M Cost ($/wet ton)(2)	Cost Basis (dry TPD)(3)	Product
Dryer					
Andritz	66	Not Given	-	-	Class A Pellet
Gryphon	-	-	84 -132	1 - 20	Class A
NEFCO	-	-	318	Not Given	Class A
Suez	-	-	280 - 335	10 (assumed)	Class A
Synagro	70 - 75	7	-	-	Class A
Wright Tech	30 - 40	52 - 60	25 - 35(4)	52 - 60	Class A
Pyrolysis					
Anaergia	-	-	18 - 20	18	Syngas, Biochar
BioForceTech			60	Not Given	Syngas, Biochar
Gasification					
Aries Clean Energy	50 - 100	Not Given	-	-	Syngas, Biochar
Thermal Hydrolysis					
Anuvia	65 - 90	Not Given			Class A
Lystek	75 - 85	60	-	-	Licensed Fertilizer

Table 5.10 Planning Level Costs for Potential BAB Coalition Options(1) 2017 Facilities Master Plan Central Marin Sanitation Agency					
	Regional Facility		**Unspecified or Onsite Facility**		
Technology Provider	**Tipping Fee ($/wet ton)(2)**	**Cost Basis (dry TPD)**	**Capital and O&M Cost ($/wet ton)(2)**	**Cost Basis (dry TPD)(3)**	**Product**
Other					
Genifuel (Hydrothermal Liquefaction)	-	-	360 - 479	2-4	Biocrude Oil, Biogas
Algae Systems (Hydrothermal Liquefaction)	250	11	-	-	Biocrude Oil, Class A
SCFI (Super Critical Water Oxidation)	-	-		3 - 12	Ash
Terax (Fermentation + Hydrothermal Oxidation)	-	-	257 - 402	Not Given	Ash, Ammonia Sulfate
Pre-Digestion					
Pondus (Thermo-Chemical Hydrolysis)	-	-	38	5 - 10	(to digestion)

Notes:
(1) These costs are preliminary planning level rates quoted to Coalition members only.
(2) Where applicable, all conversions from wet to dry tons are based on 26% solids.
(3) All are based on a 20 year facility life.
(4) Assumes Class A can be sold for $20/ton.

6.7 Produce a Class A Product On-Site

Another option for the Agency is to produce a Class A product on-site. There are a number of well established and emerging technologies to produce a Class A product. Such technologies include, but are not limited to: dryers, thermal hydrolysis, pasteurization, two stage temperature phased digestion, composting, pyrolysis, gasification, super critical oxidation, and hydrothermal liquefaction.

While there are a number of technologies that can produce a Class A product, adding infrastructure to create a Class A product on-site is not economically favorable at this time. An end use for a Class A product still needs to be identified that is as cost-effective as an end use for a Class B product. As described above, land applying Class A biosolids through Synagro or Denali does not provide any benefits over land applying Class B biosolids at this time. Additionally, space is limited and the other end use options explored (compost, Lystek, and a BAB facility) accept Class B or sub-Class B solids. Therefore, converting the Agency's biosolids to Class A onsite was not further evaluated in this TM.

If a market develops for Class A product, the Agency could re-evaluate the economics of developing a Class A alternative. An example of a product that could be marketable in the future is biochar, which will be generated from the SVCW Agency’s project. At this time, there is no market for biochar generated from biosolids, although biochar generated from wood waste can be sold for nearly $400-$500 per ton. If such a market develops for biochar generated from biosolids, the economics of pyrolysis or gasification technologies being evaluated by the BAB may become more favorable.

7.0 RECOMMENDED APPROACH

Table 5.11 summarizes the planning level cost ranges for the biosolids management options presented in Section 6. Given the costs presented in this table, the following biosolids management strategy is recommended as using biosolids for ADC becomes less favorable in the future:

- Continue with land application in the summer, as land application is currently the most cost-effective strategy. The Agency currently has a contract with Synagro, since the contract ends in December 2019, the Agency should take the opportunity to compare Synagro's costs with costs at other land application sites including Denali's sites and ISD.
- Pursue winter land application in Sacramento with Synagro if the Redwood Landfill is unable to accept the Agency's biosolids in the near future.
- As the cost of land application increases (above $60 per wet ton), consider increasing the portion of biosolids sent to compost at Synagro's CVC facility and potentially Denali's or Redwood's composing sites.
- Support implementation of a regional BAB Coalition facility, targeting a combined tipping and hauling fee of $65 to $70 per wet ton or less. At this price point sending biosolids to a regional facility would be less expensive than the projected cost of land application after 2025.

Table 5.11 Planning Level Costs for Potential Biosolids End Use Options
2017 Facilities Master Plan
Central Marin Sanitation Agency

	Summer Cost ($/wet ton)	Winter Cost ($/wet ton)	Year-Round Cost ($/wet ton)	Future Year-Round Cost ($/wet ton)
Lystek	-	-	93	Unknown
Synagro Land Application	40	45 - 50	-	65 - 70
Synagro Compost	-	-	60 - 65	65 - 70
Denali Land Application	30 - 38	-	-	Unknown
Denali Compost	-	-	Unknown	-
ISD Land Application	Unknown	-	-	-
Redwood ADC	-	-	46	Unknown
BABC Regional Facility(1)	-	-	30 - 250	-

Note:

(1) Excludes Hauling Costs. Only regional facility costs from Table 5.10 were included in this range.

APPENDIX A - BIOSOLIDS HAULING AND END USE AGREEMENTS

CENTRAL MARIN SANITATION AGENCY

BID REQUEST

FOR

BIOSOLIDS HAULING

CMSA Contract No. 15-28

May 2015

Marin County, California

TABLE OF CONTENTS

APPENDICES

N-1
NOTICE INVITING SEALED BIDS

Central Marin Sanitation Agency (CMSA) hereby gives notice that it will accept sealed bids for Biosolids Hauling, as described below, at 1301 Andersen Drive, San Rafael, California 94901, until **10:00 am** on **Wednesday, May 27, 2015** at which time they will be publicly opened and read for the following work:

> **Biosolids Hauling (CMSA Contract No. 15-28)**: Provide all labor, equipment, materials, and supervision necessary to receive, transport, and unload biosolids, Monday thru Saturday. Central Marin Sanitation Agency produces up to 7,000 wet tons of "Class B" biosolids annually. These biosolids are anaerobically digested and dewatered to an average cake solids concentration of 26%, weighing approximately 62 pounds per cubic foot. Biosolids will be loaded at CMSA's Solids Handling Building (1301 Andersen Dr., San Rafael, CA), and transported and unloaded at either the Redwood Landfill (8950 Redwood Highway, Novato), or one of Synagro West's land application sites (Sonoma County, Solano County, or Merced County), as determined by CMSA. CMSA will be responsible for all destination contracts and fees.

CMSA reserves the right, in its sole direction, to reject any or all bids, or re-bid or to waive any irregularities in any bid not involving time, price, quantity or quality of the work. The award, if made, will be made to the responsive, responsible bidder whose bid represents the lowest combined cost, item 1.J, listed in the Bid Form. No bidder shall withdraw its bid for a period of forty-five (45) calendar days after the date set by CMSA for the opening thereof.

Pursuant to the applicable sections of the Business & Professions Code and Public Contract Code, all bidders must possess proper permits and licenses for the performance of the work. Further details on the work to be performed, or Bidding Documents, may be obtained from the Central Marin Sanitation Agency, attention Brian Thomas, Engineering Manager, 1301 Andersen Drive, San Rafael, CA 94901, (415) 459-1455, extension 122. The Bidding Documents may be obtained by visiting CMSA's office at the above address, or via US Mail or email.

Jason Dow, P.E., General Manager

Date: 5/1/15

END OF SECTION

00100
INSTRUCTIONS TO BIDDERS

A. Bid Form Bids under these specifications shall be submitted on the Bid form provided in Section 00300, in a sealed envelope addressed to "CMSA" and shall be entitled as stated in the "Notice Inviting Bids". The Bid Form must be fully completed and shall be for all elements of work described in the ***Bidding Documents*** (collectively Specification Section 00100 thru 01100, Appendix A thru E). The Bid Form shall give proposed prices clearly and legibly in words and figures for which the bidder proposes to do the work required by the Bidding Documents. In case of conflict between the worded amount and figured amount, the amount in words shall prevail. The proposed price(s) shall include all labor, materials, services, equipment, supervision and other necessary costs including but not limited to permit fees (if any), taxes, disposal costs and all other costs associated with the work to be performed by Contractor, and CMSA will not make any additional reimbursement for any such additional cost.

B. Rejection of Bids Containing Alterations, Erasures or Irregularities Any material changes, alterations, conditions, limitations, or provisions made to or attached to the Bid Form will render it non-conforming and will cause it to be rejected as non-responsive. Alternative bids will not be considered unless required by the Bidding Documents. No oral, telegraphic, facsimile, email or telephonic bids or modifications will be considered. The bid may be withdrawn upon request by the bidder without prejudice to the bidder prior to, but not after, the time fixed for opening of bids, provided that the request is in writing, has been executed by the bidder or the bidder's duly authorized representative, and is filed with CMSA.

C. Bid Signature If the bid is made by an individual, it shall be signed by the individual and the individual's full name and address shall be given. If the bid is made by a partnership, it shall be signed with the co-partnership name by a member of the firm, who shall sign their own name and provide the name and address of each member. If the bid is made by a corporation, the bid shall show the name of the corporation and the State under the laws of which the corporation was chartered, the bid shall be signed by the duly authorized officer or officers of the corporation, attested by the corporate seal, and the names and titles of the principal officers of the corporation shall be given. Bids submitted as joint ventures must fully disclose the joint venture and be signed by each joint venture.

D. Information on the Project Site Each bidder is responsible for understanding the Project site and scope of work to be done by Contractor. Each bidder represents and agrees that its submission of a bid shall be considered conclusive evidence that the bidder has investigated and is satisfied as to the conditions to be encountered; as to the work to be performed by the Contractor; as to the quality and quantity of materials to be furnished; and as to the requirements of the Bidding Documents. The bidder shall not at any time after submission of the bid dispute, complain, or assert that there was any misunderstanding in regard to the nature or amount of work to be done.

E. Disqualification of Bidders

E.1 Only one bid from an individual firm, partnership, corporation, or association under the same or different names, will be considered. If there is reason to believe that any bidder has an interest in more than one bid for the work contemplated, all bids in which such a bidder is interested will be rejected.

E.2 If there is reason to believe that collusion exists among the bidders, all bids submitted by the colluding bidders will be rejected.

E.3 Bids which are incomplete, which show any material change to, alteration of form, or contain any additions or conditional or alternate bids that are not called for or otherwise permitted, shall be rejected as non-responsive.

F. Award of Contract If the contract is awarded, it will be awarded after opening of the bids, to the responsive, responsible bidder whose bid represents the lowest combined cost, item 1.J, listed in the Bid Form.

G. CMSA's Rights CMSA reserves the right, in its sole discretion, to reject any or all bids, or re-bid or to waive minor irregularities in any bid not involving time, price, quantity or quality of the work.

H. Execution of Contract The bidder to whom award is made shall execute and return to CMSA the written Agreement in the amount of its bid price on the form of Agreement provided herein, together with the required insurance, within fifteen (15) calendar days after the bidder has received the notice of award of contract.

I. Legal Address and License Number of Contractor The address given on the Bid is hereby designated as the place to which all notices, letters and other communications to the Contractor shall be mailed or delivered. The mailing to or delivering at the above-named place of any notice, letter or other communication to Contractor, shall be deemed sufficient service thereof upon the Contractor. The date of said service shall be the date of such mailing or delivery. Such address may be changed at any time by a written notice signed by the Contractor and delivered to the Agency. Nothing herein contained shall be deemed to preclude or render inoperative the service of any notice, letter or other communication upon the Contractor personally.

J. Documents That Must Be Submitted with Bids

The following documents must be submitted with the bid:

Document Number	Title
00300	Bid
00420	Bidder's Qualification
00480	Noncollusion Affidavit

K. **Timely Submittal** The bid and Noncollusion Affidavit together with any of the forms in Section J that are not already on file with CMSA are due at the time of bid opening, and failure to submit them will result in rejection of the bid as non-responsive.

END OF SECTION

00300
BID

NAME OF BIDDER: Total Waste Systems, Inc.

BUSINESS ADDRESS: 3417 Standish Ave.
Santa Rosa, Ca 95402

MAILING ADDRESS: P.O. Box 1916
Santa Rosa, Ca 95402

TO: Central Marin Sanitation Agency

The undersigned proposes and agrees, if this bid is accepted, to enter into an agreement with Central Marin Sanitation Agency to perform all work contained in the Bidding Documents to furnish any and all supervision, labor, services, material, tools, equipment, supplies, transportation, utilities, and all other necessary items and facilities to complete said work and to do everything required for the completion of the **Biosolids Hauling (CMSA Contract No. 15-28).** The undersigned further proposes and agrees, if this bid is accepted, to perform all the work called for by Specification Section 00100 thru 01100, Appendix A thru E, and to complete all such work in strict conformity with the Contract Documents, and that they will accept as full payment of the following unit price (1.A, 1.B, 1.C, and 1.D) listed below with unit cost adjustment every six months. The Contract will be awarded on the basis of the lowest combined cost, item 1.J.

	1.A	**Unit price per wet ton to transport biosolids to Redwood Landfill:**	$ 8.48
	1.B	**Unit price per wet ton to transport biosolids to Sonoma County land application site:**	$ 11.50
	1.C	**Unit price per wet ton to transport biosolids to Solano County land application site:**	$ 26.25
	1.D	**Unit price per wet ton to transport biosolids to Merced County land application site:**	$ 26.25
1.A x	**1.E**	**Cost to transport estimated 3,843 wet tons of biosolids to the Redwood Landfill:**	$ 32,358.06
1.B x	**1.F**	**Cost to transport estimated 1881 wet tons of biosolids to the Sonoma County land application site:**	$ 21,631.50
1.C x	**1.G**	**Cost to transport estimated 376 wet tons of biosolids to the Solano County land application site:**	$ 9,870.00

1.0x

1.H	**Cost to transport estimated 17.5 wet tons of biosolids to the Merced County land application site:**	$ 459.38
1.J	**TOTAL COMBINEED COST (1.J = 1.E + 1.F + 1.G + 1.H)**	$ 64,318.94

NOTES ON BID PROPOSAL:

1. Line (1.A, 1.B, 1.C and 1.D), unit price of transporting bioslids, is the bid price per wet ton to transport biosolids to Redwood Landfill, Sonoma County land application site, Solano County land application site, and Merced County land application site.

2. Line (1.E, 1.F, 1.G, and 1.H), total cost to transport biosolids to landfill site or land application sites, is a calculated value using the unit price (Line 1.A, 1.B, 1.C, and 1.D) of transporting biosolids to landfill or land application sites and multiplying by the stated estimated delivery quantities to landfill or land application sites.

3. Line (1.J), total combined cost (bid award basis), is the sum in dollars for transporting biosolids to landfill and land application sites. Line (1.A, 1.B, 1.C, and I.D) will take precedence, if error is made on the cost calculation in Line (1.E, 1.F, 1.G, 1.H, and 1.J).

It is understood and agreed that:

1. The undersigned has carefully examined the location of the proposed work and is familiar with the Provisions and Requirements, and all additions, deletions, modifications and appendices and all addenda as prepared prior to the date of bid opening setting forth any modifications or interpretations of any of said documents;

2. The undersigned has fully informed themselves as to all conditions and matters, which can in any way affect the work or the cost thereof;

3. The undersigned fully understands the scope of the work and has checked carefully all words and figures inserted in this bid and understands that CMSA will in no way be responsible for any errors or omissions in the preparation of this Bid;

4. The undersigned will execute the Agreement within fifteen (15) days after notice to them of acceptance of their bid by CMSA; and further, that their bid may not be withdrawn for a period of forty-five (45) days after the date set for the opening thereof, unless otherwise required by law;

5. The undersigned hereby certifies that this proposal is genuine and not sham or collusive or made in the interest or in behalf of any person not herein named, and the undersigned has not directly or indirectly induced or solicited any other bidder to put in a sham bid, or any other person, firm or corporation to refrain from bidding; the undersigned has not in any

manner sought by collusion to secure for themselves an advantage over any other bidder;

The undersigned acknowledge the receipt of the following addenda to the drawings and specifications.

Addendum No.	Date	Addendum No.	Date

If the bidder is an individual, so state; if a firm or co-partnership, state the firm name and give the name of all individual co-partners composing the firm. If a corporation, state legal name of corporation, also names of president, secretary, treasurer and manager thereof.

TOTal Waste Systems, Inc. - James Ratto President and CFO
James R. Salyers - Vice President and General manager
Deanna Ratto - Secretary

Bidder Signature: James R Salyers Title: Vice President

Bidder's Name: James R. Salyers Vice President

Print Bidder's Name: Total Waste Systems, Inc

Business Address: P.O. Box 1916, Santa Rosa Ca 95402

Telephone: 707-765-9995 Date: 5/27/2015

END OF SECTION

00310
BID PROTESTS

SUMMARY

A. A Bidder may file a protest with CMSA against another bidder or bidders subject to the provisions below.

B. The procedures and time limits set forth in this Section 00310 are mandatory and are the bidder's sole and exclusive remedy in protesting other bidders' bids. Failure to comply with these procedures shall constitute a waiver of any right to pursue the bid protest, including filing a Government Code claim or other legal proceedings.

TIME LIMITATIONS

A. A protest shall be in writing and shall be received by CMSA within 5 working days after the date of bid opening. A copy of the protest with all supporting documentation shall be delivered concurrently by the protesting bidder to all bidders against whose bids the protest is directed.

B. CMSA will give the protested bidders five (5) working days to respond in writing to the protest.

C. All protests and responses that are received after the time set forth herein will be rejected.

D. CMSA will evaluate all protests and responses and issue a written decision on such protests, responses and other matters related to award of the Agreement.

DELIVERY OF PROTEST

A. If a protest is mailed, the protesting Bidder bears the risk of non-delivery within the required time period. Protests should be transmitted by Certified Mail-Return Receipt Requested or by other means which objectively establish the date of receipt by CMSA.

B. Telephoned protests will not be considered.

C. Protests shall be transmitted to the CMSA in care of:

General Manager
Central Marin Sanitation Agency
1301 Andersen Drive
San Rafael, CA 94901

D. Protests not received within the time and in the manner specified will not be considered.

CONTENT OF PROTEST

A. The protest document shall state the basis for the protest and provide supporting evidence.

B. The protest shall refer to the specific portion of the bid that forms the basis of the protest.

C. The protest shall include the name, address, and telephone number of the person representing the protesting bidder.

END OF SECTION

00420
BIDDER'S QUALIFICATIONS

The Bidder has been engaged in business, under the present business name for 30 years years. Experience in work of a nature similar to that covered in the proposal extends over a period of 30 years.

The Bidder, as a contractor, has never failed to satisfactorily complete a contract awarded to him, except as follows:

NoNe

END OF SECTION

00480
NONCOLLUSION AFFIDAVIT

In accordance with Section 7106 of the State of California Public Contract Code, Bidders are required to execute the following Noncollusion Affidavit.

I, James R. Salyers, declare that I am Vice President
(Name) (Title)
of Total Waste Systems INC, the party making the foregoing bid.

The bid is not made in the interest of, or on behalf of, any undisclosed person, partnership, company, association, organization, or corporation. The bid is genuine and not collusive or sham. The bidder has not directly or indirectly induced or solicited any other bidder to put in a false or sham bid. The bidder has not directly or indirectly colluded, conspired, connived, or agreed with any bidder or anyone else to put in a sham bid, or that anyone shall refrain from bidding. The bidder has not in any manner, directly or indirectly, sought by agreement, communication, or conference with anyone to fix the bid price of the bidder or any other bidder, or fix any overhead, profit, or cost element of the bid price, or of that of any other bidder. All statements contained in the bid are true. The bidder has not, directly or indirectly, submitted his or her bid price or any breakdown thereof, or the contents thereof, or divulged information or data relative thereto, to any corporation, partnership, company association, organization, bid depository, or to any member or agent thereof to effectuate a collusive or sham bid, and has not paid, and will not pay any person or entity for such purpose.

Any person executing this declaration on behalf of the bidder that is a corporation, partnership, joint venture, limited liability company, limited liability partnership, or any other entity, hereby represents that he or she has full power to execute, and does execute, this declaration on behalf of the bidder.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct and this declaration is executed on 5/26 2015, in Santa Rosa.

James R Salyers
(Signature of Declarant)

END OF SECTION

00500
AGREEMENT

THIS AGREEMENT made and entered into this 19th day of June, 2015, by and between the CENTRAL MARIN SANITATION AGENCY, hereinafter referred to as CMSA, and Total Waste Systems, Inc., hereinafter designated as the Contractor.

WITNESSETH: That the parties hereto do mutually agree as follows:

ARTICLE 1: For and in consideration of the payments and agreements hereinafter mentioned to be made and performed by CMSA, the Contractor agrees with CMSA to service the contract entitled **Biosolids Hauling (CMSA Contract No. 15-28)** and to perform all work described in the Contract Documents and to do everything required by this agreement.

ARTICLE 2: CMSA promises and agrees with the Contractor to employ and does employ the Contractor to provide the materials and do the work according to the terms and conditions referred to at the unit price as set forth in the Bid Form, and contracts to pay the same, at the time, in the manner, and upon the condition set forth in the specifications; and the parties for themselves, their heirs, executors, administrators, successors and assigns, do agree to the full performance of these covenants.

ARTICLE 3: The Notice Inviting Sealed Bids, the Instructions to Bidders, the Bid Form, the General and Supplemental Provisions, the Appendices, and all Addenda issued by CMSA prior to the opening of bids are incorporated in and made a part of this agreement.

ARTICLE 4: The Contractor is aware of, and hereby agrees to comply with Section 3700 of the Labor Code requiring every employer to be insured against liability for Workers' Compensation or to undertake self-insurance before commencing any of the work.

This Contract's Expiration Date is June 30, 2017, with one (1) administrative extension available.

IN WITNESS WHEROF, these parties have caused this two (2) page Agreement to be executed the day and year first above written.

Contractor: TWS, Inc.

By: James R Salyers VP

Title: 6/15/15

Print Name: JAMES R SALYERS

CENTRAL MARIN SANITATION AGENCY

By: 6/19/15

Jason R. Dow, General Manager

END OF SECTION

00710
DEFINITIONS

1. Whenever the following terms are used in the Contract Documents, they shall be understood to mean the following:

Owner, or CMSA	Central Marin Sanitation Agency
Engineer or CMSA Engineer	The Engineer (either CMSA staff engineer or CMSA consultant) designated by CMSA to act either directly or through properly authorized agents.
CMSA Representative	The CMSA Engineer or designee.
Board	CMSA's Board of Commissioners.
Contract Documents	Items so designated in the Agreement, General Provisions, Supplementary Conditions, Specifications, Drawings, specific to a contract.
Contractor	Entity providing the materials, installation, or other services described in the Agreement. Any uses of plural references (i.e., "they") to the Contractor shall mean the Contractor regardless of whether the Contractor is an individual, firm, corporation, or other business entity.
Laboratory	The designated laboratory selected by CMSA to test materials and work involved in the Agreement.

END OF SECTION

00720
SPECIAL PROVISIONS: INSURANCE AND INDEMNIFICATION REQUIREMENTS FOR CONTRACTORS

A. Contractor shall procure and maintain for the duration of the contract insurance against claims for injuries to persons or damages to property that may arise from or in connection with the performance of the work hereunder by the Contractor, its agents, representatives, employees and/or subcontractors. The cost of such insurance shall be borne by the Contractor.

A.1 Minimum Scope and Limits of Insurance

Coverage shall be at least as broad as:

A.1.a **Commercial General Liability:** Insurance Services Office Occurrence Form Number CG 00 01, including products and completed operations, with limits of no less than $1,000,000 per occurrence for bodily injury, personal injury, and property damage. If a general aggregate limit applies, either the general aggregate limit shall apply separately to this project or the general aggregate limit shall be twice the required occurrence limit ($2,000,000.00).

A.1.b **Automobile Liability:** Insurance Services Office Form Number CA 0001 covering Code 1 (any auto), with limits no less than $1,000,000 per accident for bodily injury and property damage.

A.1.c **Workers' Compensation:** Insurance as required by the State of California, with Statutory Limits, and Employers' Liability insurance with a limit of no less than $1,000,000 per accident for bodily injury or disease.

A.1.d **Contractors' Pollution Liability:** covering bodily injury (including death), property damage and remediation with limits no less than $1,000,000 per occurrence or claim, and $2,000,000 policy aggregate.

A.2 Deductibles and Self-Insured Retentions:

Any deductibles or self-insured retentions must be declared to and approved in writing by CMSA prior to the start of any work on the Project. At the option of CMSA, either: the insurer shall reduce or eliminate such deductibles or self-insured retentions as respects CMSA, its commissioners and employees as well as its members including San Rafael Sanitation District, City of Larkspur, Sanitary District No. 1 of Marin County, Sanitary District No. 2 of Marin County, the City of San Rafael, the Town of Corte Madera, their officers, officials, employees and volunteers; or the Contractor shall procure a bond or other financial guarantee satisfactory to CMSA guaranteeing payment of the deductible or self-insured retention.

A.3 Other Insurance Provisions

The insurance policies shall contain, or be endorsed to contain, the following provisions:

A.3.a CMSA, its commissioners and employees as well as its members including San Rafael Sanitation District, the City of Larkspur, Sanitary District No. 1 of Marin County, Sanitary District No. 2 of Marin County, the City of San Rafael, the Town of Corte Madera, their officers, officials, employees, or volunteers, are to be covered as insureds on the Commercial General Liability, Automobile Liability and Contractor's Pollution Liability policies with respect to liability arising out of automobiles owned, leased, hired, or borrowed by or on behalf of the Contractor; and with respect to liability arising out of work or operations performed by or on behalf of the Contractor including materials, parts, or equipment furnished in connection with such work or operations. General liability coverage can be provided in the form of an endorsement to the Contractor's insurance (at least as broad as ISO Form CG 20 10, 11 85 or both CG 20 10 and CG 23 37 forms if later revisions used). The coverage shall contain no special limitations on the scope of protection afforded to CMSA, its commissioners and employees as well as its members including San Rafael Sanitation District, the City of Larkspur, Sanitary District No. 1 of Marin County, Sanitary District No. 2 of Marin County, the City of San Rafael, the Town of Corte Madera, their officers, officials, employees, or volunteers.

A.3.b For any claims related to this project, the Contractor's insurance coverage shall be primary insurance as respects CMSA, its commissioners and employees as well as its members including San Rafael Sanitation District, the City of Larkspur, Sanitary District No. 1 of Marin County, Sanitary District No. 2 of Marin County, the City of San Rafael, the Town of Corte Madera, their officers, officials, employees, or volunteers. Any insurance or self-insurance maintained by CMSA, its commissioners and employees as well as its members including San Rafael Sanitation District, the City of Larkspur, Sanitary District No. 1 of Marin County, Sanitary District No. 2 of Marin County, the City of San Rafael, the Town of Corte Madera, their officers, officials, employees, or volunteers, shall be in excess of the Contractor's insurance and shall not contribute with it.

A.3.c Any failure to comply with reporting or other provisions of the policies including breaches of warranties shall not affect coverage provided to CMSA, its commissioners and employees as well as its members including San Rafael Sanitation District, the City of Larkspur, Sanitary District No. 1 of Marin County, Sanitary District No. 2 of Marin County, the City of San Rafael, the Town of Corte Madera, their officers, officials, employees, or volunteers.

A.3.d The Contractor's insurance shall apply separately to each insured against whom claim is made or suit is brought, but the inclusion of more than one insured shall not operate to increase the limits of the insurer's liability.

A.3.e Each insurance policy required by this clause shall be endorsed to state that coverage shall not be voided, canceled, reduced in coverage or in limits without the carrier giving CMSA at least thirty (30) days' prior written notice by certified mail, return receipt requested. All notices shall be sent to:

Jason Dow
General Manager
Central Marin Sanitation Agency
1301 Andersen Drive
San Rafael, CA 94901

Contractor, upon notification of receipt by CMSA of any such notice, shall file with CMSA a certificate of the required new or renewed policy at least ten (10) days before the effective date the existing policy is voided, cancelled or changed.

A.4 Acceptability of Insurers

Insurance is to be placed with insurers with a current A.M. Best's rating of no less than A:VII.

A.5 Waiver of Subrogation

The Workers' Compensation policy shall be endorsed with a waiver of subrogation in favor of the Entity for all work performed by the Contractor, its employees, agents and subcontractors.

A.6 Verification of Coverage

Before commencement of the work by Contractor, certificates of insurance and policy endorsements in form and with insurers acceptable to CMSA, evidencing all the required insurance with proper endorsements from the Contractor's insurance carriers identifying as insureds the parties named in paragraph A.3a above shall be furnished to CMSA, with complete copies of the policies to be furnished to CMSA promptly upon request. All insurance documents shall be signed by a person authorized by that insurer to bind coverage on its behalf. All endorsements are to be received and approved by CMSA before work commences. The endorsements are to be on forms provided by CMSA. As an alternative to CMSA's endorsement forms, the Contractor's insurer may provide complete, certified copies of all required insurance policies, including endorsements affecting the coverage required by these specifications.

A.7 Subcontractors

Contractor shall require and verify that all subcontractors, at any tier, procure and maintain a commercial general liability, automobile liability and workers' compensation insurance policies that meet all the requirements contained in this Section 00720

B. Indemnification

Consistent with California Civil Code section 2782, Contractor shall assume the defense of, indemnify, and hold harmless CMSA, its commissioners and employees, its members including San Rafael Sanitation Agency, the City of Larkspur, Sanitary District No.1 of Marin County, Sanitary District No. 2 of Marin County, Town of Corte Madera and their respective officers, officials, employees and volunteers, employees, authorized representatives, or any other persons deemed necessary by any of them acting within the scope of the duties entrusted to them, from all claims, suits, actions, losses and liability of every kind, nature and description, including but not limited to attorney's fees, directly or indirectly arising out of, connected with or resulting from the performance of the Work. This indemnification shall not be valid in the instance where the loss is caused by the sole negligence or intentional tort of any person or entity indemnified herein.

Contractor's obligation to defend, indemnify and hold harmless CMSA's consultants shall not extend to the liability of a CMSA consultant or its employees or subconsultants arising out of, connected with, or resulting from a CMSA consultant's own active negligence, errors or omissions or from (1) such indemnitee's preparation or approval of maps, plans, opinions, reports, surveys, design or specifications, or (2) such indemnitee's issuance of or failure to issue directions or instructions provided that such issuance or failure to issue is the primary cause of the damage or injury.

Contractor acknowledges that any claims, demand, losses, damages, costs, expenses and legal liability that arise out of, result from, or are in any way connected with the release or spill of any legally designated hazardous material or waste or contaminated material as a result of the work performed under this Contract are expressly within the scope of this indemnity, and that the costs, expenses, and legal liability for environmental investigations, monitoring, containment, removal, repair, cleanup, restoration, remedial work, penalties, and fines arising from the violation of local, state, or federal law or regulation, attorney's fees, disbursements, and other response costs are expressly within the scope of this indemnity.

On request, Contractor shall defend any action, claim or suit asserting a claim covered by this indemnity. Contractor shall pay all costs that may be incurred by CMSA and all indemnified parties specified above including but not limited to reasonable attorney's fees, arbitration fees, if any, or court costs.

Contactor's indemnity obligations and liability shall not be limited to the amount of insurance coverages required under the Contract Documents.

END OF SECTION

00730
SPECIAL PROVISIONS: HEALTH AND SAFETY REQUIREMENTS

A. Safety

A.1 Responsibility to comply with safety regulations

A.1.a The Contractor shall comply with all applicable federal, state, and local safety regulations in the performance of the work. The Contractor is responsible for notifying its employees of the job safety requirements. The Contractor is also responsible for ensuring that its employees have the safety training and equipment appropriate for the job.

A.1.b The Contractor or their designee shall review all applicable CMSA Safety Checklists with the CMSA Representative and may be taken on a tour of the jobsite familiarize them with the facilities and alert them to potential hazards. The checklist(s) may include copies of one or more CMSA Safety Policies and Procedures, which are provided for reference only, and do not relieve the Contractor of the requirement to have its own Safety Program that meets or exceeds the current requirements of CalOSHA in effect during the term of the Agreement.

A.1.c After the start of on-site activities, the Contractor’s representative shall meet with the CMSA Representative as needed for the purpose of coordinating those activities that affect the maintenance and operations of the facility.

A.2 General Safety Rules for Contractor:

A.2.a Contractors who bring hazardous substances to the work site must inform CMSA, provide a copy of the Safety Data Sheets (SDS), and take the appropriate safety precautions to protect the Contractor's and Agency's employees from harmful exposure.

A.2.b If the contract involves confined space entries, the Contractor shall review CMSA's written confined space program and comply with Cal/OSHA safety standards for confined space entries.

A.2.c Contractors are responsible for providing their employees with the required safety equipment such as gas detection meters, rescue equipment, and personal protective equipment.

A.2.d The Contractor is not permitted to open or close valves, turn circuits or control switches off or on. These tasks are to be performed only by Agency Engineer or designee.

A.2.e The Contractor shall protect all existing utilities, equipment, piping, or other facilities, whether owned by CMSA or by third parties. Contractors who damage utilities equipment, piping, or other facilities, shall report the incident immediately to Agency Engineer or designee.

A.2.f The Contractor is solely responsible for repairing any utilities, equipment, piping, or other facilities, damaged by its own workers.

A.2.g **Smoking is prohibited anywhere on the CMSA premises except for the two designated smoking areas depicted on Drawing in Appendix A.**

A.2.h Contractor shall obey the all posted speed limits, including the 10 mph speed limit within the plant, shall and drive cautiously at all times while traveling to or between nitrate storage facilities.

A.3 First Aid

Contractors shall be responsible for providing first aid and medical treatment for their employees and for compliance with the first aid requirement of the Cal/OSHA Safety Orders. Contractors shall be responsible to make prior arrangements for emergency medical care and for transportation of injured Contractor personnel.

END OF SECTION

01000
GENERAL PROVISIONS

A. Work to be Done by Contractor

Provide all labor, equipment, materials, and supervision necessary to receive, transport, and unload biosolids, Monday thru Saturday. Central Marin Sanitation Agency produces up to 7,200 wet tons of "Class B" biosolids annually. These biosolids are anaerobically digested and dewatered to an average cake solids concentration of 26%, weighing approximately 62 pounds per cubic foot. Biosolids will be loaded at CMSA's Solids Handling Building (1301 Andersen Dr., San Rafael, CA), and transported and unloaded at either the Redwood Landfill (8950 Redwood Highway, Novato), or one of Synagro West's land application sites (Sonoma County, Solano County, or Merced County), as determined by CMSA. CMSA will be responsible for all destination contracts and fees.

B. Site Access

Unless otherwise approved through a written authorization by the Agency, Contractor access hours shall be 7:00 am to 4:00 pm, Monday through Saturday.

C. Measurement and Payment

Payment for each invoice shall be based on the bid unit price (dollars / wet tons) listed in Item 1.A, 1.B, 1.C and 1.D in the Bid Form for transporting biosolids multiplied by the wet tons transported to each specified location. Payment shall not be made for biosolids not delivered. No additional payment shall be made for any of the other activities required of the Contractor as described in the Contract Documents.

Refer to Section 01100-I and Section 01100-N Supplemental Conditions for additional payment provisions.

D. Permits

The Contractor shall obtain all required permits for the performance of the work and comply with all requirements and obligations imposed upon CMSA or Contractor as permittee in the conditions of the permits issued. All costs of compliance with the permits' requirements shall be included in the bid price for the work, and no additional compensation will be allowed.

END OF SECTION

01100
SUPPLEMENTAL PROVISIONS

A. Contract Period

The period of this contract is for two (2) years or until June 30, 2017, whichever period is shorter. The contract calendar shall begin on the first day of the first month following execution of the Agreement by both the Contractor and CMSA. At the Agency's request, and subject to Contractor's agreement, the contract may be extended for up to one (1) additional one-year increment.

B. Quantities

Central Marin Sanitation Agency produces up to 7,200 wet tons of Class B biosolids annually. The historic five year average of biosolids generated by CMSA is 6,100 wet tons. The actual amount will vary and may be either more or less than this amount. The Contractor shall haul the varying amounts of biosolids at the bid unit price during the contract period.

C. Facility Description

The CMSA dewatering facility has three (3) biosolids hoppers. Each hopper is dedicated to a single dewatering centrifuge and can hold maximum of 30 cubic yards, and is located inside the Solids Handling Building. The bottom of each hopper is ten feet two inches (10'-2") aboveground for hauling vehicles clearance.

Refer to Appendix A CMSA site plan for the location of the loading facility. Appendix B shows photographs of CMSA's Solids Handling Building load bay.

D. Equipment & Requirements

1. All bidders must have equipment that meets and passes safety rules and inspections performed by the California Highway Patrol.

2. Bidder must be able to haul six days per week to Redwood Landfill and Synagro West site for land application.

3. Transport trailers must meet all legal requirements to haul a minimum of 25 tons per trip. Only during emergency situations may Contractor be allowed to use a trailer that hauls less than 25 tons.

4. Each trailer or container shall be end-dump and equipped with covers (canvas or suitable alternative material) that can be securely fastened to reduce odors and contain the biosolids as required by the Regional Water Quality Control Board's Water Quality Order No 2000-10DWQ and all applicable State and local regulations. Each trailer shall meet locals and state requirements for equipment used to transport biosolids. The

trailers must be water-tight to prevent any leakage.

5. The Contractor shall have enough drivers, tractors and trailers to accommodate fluctuations in service. This includes transporting multiple loads per day from CMSA to landfill or land application reuse sites.

6. Contractor shall have sufficient qualified personnel to ensure CMSA's hauling requirements can be met under all foreseeable conditions.

7. The Contractor shall take care to keep ignition sources away from covered loads.

8. If at any time during operation the Contractor does not have equipment available to receive the biosolids, CMSA may elect to have the biosolids hauled by an outside source. The cost for such hauling by an outside source, any other additional costs incurred above the contract price, including indirect and administrative costs, shall be reimbursed by the Contractor or withheld from Contractor payments.

9. The Contractor shall be solely responsible for the condition of their equipment. CMSA may reject pieces of equipment found to be in unsatisfactory condition, which must then be replaced with acceptable equipment.

10. Contractor shall provide CMSA with a list of identification numbers, tare weights, maximum legal load limit, and biosolids volume capacities for all biosolids hauling containers, trucks, and/or trailers being utilized under this contract. Contractor shall conspicuously mark each tractor/trailer unit with the maximum legal weight of the unit when loaded and a corresponding "full load" indicator inside the trailer to guide loading.

11. The Contractor may need to place identifying marks on its trucks, fit its trucks with electronic transponders and decals, or use a gate code in order to enter Redwood Landfill. If needed, Redwood Landfill will supply and install the initial transponder at no cost to the Contractor. The transponder shall be returned to Redwood Landfill at the completion of the contract. Additional transponders (lost or broken) will be charged to the Contractor.

12. CMSA will not be responsible for damage to or theft of any property of the Contractor or the Contractor's agents on or off CMSA's property.

E. Response Time

CMSA normally produces biosolids twenty-four (24) hours per day, seven (7) days per week, and three hundred sixty-five (365) days per year. Each day CMSA produces approximately 17.5 wet tons of biosolids, but this quantity may vary from 0 to 75 wet tons. The Contractor shall be available to haul the above stated amount of biosolids Monday thru Saturday for the year.

Actual hauling and delivery schedules may vary based upon Redwood Landfill, Solano County land application site, Sonoma County land application site, and Merced County land application site's operational requirements.

The Contractor shall respond to requests for hauling from CMSA and arrive at CMSA within twenty-four (24) hours from the time of request. Requests may come directly from CMSA staff or be recorded on the CMSA voice mail system which can be accessed via telephone by the Contractor. The Contractor shall be responsible for calling into the voicemail system and checking for hauling requests daily. Voice mail access procedures will be provided to Contractor by CMSA, after contract execution.

CMSA will discount the prior months billing invoice 10% for noncompliance with the 24 hour response provision. Non-compliance is defined as failure to respond within the twenty-four hour time period two times in a one-month period.

Biosolids production may be increased, decreased, or suspended. Advance notice of temporary stoppages will be given to the Contractor whenever possible. CMSA can store biosolids in hoppers for a limited time.

F. Biosolids Material

The biosolids material in this contract is non-hazardous (Title 22) biosolids (dewatered biosolids) which are anaerobically digested. The biosolids are dewatered using centrifuges, and have an average moisture content of approximately 74% and weigh approximately 62.38 pounds per cubic foot (1,684 lbs/cubic yard).

Contractor should be aware that biosolids may contain pathogenic microorganisms. Contractor should follow proper hygiene practices and utilize appropriate personal protective equipment when coming into direct contact with material and should refer to the recommended practices in Appendix E.

G. Contractor Personnel

Contractor shall insure that its subcontractor(s), and all workers that the Contractor and subcontractor(s) employ, have proper and valid licenses and/or certifications as required by local, State, and Federal law to perform work as described in the Contract Documents. The Contractor shall, at the request of CMSA, supply proof of these licenses and/or certifications.

All workers employed by the Contractor and subcontractors shall be competent and skilled in the performance of the work to which they are assigned. Failure or delay in the performance of this contract due to an inability by the Contractor, for any reason, to obtain employees of the number and skill required, may be deemed by the Agency to constitute a default of this contract.

If a person employed to perform work by the Contractor be considered by CMSA to be incompetent, negligent, unfaithful, or otherwise unsatisfactory, he or she shall be removed from the performance of work under this contract. Removed persons shall not again be employed on the work under this contract except with the prior consent of CMSA; provided that, this paragraph shall be interpreted and enforced in such a manner as will respect and give effort to agreements on such subject between the Contractor and the union representing any or all of its employees.

The Contractor shall provide operating and safety training for all its personnel. Supervisory personnel shall be trained in first aid and each vehicle shall be equipped with a first aid kit. The Contractor shall include all tests of its drivers consistent with State and Federal Department of Transportation requirements during the length of this Contract

H. Load Contamination

The Contractor shall provide trailers that are clean, free of any garbage, debris, recyclables, residual biosolids, hazardous waste or any other material that could contaminate CMSA's biosolids. Trailers that are not suitable for transporting biosolids, as reasonably determined by CMSA, will not be loaded. In that case, the Contractor shall return with acceptable equipment within four (4) hours. The Contractor will be responsible for any loads contaminated prior to or after loading at CMSA, except for contamination that is the responsibility of CMSA or that was beyond the control of Contractor. The Contractor will be responsible for any and all incurred costs associated with the cleanup and disposal of contaminated loads.

I. Payment

CMSA will pay the Contractor based on the number of wet tons of biosolids hauled. CMSA does not have on-site facilities to weigh the material or trucks. For landfill disposal, payment will be made on a per-ton basis using landfill scale data. For land application, the payment basis shall be seventeen and a half (17.5) tons per load, using the historic annual average landfill scale data. CMSA and the Contractor may negotiate a different tonnage once each anniversary year. The Contractor shall furnish invoices each month, including a copy of each load delivery tag along with destination, tons hauled to each destination, and standby time.

The monthly receipts indicating load and tare weights must be received by CMSA on or before the seventh (7th) day of each successive month. These receipts are required by CMSA to prepare the Monthly Report, required by the State Water Resources Control Board. CMSA will discount the prior month's invoice by ten percent (10%) if the above specified information is not received by CMSA as required.

Payment will be calculated as follows:

Payment for landfill = (Bid unit price per wet ton x tons hauled)

Payment for land application = (Bid unit price per wet ton x 17.5 wet ton)

J. Agency/Contractor Responsibilities

CMSA personnel will operate Agency loading equipment to physically place biosolids in Contractor's trailers. Contractor is responsible to ensure each loading does not exceed the legal weight limit for the respective equipment being loaded, by informing CMSA personnel when to stop filling the trailer. CMSA may at random require the Contractor to supply weight tickets from a certified truck scale to confirm loading accuracy.

All de-watered biosolids transported to any destination shall remain the property of CMSA until unloaded. The Contractor shall be responsible for all transportation, holding, and unloading. The Contractor shall ensure trailers are completely empty prior to leaving the haul destination. The Contractor shall be responsible for coordination with appropriate authorities to conduct acceptable unloading operations to meet both CMSA and receiving site requirements.

The Contractor shall be responsible for controlling and abating any odor, spillage, insect, vermin, or any other nuisance arising from their operation. CMSA shall provide reclaimed water and a wash down area, for the use by the Contractor to keep their trucks clean and free of spillage after loading at CMSA. Any spillage or discharge of material to CMSA's plant road or public roads shall be cleaned up promptly by the Contractor. If CMSA is required to clean up the spillage, all costs incurred shall be reimbursed by the Contractor, including direct and administrative cost.

The Contractor shall be responsible for handling the trailer covers for loading and unloading. Covers shall be securely fastened before leaving the CMSA's solids loading facility. Trailers without covers will not be loaded.

All loads must be covered before leaving CMSA property. If there is a problem securing the cover, it must be resolved including onsite repair, if needed, by Contractor or Contractor's agent, before the load leaves CMSA property.

Delivery of biosolids to the landfill or land application sites shall be at the direction of CMSA. CMSA reserves the right to review and modify the haul route to any destination, and to require drivers not to stop en route except for the observance of normal traffic requirements.

The destination of each load will be the decision of CMSA. The Contractor will deliver all loads to the designated destination as directed by the CMSA's personnel. Any and all additional costs for loads hauled to a location different than that designated by CMSA will be billed to the Contractor.

The Contractor shall comply with all applicable Federal, State and local laws, ordinances, codes, safety orders, rules, recommendations and regulations. The Contractor will obey all safety rules or regulations stipulated by receiving site managers.

The Contractor shall be responsible and liable for any damage to CMSA facilities, structures, roadways, vehicles or landscaping while their trucks/trailers are on CMSA property. Damages shall be promptly repaired by the Contractor. In the event that the Contractor does not initiate the repair work within 30 days, CMSA shall perform the repair work and deduct the resulting costs from the Contractors monthly billing statements.

K. Hauling Destinations

Generally, all biosolids loads generated during the months of November through April are transported to the Redwood Landfill (Novato). Biosolids loads generated during the months of April through September are transported to the Synagro West's land application sites in Sonoma County or in Solano County, and one load once a year to the Dos Palo site in Merced County. Loads generated during the months of May and October may go either to the landfill or the land application site dependent on weather, and as determined by CMSA. In the event CMSA changes the hauling destination to a site other than the sites listed above, CMSA and the Contractor will negotiate the unit price for that destination to a mutually agreed upon amount, for the remaining duration of the initial contract period or any fraction of the remaining contract period. CMSA may re-bid the hauling contract if there is no agreement on a unit price at the time of the destination change.

L. Contact Information

The Contractor shall provide Contract Administrator contact phone number as well as contact phone numbers for scheduling and canceling loads, 24-hour emergency contact number(s). All phone numbers must indicate available hours of use and time zone where applicable. The contractor must notify CMSA in writing, if any contact phone numbers are changed.

M. Biosolids Hauling Contingency Plan

The Contractor shall prepare a contingency plan for responding to accidents or spills and submit this plan to CMSA for review <u>within three (3) weeks after receipt of the contract award letter</u>. Below is an outline of the content of a typical contingency plan. CMSA will withhold 10% from amounts owed the Contractor until a satisfactory spill response plan is submitted.

The Biosolids Hauling Contingency Plan shall consist of a three-ring binder to be carried in each biosolids hauling truck and readily available to the driver.

The binder shall contain the following information:

1. A Table of Contents

2. Transportation Section: The Transportation Section shall discuss the responsibilities of the parties, on-board safety equipment, safety training, biosolids sensitivity and the public, equipment maintenance, truck routes, and any other applicable subjects.

3. Emergency Procedures Section: The Emergency Procedures Section shall discuss incident protocol, determining the extent of the incident, non-spill incident procedures, and spill cleanup procedures.

4. Emergency Contacts Section: The Emergency Contacts Section describes who will be called in the event of an incident and in what order, subcontractor contacts that can be called for cleanup assistance, with telephone numbers, and the division of responsibility if an incident occurs.

5. List of Illustrations: The List of Illustrations shall include maps showing the routes to biosolids unloading destinations to allow the driver and dispatcher to clearly identify and record accident site information.

6. Basic First Aid Principles: The section of Basic First Aid Principles is for the drivers' information because he/she may be the first person on the scene of an accident. It can be a suitable pamphlet or card published by a recognized authority (i.e., American Red Cross).

7. Incident Report Forms The binder shall contain a supply of Incident Report Forms. The incident report form shall contain, at a minimum, the following information:

   - Date, time and location of incident
   - Date, time, and location of report taking
   - Did a law enforcement agency investigate (Yes/No)?
   - Name of person taking report
   - Name of person reporting incident
   - Driver’s name
   - Truck Identification Number/License Plate Number
   - Description of Incident, including containment and cleanup measures taken
   - Name, address, and telephone number of person(s) to contact for additional information.

N. Adjustment of Unit Price

CMSA will analyze the contract price every six months during the Contract term, including extensions, if any. This analysis will be based on comparison of the US Bureau of Labor Statistics (USBLS) cost indexes depicted below at the time of Contract execution with the same indexes as most currently published on the date of the analysis, and the unit costs will be adjusted accordingly.

Component	**Applicable Index**	**Percentage of Unit Price**
Transportation	PPI for #2 Diesel Fuel (series ID #WPU05730302)	50%
Labor	San Francisco CPI – ID# CUURA422SA0,CUUSA422SA0 (Adjusted) for labor	10%
Fixed Cost	None – no adjustment	40%

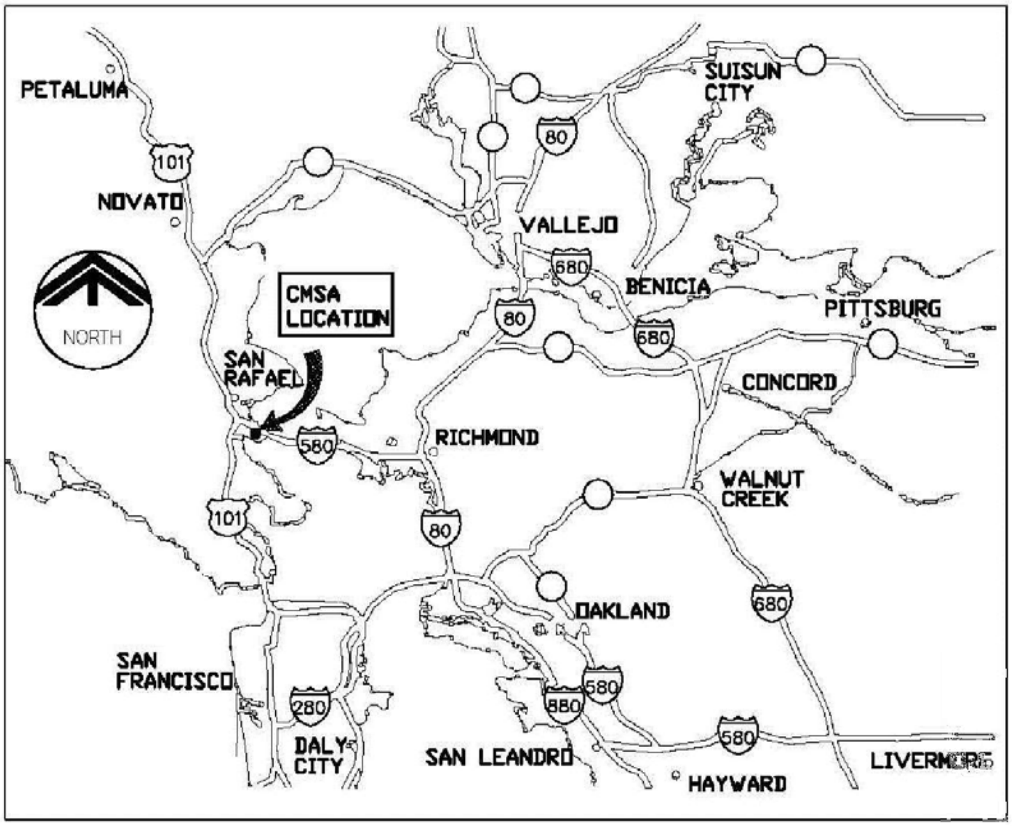
Adjustments shall become effective on the first day of the month following the analysis during the Contract term and any Contract extensions. Any cost adjustment calculation that fails to support a need to adjust price by at least 1.00% will not be implemented. When this occurs, the subsequent price adjustment will be calculated by comparing the most-recently published index value to the index value last used to calculate an allowable price change. This will allow for the accumulation of multiple “less than 1%” price changes. A sample of adjustment calculations is shown in Appendix D of this Contract.

END OF SECTION

APPENDICES

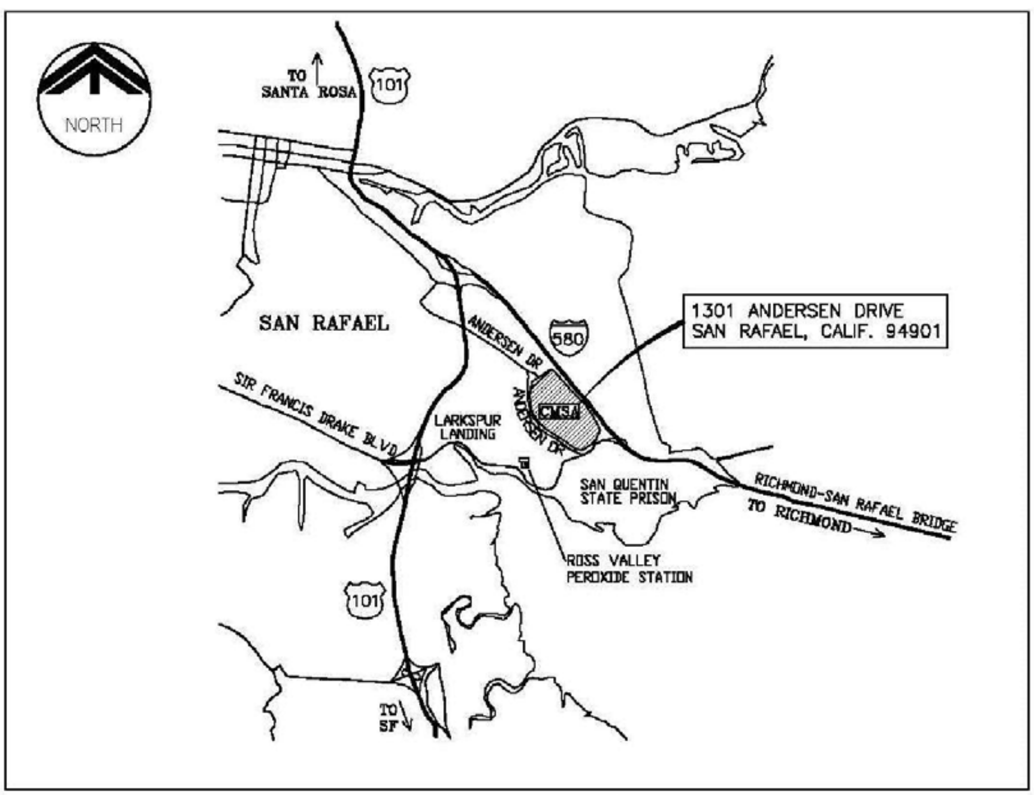
APPENDIX A

CMSA Location Map, Vicinity Map, Site Plan, and Designated Smoking Area Map



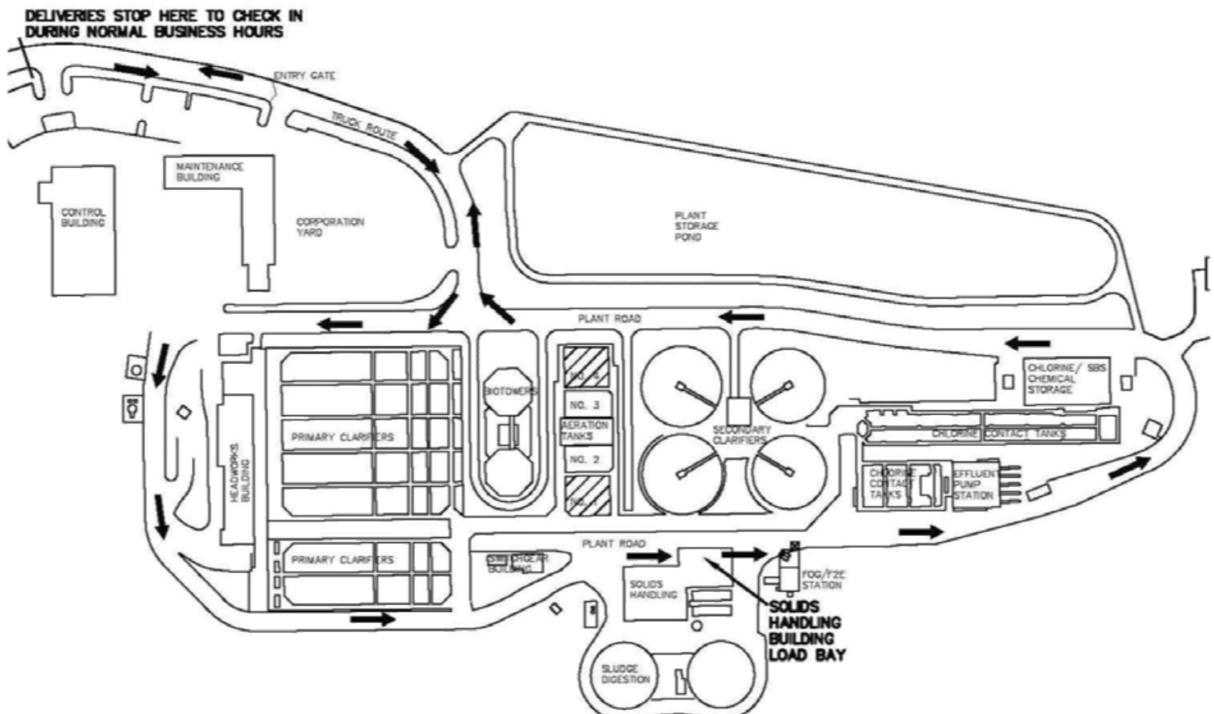
LOCATION MAP

(NOT TO SCALE)

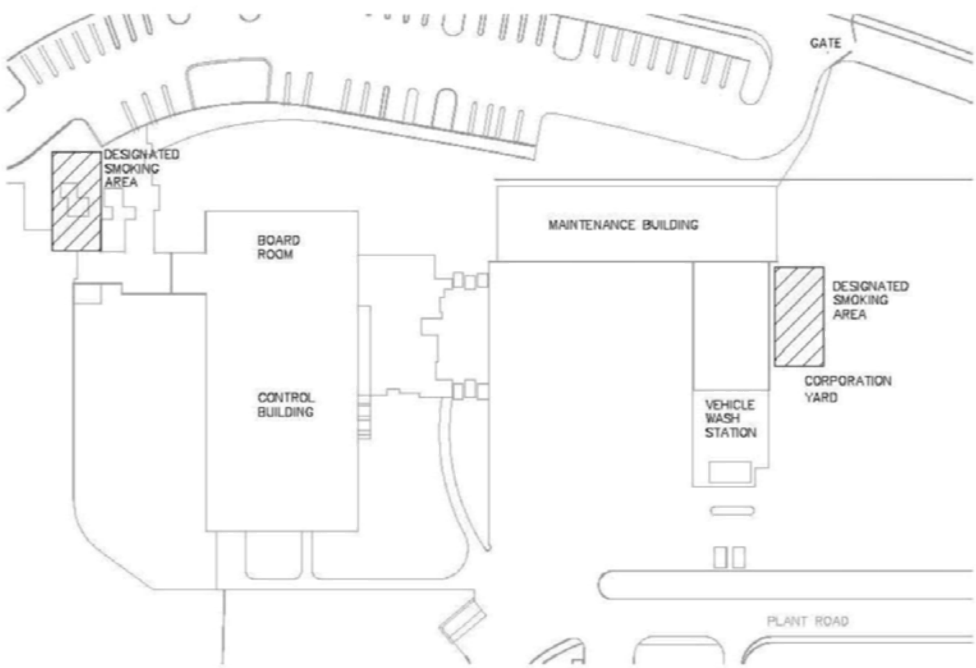


VICINITY MAP

(NOT TO SCALE)



SITE PLAN
(NOT TO SCALE)



DESIGNATED SMOKING AREA MAP
(NOT TO SCALE)

APPENDIX B

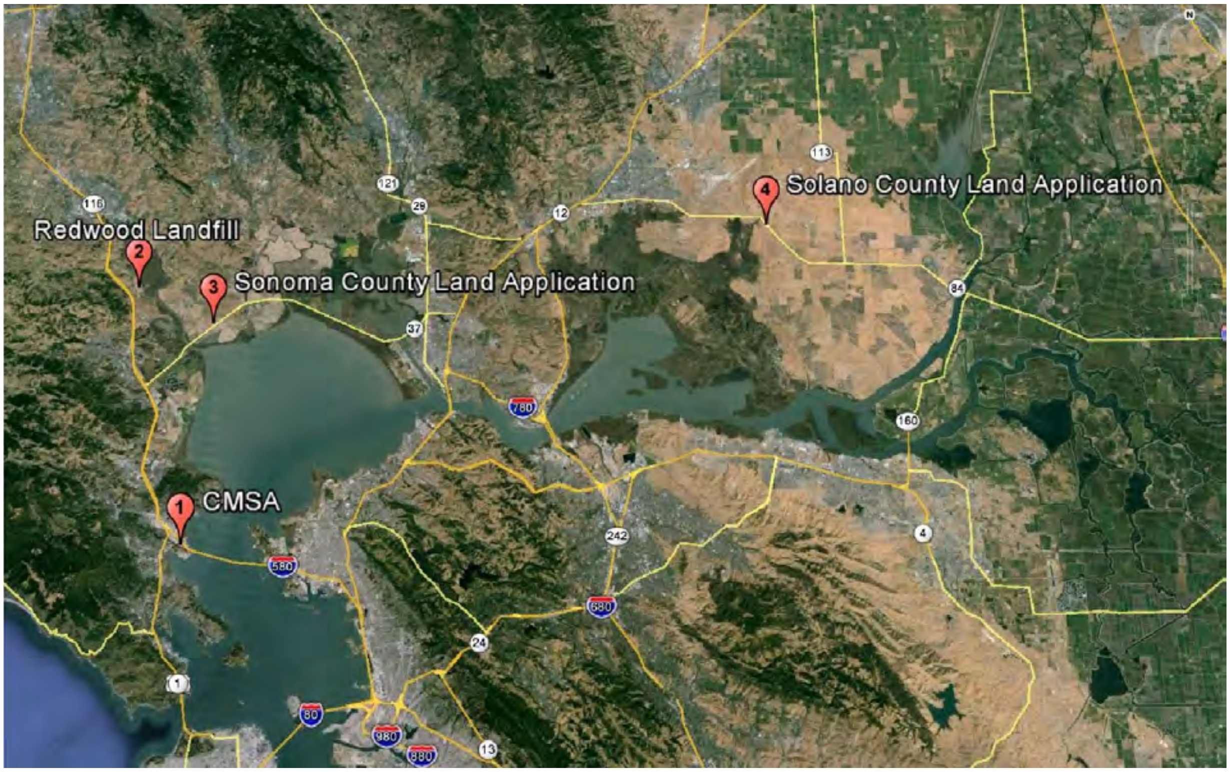
CMSA Solids Handling Building Photographs

Photo 1 - Truck entering solids handling loading bay

Photo 2 - Truck beneath biosolids hoppers

APPENDIX C

Landfill and Land Application Sites Location



1. CMSA: 1301 Andersen Dr. San Rafael CA;

2. Redwood Landfill site: 8950 Redwood Hwy Novato CA;

3. Sonoma County land application site: Highway 37 @ Highway 116 Sonoma County;

4. Solano County land application site: Hwy 12 and Lambie Road, Solano County.

5. Merced County land application site: 13757 Harmon Road, Dos Palos, CA (location is not shown on the map above)

APPENDIX D

Unit Cost Adjustment Procedures

Per Section 01100.N of the Contract Documents, CMSA will analyze the contract price every six months during the Contract term, including extensions, if any. The analysis is based on division of the contract price into fixed and variable costs, with the variable costs being raw material costs and transportation costs. The variable costs are calculated using the most recently-published US Bureau of Labor Statistics Producer Price Indexes, the Consumer Price Index and cost fractions listed below:

Variable Cost Component	**Applicable Index**	**Percentage of Unit Price**
Transportation	PPI for #2 Diesel Fuel (series ID #WPU05730302)	50%
Labor	San Francisco CPI – ID# CUURA422SA0,CUUSA422SA0 (Adjusted) for labor	10%

The contract price analysis is carried out as depicted in the example below – numbers are examples only, not actual costs. Cost adjustments, if any, will become effective on the first day of the month following each price analysis.

Diesel Fuel WPU05730302
San Francisco CPI: CUUSA422SA0
http://data.bls.gov/cgi-bin/srgate

	Original Bid Price	Diesel Fuel Index	Transport & Energy Cost Fraction	San Francisco CPI for Labor Index	Labor Cost Fraction	Fixed Costs	Final Cost
Cost Fraction			**50%**		**10%**	**40%**	
Contract Execution, Month Year Hauling to Redwood Landfill	$ 7.500	239.2	$ 3.750	225.692	$ 0.750	$ 3.000	$ 7.500
Contract Execution, Month Year Hauling to Lakeville Land Application	$ 9.000		$ 4.500		$ 0.900	$ 3.600	$ 9.000
Contract Execution, Month Year Hauling to Solano County Land Application	$ 18.000		$ 9.000		$ 1.800	$ 7.200	$ 18.000

First semi-annual adjustment Month Year		**Diesel Fuel Index**	**Transport & Energy Cost Fraction**	**San Francisco CPI for Labor Index**	**Labor Cost Fraction**	**Fixed Costs**	**Final Cost, Before Tax**
Previous Index		239.2		225.692			
Current Index		254.5		224.239			
Percent Change in Indices		6.40%		-0.64%			
New Commodity Fractions Hauling to Redwood Landfill			$ 3.990		$ 0.745	$ 3.000	$ 7.735
New Commodity Fractions Hauling to Lakeville			$ 4.788		$ 0.894	$ 3.600	$ 9.282
New Commodity Fractions Hauling to Lakeville			$ 9.576		$ 1.788	$ 7.200	$ 18.564
						Overall cost change	3.13%

Any cost adjustment calculations that fails to support a need to adjust price by at least 1.00% will not be implemented. When this happens, the subsequent price change will be calculated by comparing the current index value to the index value last used to calculate an allowable price change. This will allow for the accumulation of multiple "less than 1%" price changes.

APPENDIX E

Biosolids Fact Sheet

Biosolids are treated, stabilized, reusable solids from the wastewater treatment process. At Central Marin Sanitation Agency (CMSA), biosolids have been treated by anaerobic digestion and de-watered by centrifuges. The solid de-watered form is referred to as cake.

Biosolids are not a hazardous material. The biosolids cake produced at CMSA is primarily organic. It is beneficially reused as a soil amendment on agricultural land (land application). Routine analyses demonstrate that metals concentrations meet Environmental Protection Agency (EPA) standards which allow the material to be land-applied. Anaerobic digestion significantly reduces, but does not completely eliminate, pathogens (disease-causing microorganisms). Digesters, which are operated at specific time and temperature parameters, stabilize these solids over a period of weeks.

Typical Characteristics

Appearance	Black, semi-solid
Total Solids	26% (moisture 74%)
Volatile Solids	67% (mainly organic material)
pH	7 (neutral)
Ammonia nitrogen	1.4% (dry weight basis)
Total Kjeldahl nitrogen	5% (dry weight basis)
Pathogen Reduction	Meets EPA Class B
Metals	Meets EPA Table 3; non-hazardous per CA Title 22 TTLC + STLC

Handling

Biosolids are treated to reduce pathogens. Nonetheless, there is the potential for exposure to pathogenic microorganisms. Major routes of infection are ingestion, inhalation, and direct contact. Common sense, personal hygiene, and good work habits provide adequate protection for workers handling biosolids.

- Always wash hands after contact with biosolids.
- Never eat, drink, or smoke before washing hands.
- Avoid touching face, mouth, eyes, nose, or genitalia before washing hands.
- Use gloves if you will be handling biosolids.
- Do not smoke around biosolids.
- Do not chew tobacco or gum while working in direct contact with biosolids.
- Eat in designated areas away from biosolids handling activities.
- Keep wounds covered with clean dry bandages.
- Change into clean work clothes every day.

If contact occurs, wash area thoroughly with soap and water. Use antiseptic solutions on wounds, and bandage. For contact with eyes, flush thoroughly but gently.

Hazard Potential

Biosolids are not combustible under ordinary circumstances. If stored in an airtight container for an extended period, methane gas may be produced, which could ignite in the presence of a spark, cigarette, or open flame. Extinguish with dry chemical, water spray, or foam. Do not smoke, and avoid use of open flames in confined areas and around sealed transport vehicles. Vent confined areas and transport containers if biosolids have been stored for any significant length of time.

Hydrogen sulfide may also be generated in sufficient quantities to be a hazard in enclosed areas such as covered transport containers. Hydrogen sulfide gas, which smells like rotten eggs, is flammable and can be toxic. Exposure can be avoided by removing the container tarp prior to unloading, and discharging as much material as possible before employees enter the container.

CENTRAL MARIN
SANITATION AGENCY

Jason R. Dow P.E.
General Manager

1301 Andersen Drive, San Rafael, CA 94901-5339 Phone (415) 459-1455 Fax (415) 459-3971 www.cmsa.us

AMENDMENT #1

BIOSOLIDS HAULING CONTRACT (GL 6200-050-02)

AGREEMENT TO AMEND CMSA CONTRACT NO 15-28

This Amendment to the Agreement is made by and between Central Marin Sanitation Agency (hereinafter CMSA), a joint powers agency in Marin County, California, and Total Waste Systems (hereinafter Contractor).

RECITALS

A. CMSA entered into a Biosolids Hauling Agreement with Contractor, dated June 19, 2015, to provide all labor, equipment, materials, and supervision necessary to receive, transport, and unload biosolids from CMSA to designated biosolids reuse sites, and

B. CMSA and Contractor now desire to amend the Agreement to incorporate a new biosolids reuse site at 1010 Chadbourne Road, Fairfield, Solano County, California.

NOW, THEREFORE, in consideration of the recitals and mutual promises contained herein, CMSA and TWS agree to amend the above-referenced Agreement as follows:

1) Scope: Add Lystek Organic Materials Recovery Center site at 1010 Chadbourne Road, Fairfield, CA 94534 to the hauling destinations in the Agreement's Contract Specification Section 01100-K.

2) Fee: The unit price for transporting biosolids to Lystek Organic Material Recovery Center site is $21.50 per wet ton.

All other terms and provisions of the Agreement dated June 19, 2015 (as amended) remain unchanged.

IN WITNESS THEREOF, the parties have executed this Agreement and accept all terms and conditions this _________day of September 2016.

Total Waste Services	Central Marin Sanitation Agency
_________________________	_________________________
James R. Salyers, Vice President	Jason Dow, General Manager

BIOSOLIDS DISPOSAL & MANAGEMENT AGREEMENT
CUSTOMER
(Five Year)

This Agreement is made as of the first day of June, 2009, by and between REDWOOD LANDFILL, INC., a California corporation, hereinafter referred to as "REDWOOD" and, CENTRAL MARIN SANITATION AGENCY, hereinafter referred to as "CMSA".

RECITALS

A. REDWOOD is the operator of a landfill disposal site approximately four miles north of Novato, California to the east of Highway 101, which is hereinafter called the "Landfill."

B. The Landfill is a Class III disposal facility and it is properly permitted by the required local, state, and federal regulatory agencies to accept processed wastewater residuals, in the form of Class B Biosolids, which is hereinafter called "Biosolids" for disposal and/or reuse.

C. REDWOOD currently possesses a full solid waste facilities permit, and maintains facilities and equipment for co-composting of Class B Biosolids at the Landfill. REDWOOD also is currently permitted to utilize Class B Biosolids for Alternative Daily Cover (ADC) or disposal in the Landfill.

D. CMSA is currently responsible for the treatment, collection, and disposal and/or reuse of Biosolids from the CMSA's wastewater treatment plant, "The Wastewater Treatment Plant."

E The parties wish to enter into this Agreement for beneficial reuse or disposal of CMSA's Class B Biosolids from the Wastewater Treatment Plant, at the Landfill. Landfill will continuously and beneficially reuse CMSA's Biosolids, unless the operation warrants disposal in the Landfill.

AGREEMENT

Now Therefore, the parties agree as follows:

1. Delivery and Acceptance of Biosolids.

   a) CMSA shall deliver to REDWOOD Biosolids generated at the Wastewater Treatment Plant, but in any event no less than a total of 2,500 wet tons per year.

b) REDWOOD shall not be required to accept more than 40 wet tons of Biosolids per day or 7,500 wet tons per year, in the aggregate, without prior approval.

c) The primary Biosolids processing methods will be beneficial reuse, which includes Co-Composting and Alternative Daily Cover when biosolids are delivered to REDWOOD.

d) CMSA retains the right to beneficially reuse its biosolids, with land application May thru October, weather permitting.

e) REDWOOD shall use its best efforts to beneficially reuse all of CMSA's Biosolids.

2. Term and Extensions.

Unless otherwise terminated pursuant to this Agreement or by law, this Agreement shall have a term of five (5) years, commencing upon execution and ending June 30, 2014. Rates (paragraph 8, below) are effective July 1, 2009 so long as agreement is executed by all parties on or before this date. After the initial term of the Agreement, this agreement shall be extended in successive one (1) year increments unless either CMSA or REDWOOD provides written notice of termination at least 120 days prior to the expiration of the then-existing term.

3. Loading, Transportation and Discharge.

CMSA agrees to load from the Wastewater Treatment Plant, transport, unload and discharge Biosolids at REDWOOD, by themselves or through sub-contract haulers.

4. Direct Disposal.

CMSA shall have the right during the term of this Agreement to use available disposal capacity at REDWOOD up to 7,500 wet tons per year, and such excess capacity as may be made available by REDWOOD.

5. Source Reduction and Recycling Credits.

Source reduction and recycling credits obtained under any law as the result of any program implemented at REDWOOD, designed to reduce the volume of Biosolids disposed of by CMSA shall be credited to the Cities or unincorporated areas that are serviced by CMSA, as CMSA may solely determine.

6. <u>Biosolids Characteristics</u>.

a) CMSA hereby warrants and covenants that the Biosolids designated for delivery to REDWOOD for beneficial reuse or disposal shall be free of grit, screenings, common grease and trash, shall contain no hazardous or toxic materials or substances or pollutants in levels above applicable regulatory limits, and shall comply with applicable local, state, and federal statutes, ordinances, regulations and permit requirements, including without limitation, 40 CFR Part 503 and CCR Title 22. CMSA shall, at the time of tender, provide to REDWOOD accurate and complete documents, shipping papers or manifests as are required for the lawful transfer of the waste under all applicable federal, state or local laws or regulations. Tender of delivery shall be considered nonconforming if not in accordance with this Paragraph.

b) Title to and liability for Nonconforming Waste shall remain with CMSA at all times, until accepted by REDWOOD. Nonconforming Waste shall be defined as Biosolids that do not meet the requirements in Section 6a. REDWOOD shall have the right to inspect, analyze or test any waste delivered by CMSA. If CMSA's Waste is Nonconforming Waste, REDWOOD can, at its option, reject Nonconforming Waste and return it to CMSA or require CMSA to remove and dispose of the Nonconforming Waste at CMSA's expense. CMSA shall indemnify, hold harmless and pay or reimburse REDWOOD for any and all costs, damages and/or fines incurred as a result of or relating to CMSA's tender or delivery of Nonconforming Waste or other failure to comply or conform to this Agreement, including costs of inspection, testing and analysis. If REDWOOD elects to handle, rather than reject, Nonconforming Waste, REDWOOD shall have the right to manage the same in the manner deemed most appropriate by REDWOOD given the characteristics of the Nonconforming Waste. REDWOOD may assess and CMSA shall pay additional fees associated with delivery of Nonconforming Waste, including, but not limited to, special handling or disposal charges, and costs associated with different quantities of waste, different delivery dates, modifications in operations, specialized equipment, and other operational, environmental, health, safety or regulatory requirements. Title to and ownership of acceptable waste shall transfer to REDWOOD upon its final acceptance of such waste.

c) CMSA shall supply REDWOOD with laboratory analysis of dewatered Biosolids on a timely basis as required by regulatory agencies, waste discharge requirements, and REDWOOD's best management practices. CMSA shall provide REDWOOD with all dewatered Biosolids quality testing results for REDWOOD's site specific requirements, EPA priority pollutants, and State of California Title 22 listed compounds from tests conducted by CMSA or its contractors.

d) CMSA may implement pre-treatment standards to continue to improve the quality of the Biosolids produced and to maintain beneficial reuse as a viable alternative. Should CMSA's Biosolids fail to meet the EPA 503 Clean Biosolids (Class B) criteria, REDWOOD shall have the right to landfill these Biosolids at the rate detailed in paragraph 8b, as adjusted in accordance with paragraph 8.

7. Hours of Operation.

REDWOOD agrees that the facility shall be open to receive biosolids a minimum of 8 hours a day, 5 days a week. At the time of this contract, the landfill is available to receive Biosolids between the hours of 4:00am and 2:00pm Monday through Saturday. REDWOOD will notify CMSA in writing if the hours of receipt of Biosolids change during the term of this contract.

8. Measurements, Fees, Adjustments.

a) CMSA and REDWOOD have agreed that the method of measuring and recording the weight (wet tons) of Biosolids delivered to the Landfill shall be at the REDWOOD scale with loaded and unloaded vehicle weights taken upon entrance and exit, the difference (net weight of Biosolids) being the basis for measurement and payment.

b) CMSA shall pay to REDWOOD for the Biosolids delivered to the Landfill a base rate of $33.00 per wet ton.

c) The base rates per wet ton as listed above will be in effect for a period of one (1) year, beginning July 1, 2009 and continuing through June 30, 2010. Each year thereafter for the initial 5-year term, the "base rate," as adjusted herein, then in-effect, shall be adjusted by a factor equal to the Consumer Price Index ("CPI") defined in (e) below, provided that the adjustment shall not be greater than five percent in any one year over the rate in effect the preceding year. All adjustments will be rounded up to nearest $0.10 increment. By way of example, if the base rate as of June 30, 2010, is $33.00 and if the CPI for the prior year is 3%, the new base rate shall be $33.00 x 1.03 = $33.99; rounded to $34.00 for the period.

d) All amounts payable are due within thirty (30) calendar days following receipt of an invoice. REDWOOD will be billing CMSA for Biosolids received at the Landfill.

e) "CPI" Consumers Price Index (All Urban Consumers) for the San Francisco-Oakland-San Jose Area) adjustments are to be defined, as published by the Bureau of Labor and Statistics, as the Annual Percent

Change for the previous calendar year, as compared to the year immediately preceding that year. The CPI values will be for the month of April, as published in the month of May, from the base year preceding the execution date and the year preceding each adjustment date. By example, if the All Urban Consumers Percent Change for the Year ending April 2010, published in May 2010, for the San Francisco-Oakland-San Jose area, is 3.0% over the base year CPI published for April 2009, then the new base rate will be $34.00 as calculated in paragraph (c) above.

f) In addition, rates may be increased over and above the CPI adjustment to cover REDWOOD's additional costs incurred to comply with any Changes in Law, Permits, or other regulatory requirements, which occur after the Effective Date of this Agreement including any changes in law effecting closure and post-closure obligations. Said changes in law, permit requirements, or regulatory requirements shall include, but are not limited to: (i) any new laws, permits, or regulations enacted or promulgated after the Effective Date of this Agreement; (ii) any amendments to or revisions of existing laws, permits, or regulations which amendments or revisions become effective after the Effective Date of this Agreement; (iii) any judicial or administrative agency declarations or interpretations of laws, permits, or regulations which declarations or interpretations effect change in existing law and are issued after the Effective Date; and (iv) any imposition of any fees or charges or changes in fees or charges by any federal, state, or local entity, including but not limited to mitigation and/or host fees, which in the case of said fees shall be treated as a pass through. REDWOOD shall notify CMSA in writing within sixty (60) days of all changes in law or permit requirements, or the imposition of new fees or charges and the rate adjustment. The rate adjustment shall be effective immediately upon notice.

g) If at the end of any year during the term of this Agreement, CMSA has not fulfilled the minimum tonnage requirement as provided for in Section 1, CMSA shall pay to REDWOOD an amount equal to $16.00 per ton for the difference between the tonnage delivered and the annual minimum. Such amount shall be invoiced to CMSA and shall be due in accordance with 8(d) above. In the event that REDWOOD terminates this Agreement pursuant to Section 9, CMSA has no obligation to meet the minimum tonnage requirement in the year in which the Agreement is terminated.

9. <u>Certain Rights of Termination or Suspension</u>.

a) REDWOOD shall use its best efforts to obtain all required governmental approvals relating to acceptance and handling of

Biosolids and keep them in force during the term of this Agreement. REDWOOD shall have the option to terminate this Agreement in the event of any change in law, regulations, or permits which would either prohibit operation of the Landfill or substantially change or alter the requirements with respect to the manner in which the Landfill must be operated so as to make its continued operation economically infeasible. This Agreement shall terminate or be suspended in the event that REDWOOD's authority to operate the Landfill is revoked or suspended for reasons beyond its control. REDWOOD shall notify CMSA immediately upon the occurrence of any event that could cause the revocation or suspension of REDWOOD's authority to operate the Landfill.

b) The Agreement shall terminate should CMSA lose authority to operate CMSA's wastewater treatment plant.

c) REDWOOD will use their best efforts to make certain that the Landfill will be available for receipt of Biosolids on a regular basis throughout each disposal period. In the event of causes or events beyond the reasonable control and without the fault or negligence of REDWOOD or CMSA including but not limited to fire, flood, earthquake, or other natural disaster, war, strike, work stoppage, and any material change in deliverable Biosolids, or any applicable law, rule, regulation or related administrative policy or practice, the affected party may temporarily suspend performance under this Agreement. Any such suspension shall not be deemed a default under this Agreement and the parties shall not have liability to each other for the resulting non-performance. In such event, the affected party shall give the other party as much advance notice of such conditions as is reasonably possible under the circumstances and will make every effort to remedy its inability to perform and to ensure that the suspension of performance is of no greater scope and of no longer duration than required by the event.

10. <u>Compliance with Regulatory Requirements</u>.

a) REDWOOD shall comply with all existing and future permit requirements for operation of the Landfill. REDWOOD shall act expeditiously to comply with all regulatory requirements to prevent short-term and long-term impacts to their Biosolids disposal and/or reuse operations. If requested, REDWOOD shall permit CMSA to examine at REDWOOD's office, copies of regulatory orders, waste discharge permit requirements and correspondence to regulatory agencies related to processing / composting of Biosolids. REDWOOD will use its best efforts to make certain that the Landfill is available for the continuous receipt of the CMSA's Biosolids throughout the term of this Agreement, including any extensions.

b) CMSA has been advised that in order to continue to accept Biosolids from CMSA, REDWOOD may from time to time, be required to amend their existing permits from various governmental bodies having jurisdiction over the Landfill. There is no guarantee that the necessary amendments will be approved. The obligations of REDWOOD under this Agreement are conditioned upon its ability to secure and maintain all necessary permits and approvals.

11. Rules.

REDWOOD reserves the right to make reasonable rules with respect to the operation of vehicles within the Landfill to insure the safety and preservation of the property. CMSA agrees to enforce upon its subcontract haulers the requirement to abide by such rules and regulations.

12. Notices.

All notices which may be given hereunder, shall be in writing and may be personally delivered or shipped to the physical addresses of the parties set forth below, or may be mailed, postage prepaid, certified mail, return receipt requested to the other party at such mailing (post office box) address.

REDWOOD LANDFILL, INC.
8950 Redwood Highway
Novato, CA 94945
P.O. Box 793
Novato, CA 94948
Attention: District Manager

Central Marin Sanitation Agency (CMSA)
1301 Andersen Dr.
San Rafael, CA 94901
Attention: General Manager

Either party may, by written notice to the other, change the address for delivery of subsequent notices to it hereunder.

13. No Third Party Beneficiaries.

This Agreement is not intended for the benefit of any persons or entities other than the parties hereto and their successors in interest.

14. Indemnification.

a) REDWOOD shall indemnify, hold harmless and defend CMSA's officers, directors and employees, its members including San Rafael Sanitation District, City of Larkspur, Sanitary District No. 1 and Sanitary District No. 2 of Marin County, the City of San Rafael, the Town of Corte Madera, and their officers, officials, employees and volunteers, from and against all liabilities, expenses (including, but not limited to, reasonable attorney's fees and expenses of investigation and litigation), claims and damage which any such person or entity may at any time suffer or sustain or become liable for by reasons of any accidents, damages or injures, including, without limitation, injuries resulting in death, either to persons or property, real or personal, or both, in any manner caused by or resulting from the sole negligence, gross negligence or willful misconduct of REDWOOD or its employees or agents, or resulting from the breach of, misrepresentation in, untruth in or inaccuracy in any representation, warranty or covenant of REDWOOD set forth in this Agreement.

b) CMSA shall indemnify and hold harmless REDWOOD and all its affiliates, and their respective officers, directors and employees, from and against all liabilities, expenses (including, but not limited to, reasonable attorneys' fees and expenses of investigation or litigation), claims and damage which any such person or entity may at any time suffer or sustain or become liable for by reason of any accidents, damages or injuries, including, without limitation, injuries resulting in death, either to persons or property, real or personal, or both, in any manner caused by or resulting from the sole negligence, gross negligence, or willful misconduct of both CMSA and CMSA's subcontract hauler's employees or agents, or resulting from the breach of, misrepresentation in, untruth in or inaccuracy in any representation, warranty or covenant of CMSA set forth in this Agreement.

15. Insurance.

At all times during the Term of this Agreement, CMSA and REDWOOD shall keep in force and effect workers' compensation and general liability insurance, either with an insurance company licensed to do business in the State of California or through a self-insurance program duly approved by the State of California in the amount required by law for workers' compensation and in an amount of at least one million dollars ($1,000,000) with respect to injury or death to any one person and two million dollars ($2,000,000) with respect to injury or death to more than one person in any one accident or other occurrence, and one hundred thousand dollars ($100,000) with respect to damage to property. CMSA and REDWOOD shall provide to each other upon request certificates or other evidence of such insurance and shall cause any such insurer to notify the other party at least thirty (30) days prior to the cancellation of any such insurance

REDWOOD shall obtain, and keep in force and effect during the entire term of this Agreement, insurance which meets the specific terms of the CMSA's insurance requirements, attached hereto as Exhibit A.

16. Understanding.

This agreement represents the entire understanding of the parties regarding the subject matter herein contained, and any modification hereof must be in writing signed by both parties.

17. Void Provisions.

If any provision to this agreement is determined by court of competent jurisdiction to be void or unenforceable as a matter of law, the remaining provisions hereof shall continue in full force and effect.

18. Governing Law.

This Agreement is made in and shall be governed by the laws of the State of California.

IN WITNESS WHEREOF, the parties have executed this agreement effective upon the date above written.

CMSA	REDWOOD LANDFILL, INC.
By: [signature]	By: [signature]
General Manager	Area Vice President
5/12/09	

such insurance and shall cause any such insurer to notify the other party at least thirty (30) days prior to the cancellation of any such insurance

REDWOOD shall obtain, and keep in force and effect during the entire term of this Agreement, insurance which meets the specific terms of the CMSA's insurance requirements, attached hereto as Exhibit A.

16. Understanding.

This agreement represents the entire understanding of the parties regarding the subject matter herein contained, and any modification hereof must be in writing signed by both parties.

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If any provision to this agreement is determined by court of competent jurisdiction to be void or unenforceable as a matter of law, the remaining provisions hereof shall continue in full force and effect.

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This Agreement is made in and shall be governed by the laws of the State of California.

IN WITNESS WHEREOF, the parties have executed this agreement effective upon the date above written.

CMSA	REDWOOD LANDFILL, INC.
By:	By:
General Manager	Vice President
5/12/09	

wet sign: 6/1/09

Biosolids Land Application Agreement
Between
Central Marin Sanitation Agency and Synagro West, LLC.

This Biosolids Management Agreement ("AGREEMENT") made and entered into this 10th day of **December 2014** and shall be effective January 1, 2015 (the EFFECTIVE DATE) by and between **Central Marin Sanitation Agency** ("AGENCY") and **Synagro West, LLC** ("CONTRACTOR").

WITNESSETH:

In consideration of the following covenants and agreements, the AGENCY and the CONTRACTOR hereby agree as follows:

SECTION 1 DEFINITIONS

For purposes of this AGREEMENT, the following terms shall have the meanings set forth below. Capitalized terms not specifically defined in this Section 1 shall have the meanings ascribed to them elsewhere in this AGREEMENT.

1.1 "AUTHORIZATIONS" means all governmental authorizations, including but not limited to permits, applications, notices of intent, registrations, variances, and exemptions, required for the removal, transportation, land application and/or other beneficial reuse of BIOSOLIDS in compliance with all applicable LEGAL REQUIREMENTS.

1.2 "BIOSOLIDS" means sewage sludge meeting Class B pathogen requirements, vector attraction reduction requirements and pollutant concentrations (as defined by Title 40 Code of Federal Regulations (C.F.R.), Part 503 and State of California requirements for land application) that have been dewatered at AGENCY'S expense to a minimum of 20% solids concentration. Biosolids do not include any HAZARDOUS MATERIALS or substance and must be suitable for either land application or beneficial reuse under all applicable laws.

1.3 "LEGAL REQUIREMENT" means any governmental requirement, including but not limited to any applicable federal, state, or local law, rule, regulation, ordinance, order, decision, principle of common law, AUTHORIZATIONS, consent decree or order, of any GOVERNMENTAL AUTHORITY, now or hereafter in effect, including without limitation, ENVIRONMENTAL LAWS.

1.4 "ENVIRONMENTAL LAWS" means any applicable federal, state, or local law, rule, regulation, ordinance, order, decision, AUTHORIZATIONS, principle of common law, consent decree or order, of any GOVERNMENTAL AUTHORITY, now or hereafter in effect relating to HAZARDOUS MATERIALS, BIOSOLIDS, or the protection of the environment, health and safety, or a community's right to know, including but not limited to , the Comprehensive

Environmental Response, Compensation, and Liability Act, the Resource Conservation and Recovery Act, the Safe Drinking Water Act, the Clean Water Act, the Clean Air Act, the Emergency Planning and Community Right to Know Act, the Hazardous Materials Transportation Act, the Occupational Safety and Health Act, and any analogous state or local law.

1.5 "GOVERNMENTAL AUTHORITY" means any governmental authority, including but not limited to foreign governments, the United States of America, any State of the United States of America, any local authority, and any political subdivision of any of the foregoing, and any agency, department, commission, board, bureau, court, tribunal or any other governmental authority having jurisdiction over this AGREEMENT, BIOSOLIDS, AGENCY, CONTRACTOR or any of their respective assets, properties, sites, facilities or operations.

1.6 "HAZARDOUS MATERIALS" means any "petroleum," "oil," "hazardous waste," "hazardous substance," "toxic substance," and "extremely hazardous substance" as such terms are defined, listed, or regulated under ENVIRONMENTAL LAWS, or as they become defined, listed, or regulated under ENVIRONMENTAL LAWS.

1.7 "REMEDIAL WORK" means environmental work, including but not limited to investigations, monitoring, clean-up, containment, removal, storage, remedial or restoration work associated with HAZARDOUS MATERIALS and/or BIOSOLIDS.

SECTION 2 SCOPE OF SERVICES

The CONTRACTOR shall provide biosolids management services to the AGENCY that include land application and/or other beneficial reuse in accordance with the terms of this AGREEMENT (hereinafter called SERVICES) of the AGENCY'S BIOSOLIDS generated by the AGENCY at its Wastewater Treatment Plant located in San Rafael, California (the PLANT).

SECTION 3 CONTRACTOR OBLIGATIONS

The CONTRACTOR shall:

3.1 Within one (1) week after receipt of notice from the AGENCY, receive for land application or other beneficial reuse the AGENCY's BIOSOLIDS and, in connection with such activities, maintain AUTHORIZATIONS and landowner agreements required of CONTRACTOR for agricultural land application and/or disturbed land reclamation in accordance with all applicable LEGAL REQUIREMENTS which are currently in effect, or which take effect during the term of this AGREEMENT.

3.2 Will accept BIOSOLIDS from the AGENCY at the Sonoma County Site located at the Hwy 37 and Lakeville Hwy site (subject to site availability), the Solano County Site located at the Hwy 12 and Lambie Road site and one (1) load per year at the Central Valley Compost Facility located at 13757 Harmon Road, Dos Palos, (collectively "Disposal Sites") during the term of this AGREEMENT.

3.3 At the written request of AGENCY, and as applicable, provide any AUTHORIZATIONS which are issued by applicable GOVERNMENTAL AUTHORITIES for all land approved for BIOSOLIDS land application and/or beneficial reuse.

3.4 Notify in writing the AGENCY within two (2) working days of its receipt of any notice of negative event, including but not limited to any violation, legal action, lawsuit, claim, citation, fine or other legal proceeding against CONTRACTOR relating to any aspect of the AGENCY's BIOSOLIDS managed pursuant to this AGREEMENT or CONTRACTOR's SERVICES.

3.5 For BIOSOLIDS which are land applied, employ land application methods approved or allowed by applicable GOVERNMENTAL AUTHORITIES and any private property owner, whose land is accepting the BIOSOLIDS, whichever is stricter.

3.6 Provide monitoring, record keeping, and reporting programs as required by applicable LEGAL REQUIREMENTS, and as set forth in Section 9 of this AGREEMENT.

3.7 Procure and maintain throughout the entire term of this Agreement the insurances set forth in Section 8 of this AGREEMENT.

3.8 Indemnify, defend, and hold harmless AGENCY, its officers, commissioners, employees, and volunteers, its members including San Rafael Sanitation District, the City of Larkspur, Sanitary District No. 1 and Sanitary District No. 2 of Marin County, the City of San Rafael, the Town of Corte Madera, and their directors, officers, officials, employees and volunteers (hereinafter referred to collectively in this section as AGENCY INDEMNITEES) from and against all claims, damages, losses, costs, suits, settlements, causes of action, liabilities (INCLUDING WITHOUT LIMITATION STRICT LIABILITIES) fines, penalties, costs, and expenses (including but not limited to, investigation and legal expenses, and costs and expenses associated with REMEDIAL WORK) (collectively, CLAIMS) to the extent caused by a breach of obligations under this AGREEMENT or violation of applicable LEGAL REQUIREMENTS by CONTRACTOR, or its employees, officers, directors, representatives, contractors, subcontractors, agents, or affiliates, or any licensee in the performance of SERVICES pursuant to this AGREEMENT.

3.9 Comply with all LEGAL REQUIREMENTS applicable to CONTRACTOR's provision of the SERVICES.

3.10 CONTRACTOR's obligations to receive for land application or for beneficially reuse BIOSOLIDS shall be suspended during a Force Majeure event.

SECTION 4 AGENCY OBLIGATIONS

The AGENCY shall:

4.1 Provide to CONTRACTOR for land application and/or beneficial reuse at least eighty percent (80%) of the volume of BIOSOLIDS generated at the PLANT during the period April 16 and October 31 of each year that this AGREEMENT is in effect, providing CONTRACTOR has available capacity during that time.

4.2 AGENCY shall have the right, but not obligation on a random basis, to have access to the Disposal Sites or any other location the CONTRACTOR uses for BIOSOLIDS storage, land application or beneficial reuse for inspection. The purpose of the inspections is to ensure all applicable regulations are being satisfied, including site restrictions as specified by the LEGAL REQUIREMENTS, including but not limited to Title 40 CFR, Part 503, and any conditions that may present a public nuisance or adversely affect the storage, land application or reuse of the AGENCY's BIOSOLIDS. The CONTRACTOR's on-site manager will be notified of the inspections in advance to allow access. Any findings of the inspection that AGENCY considers to be either a regulatory compliance issue or a reason for concern, will be sent to CONTRACTOR for review, comment and correction, if required.

4.3 Provide CONTRACTOR written notice of the concentration of total nitrogen (as N on a dry weight basis) in the BIOSOLIDS which AGENCY provides, plus all other information which CONTRACTOR may request to facilitate its compliance with applicable LEGAL REQUIREMENTS, including but not limited to 40 C.F.R. Part 503 and Title 22, California Code of Regulations (CCR), Division 4.5. Information which CONTRACTOR may obtain shall include, without limitation, the monthly average concentrations (in milligrams per kilogram) of arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc per 40 C.F.R. Part 503 or other potentially HAZARDOUS MATERIALS present in the BIOSOLIDS as defined in Title 22, CCR, Division 4.5, the level of pathogen reduction which AGENCY has achieved, and the method of vector attraction reduction which AGENCY has applied. The methods and procedures by which AGENCY samples and analyzes concentrations of potentially HAZARDOUS MATERIALS, pathogen reduction, and vector attraction reduction, shall comply with methods and procedures prescribed by applicable LEGAL REQUIREMENTS, including without limitation 40 C.F.R. Part 503 and Title 22, CCR, Division 4.5. AGENCY shall provide CONTRACTOR with a certification regarding concentrations of HAZARDOUS MATERIALS, pathogen reduction, and vector attraction reduction, as well as certification that all methods and procedures used by customer for the sampling and analysis of BIOSOLIDS comply with requirements of 40 C.F.R. Part 503, Title 22, CCR, Division 4.5, and any other applicable LEGAL REQUIREMENTS. The form of certification, and the type of information which the CONTRACTOR may request from AGENCY may include the form of certification or the type of information which AGENCY must maintain under 40 C.F.R. § 503 .17. CONTRACTOR shall have the undisputed right to rely upon any information or certification provided by AGENCY, and shall not have any independent duty to investigate or inquire regarding the subject matter of the AGENCY's certification or of the information which AGENCY provides to CONTRACTOR.

4.4 Not provide to CONTRACTOR any BIOSOLIDS which contain HAZARDOUS MATERIAL or are hazardous in accordance with 40 C.F.R. Part 261, other federal law, state law, or which contains a concentration of polychlorinated biphenyls equal to or greater than 50 milligrams per kilogram of total solids (on a dry weight basis).

4.5 Provide CONTRACTOR with at least one (1) week advance notice of when AGENCY will require the CONTRACTOR to receive BIOSOLIDS generated at the PLANT at one of the Disposal Sites.

4.6 Indemnify, defend, and hold harmless CONTRACTOR from and against all claims, damages, losses, costs, suits, settlements, causes of action, liabilities (INCLUDING WITHOUT LIMITATION STRICT LIABILITIES) fines, penalties, costs, and expenses (including but not limited to, investigation and legal expenses, and costs and expenses associated with REMEDIAL WORK) (collectively, CLAIMS) arising out of or in connection with any acts or omissions of AGENCY, or its employees, officers, directors, representatives, contractors, subcontractors, agents, or affiliates, or any licensee or invitee of the PLANT (other than CONTRACTOR), or AGENCY'S breach of any of its obligations under this AGREEMENT, or any violation of any applicable LEGAL REQUIREMENT by AGENCY or its employees, officers, directors, representatives, contractors, subcontractors, agents, or affiliates, or any discrepancy in the character or composition of the BIOSOLIDS from the PLANT compared to analytical results, certifications or other information provided by AGENCY to CONTRACTOR.

4.7 AGENCY will not haul or authorize disposal of the AGENCY's BIOSOLIDS at any other site owned or operated by CONTRACTOR, unless mutually agreed upon in writing in advance.

4.8 Notify the CONTRACTOR of operating changes or any other conditions that would reasonably be expected to affect the BIOSOLIDS handled by CONTRACTOR under this AGREEMENT.

SECTION 5 TERM

This AGREEMENT shall be effective from the EFFECTIVE DATE until December 31, 2019 (the INITIAL TERM). At the end of this INITIAL TERM, this AGREEMENT shall terminate unless it is extended on a yearly or longer basis as mutually agreed in writing by both parties.

SECTION 6 AGREEMENT PRICE

6.1 Except as otherwise provided in this AGREEMENT, AGENCY will pay the following fixed prices for CONTRACTOR's SERVICES hereunder for the duration of the INITIAL TERM of this Agreement:

Year 1	\$28.00 per wet ton at Sonoma site \$16.50 per wet ton at Solana site \$0 per wet ton at Dos Palos site (one load only per year)

6.2 Each truck load received at the CONTRACTOR'S approved disposal site shall be considered 17.5 wet tons for accounting and billing purposes. The AGENCY and the CONTRACTOR may negotiate a different tonnage once each anniversary year. The CONTRACTOR shall provide the AGENCY with an accounting of the truck loads received from the AGENCY'S PLANT.

6.3 After Year 1, if there are documented increases in CONTRACTOR'S costs due to changes in LEGAL REQUIREMENTS, CONTRACTOR may no more than once each anniversary year, request an increase in the fixed price per wet ton per site set forth above, which shall be negotiated by the parties in good faith and be effective at the beginning of the next anniversary of the EFFECTIVE DATE. In addition, the CONTRACTOR'S stated prices shall be increased each anniversary consistent with the All Urban Consumers Price Index for the San Francisco-Oakland-San Jose, CA, 82-84=100 (CPI-U) provided that the adjustment shall not be greater than five percent in any one year over the rate in effect the preceding year. CPI adjustments shall automatically become effective on the anniversary date of the EFFECTIVE DATE.

SECTION 7 PAYMENT

7.1 The CONTRACTOR shall submit an invoice to the AGENCY once each month for SERVICES provided by CONTRACTOR the prior month, using the rates and the amounts agreed in Section 6 of this AGREEMENT. The AGENCY shall pay all invoices within thirty (30) days after receipt of the invoice.

7.2 It is agreed that in the event of any dispute concerning invoice amount, AGENCY will pay CONTRACTOR the undisputed portion of the invoice amount within thirty (30) days after receipt of the invoice.

SECTION 8 INSURANCE

The CONTRACTOR shall procure and maintain throughout the term of this AGREEMENT the following insurance policies:

8.1 Worker's Compensation meeting at least the minimum requirements of the laws of the State of California, and Employer's Liability with a minimum single limit of $1,000,000. The Workers' Compensation policy shall be endorsed with a waiver of subrogation in favor of the AGENCY for all work performed by the CONTRACTOR.

8.2 Commercial General Liability and Automobile Liability Insurance to include premises, operations, and subcontractors. Completed Operations and Contractual Liability are to be included under the Commercial General Liability coverage. The insurance policies will have limits of no less than $1,000,000 per occurrence and $2,000,000 aggregate.

8.3 The insurances required by this AGREEMENT may be contained in one or more policies issued by one or more insurers; provided, however, that such insurers shall be authorized to sell insurance in California, and otherwise be reasonably acceptable to the AGENCY.

8.4 Each insurance policy shall provide that no cancellation, non-renewal, reduction in coverage or substantial modification shall occur without the insurer giving at least 30 days' advance written notice to AGENCY. Upon AGENCY's receipt of any such notice, CONTRACTOR shall file with AGENCY a copy of the required new or renewed policy, or a certificate evidencing the procurement of such policy if the AGENCY so elects in its sole discretion, at least ten days before the effective date of the scheduled cancellation, non-renewal, reduction or other modification.

8.5 Within ten days after execution of this AGREEMENT and from time to time thereafter upon the AGENCY's request, CONTRACTOR shall deliver to the AGENCY certificates of insurance evidencing that all required insurance coverages are in full force and effect (provided that the AGENCY may require copies of all required insurance policies and endorsements).

8.6 AGENCY and the AGENCY INDEMNITEES shall be named as additional insureds under the liability and automobile insurance policies described above. These policies shall provide coverage for all the additional insureds against direct or contingent loss or liability for bodily and personal injury, death or property damage, arising out of, in connection with or incident to this AGREEMENT or the SERVICES provided by CONTRACTOR, and shall cover all supervisory acts and other activities performed by for or on behalf of CONTRACTOR.

SECTION 9 RECORD KEEPING

The CONTRACTOR shall maintain records and submit a summary report to the AGENCY after each hauling event (as requested by AGENCY) and on an annual, cumulative basis. Reports shall include information regarding, but not be limited to:

9.1 Number of loads transported and applied with identification of disposal site(s).

9.2 Such other information as will reasonably allow AGENCY to fulfill its recordkeeping and reporting requirements under applicable LEGAL REQUIREMENTS.

SECTION 10 NOTICES

10.1 Except as otherwise provided herein, any notice, demand or other communication shall be in writing and shall be personally served, sent by commercial courier service or prepaid registered or certified mail, or sent by telephonic facsimile delivery with confirmation thereof. Any such notice shall be deemed communicated upon receipt.

10.2 The following address is hereby designated as the legal address of the CONTRACTOR. Such address may be changed at any time by notice in writing delivered to AGENCY.

Synagro West, LLC
3110 Gold Canal Drive, Suite E.
Rancho Cordova, CA 95670
Attn: Regional General Manager
Phone: (916) 862-9300
Fax: (916) 863-2065

With a copy to:
Diana Floyd, General Counsel
Synagro Technologies, Inc.
435 Williams Court, Suite 100
Baltimore, MD 21220
Phone: (443) 489-9000
Fax: (443) 489-9042

10.3 The following address is hereby designated as the legal address of the AGENCY. Such address may be changed at any time by notice in writing delivered to CONTRACTOR.

Name:	Central Marin Sanitation Agency
Street Address:	1301 Andersen Drive
Mailing Address:	San Rafael, CA 94901
Phone Number:	(415) 459 -1455
Fax Number:	(415) 459-3971
Contact Person:	Jason Dow, General Manager

SECTION 11 FORCE MAJEURE

Wherever the word "Force Majeure" is used, it should be understood to mean:

11.1 acts of God, landslides, lightning, earthquakes, hurricanes, tornadoes, blizzards and other adverse and inclement weather, fires, explosions, floods, acts of a public enemy, wars, blockades, insurrections, riots or civil disturbances;

11.2 labor disputes, strikes, work slowdowns, or work stoppages;

11.3 orders or judgments of any Federal, State or local court, administrative agency or governmental body, if not the result of willful or negligent action of the party relying thereon;

11.4 power failure and outages affecting the PLANT or Disposal Sites; and

11.5 any other similar cause or event, including a change in law, regulation, ordinance or permit, provided that the foregoing is beyond the reasonable control of the party claiming Force Majeure.

If, because of Force Majeure event any party's cost is increased by more than 15% or any party hereto is rendered unable, wholly or in part, to carry out its obligations under this AGREEMENT, then such party shall give to the other party prompt written notice of the Force Majeure event with sufficient details and documentation evidencing the event; thereupon the obligation of the party giving the notice, so far as they are affected by the Force Majeure event, shall be suspended during, but no longer than, the continuance of the Force Majeure event. The affected party shall use all possible diligence to remove the Force Majeure event as quickly as possible, but its obligation shall not be deemed to require the settlement of any strike, lockout, or other labor difficulty contrary to the wishes of the party involved. If, because of a Force Majeure event, CONTRACTOR'S cost is increased then AGENCY agrees to increase the price paid to CONTRACTOR to cover those increased costs for the duration of the Force Majeure event. However, if because of Force Majeure CONTRACTOR'S cost is increased by more than 15% then AGENCY may suspend performance for the duration of the Force Majeure event.

SECTION 12 RIGHT OF TERMINATION

12.1 AGENCY may terminate this AGREEMENT upon (10) days prior written notice to CONTRACTOR and have no further obligation to CONTRACTOR as follows:

12.1.1 If either (i) the CONTRACTOR fails to observe or perform any material covenant or agreement contained in this AGREEMENT for ten (10) business days after written notice thereof has been given to the CONTRACTOR or (ii) at any time upon the insolvency of CONTRACTOR, or the institution by or against the CONTRACTOR of any proceeding in bankruptcy or insolvency or for the appointment of a receiver or trustee or for an assignment for the benefit of creditors.

12.2 CONTRACTOR may terminate this AGREEMENT upon written notice to AGENCY and have no further obligation to AGENCY if:

12.2.1 The CONTRACTOR is unable to utilize the BIOSOLIDS due to a change in any LEGAL REQUIREMENTS that renders the SERVICES illegal, or place such restrictions or requirements thereon so as to make the provision of the SERVICES cost prohibitive or to otherwise frustrate the commercial intent of this AGREEMENT.

12.2.2 The BIOSOLIDS become unsuitable for land application by the CONTRACTOR by reason of (i) the act or omission of any third party or AGENCY, and through no fault of CONTRACTOR, or (ii) the condition of the BIOSOLIDS is materially inconsistent with the description and analysis, certifications or other information the AGENCY has provided to the CONTRACTOR regarding the BIOSOLIDS, including analytical results attached in **Exhibit A**, or (iii) AGENCY breaches its obligations hereunder regarding the quality of the BIOSOLIDS.

12.2.3 In the event of any change in federal, state or local law or regulation, or any change in any one of CONTRACTOR'S permits, which is implemented during the INITIAL TERM of this AGREEMENT or any extension and which results in a significant increase or decrease in the cost of performing the SERVICES, and the AGENCY and CONTRACTOR are unable to negotiate a mutually agreeable adjustment to the payment terms specified in this AGREEMENT. .

12.2.4 If either (i) the AGENCY fails to observe or perform any material covenant or agreement contained in this AGREEMENT for ten (10) business days after written notice thereof has been given to the AGENCY or (ii) at any time upon the institution by or against the AGENCY of a Chapter 9 proceeding.

SECTION 13 ASSIGNMENT

The AGENCY and/or CONTRACTOR shall have the right to assign this AGREEMENT in writing to any successor in interest, subject to the written approval of the other party, which approval shall not be unreasonably withheld.

SECTION 14 GENERAL PROVISIONS

14.1 Governing Law. This AGREEMENT and all the rights and duties of the parties arising from or relating in any way to the subject matter of this AGREEMENT or the SERVICES contemplated by it, shall be governed by, construed, and enforced in accordance with the laws of the state of California.

14.2 Costs and Fees. The prevailing party in any legal proceeding brought by or against the other party to enforce any provision or term of this AGREEMENT shall be entitled to recover against the non-prevailing party the reasonable attorneys' fees, court costs and other expenses incurred by the prevailing party.

14.3 No Special Damages. Neither party will be liable to the other party for indirect, special, incidental, punitive, or consequential damages (including without limitation, damages resulting from loss of profits), even if such party has been notified of the possibility or likelihood of such damages.

14.4 Consent to Breach Not Waiver. No term or provision hereof shall be deemed waived and no breach excused, unless such waiver or consent is in writing and signed by the party claimed to have waived or consented. No consent by any party to, or waiver of, a breach by the other party shall constitute consent to, waiver of, or excuse of any other different or subsequent breach.

14.5 Severability. If any term or provision of this AGREEMENT should be declared invalid by a court of competent jurisdiction, (i) the remaining terms and provisions of this AGREEMENT shall be unimpaired, and (ii) the invalid term or provision shall be replaced by such valid term or provision as comes closest to the intention underlying the invalid term or provision.

14.6 Entire Agreement. This agreement hereto constitute the complete and exclusive statement of the agreement between the parties with regard to the matters set forth herein, and it supersedes all other agreements, proposals, and representations, oral or written, express or implied, with regard thereto.

14.7 Amendments. This AGREEMENT may be amended from time to time only by an instrument in writing signed by the parties to this AGREEMENT.

14.8 Counterparts. This AGREEMENT may be executed in counterparts, which together shall constitute one and the same contract. The parties may execute more than one copy of this AGREEMENT, each of which shall constitute an original.

IN WITNESS WHEREOF, the parties of this AGREEMENT have hereunto set their hands and seals, dated as of the day and year first herein written.

Central Marin Sanitation Agency ("Agency")

By:	ATTEST:
Name: Jason Dow	Name: Hank Jen
Title: General Manager	Title: Administrative Services Manager
Date: 12/12/14	

Synagro West, LLC ("CONTRACTOR")

By:	ATTEST:
Name: Stephen W. Cole	Name: Matt DeWitt
Title: President and CEO	Title: Assistant Secretary
Date: December 10, 2014	

Exhibit A
Analytical Testing

Frequency of Monitoring - Land Application

Table 1 of 40 CFR Part 503 Section 503.16

AMOUNT OF SEWAGE SLUDGE* (Metric tons per 365 day period)	FREQUENCY
Greater than zero but less than 290	Once per year
Equal to or greater than 290 but less than 1,500	Once per quarter (four times per year)
Equal to or greater than 1,500 but less than 15,000	Once per 60 days (six times per year)
Equal to or greater than 15,000	Once per month (12 times per year)

*Amount of sewage sludge placed on an active sewage sludge unit (dry weight basis)

Per CFR Part 503 (Frequency determined by dry tons land-applied per year, see table above)

503 Metals (As, Cd, Cu, Pb, Hg, Mo, Ni, Se, Zn, reported in mg/kg, dry weight basis)
Organic Nitrogen
Ammonia-Nitrogen
Nitrate-Nitrogen
Percent Solids
Signed NANI form from Generator

Per CA Title 22 (to be conducted 2/year, based on Agency's NPDES permit requirements)

PARAMETER	EPA TEST NUMBER
Cyanide	EPA 9012N9020B/9014
pH	EPA 9045
Ec	EPA 9050/120.1
Semivolatile Organic Compounds	EPA 8270

Volatile Organic Compounds	EPA 8260B
Chlorinated Pesticides & PCBs	EPA 8081/8082
Title 22 Metals	EPA 6010B/7471A
Total Solids	EPA 160.3/SM20-2540B

Per Synagro policy and County regulation (to be conducted with EPA Part 503 testing)

Phosphorous, as P	Reported in mg/kg, dry weight basis
Potassium	Reported in mg/kg, dry weight basis

MEMORANDUM OF UNDERSTANDING
BETWEEN
CENTRAL MARIN SANITATION AGENCY
AND
LYSTEK INTERNATIONAL LIMITED (LYSTEK)
FOR TREATMENT AND REUSE OF WASTEWATER BIOSOLIDS

This Memorandum of Understanding ("MOU"), dated ________ is made and entered into as of 9/14/16, 2016 by and between the Central Marin Sanitation Agency ("CMSA"), a separate governmental entity formed through a Joint Powers Agreement in 1979 and Lystek International Limited, a corporation organized and existing under the laws of the State of Delaware ("Lystek"), a wholly-owned subsidiary of Lystek International Inc., a corporation organized and existing under the laws of Canada.

Recitals

A. CMSA owns and operates a wastewater treatment facility that produces on average 6,500 wet tons of biosolids a year.

B. Lystek operates a treatment facility, at the Fairfield-Suisun Sewer District (FSSD) facility in Fairfield, Solano County, CA, that has the capacity to process biosolids to create a sustainable product that meets Class A standards as defined under 40 C.F.R., Part 503.

C. Lystek's process uses a combination of heat, alkali, and high-shear mixing to produce liquefied fertilizer to be sold for agricultural use, as well as other beneficial use products.

D. CMSA wishes to diversify its biosolids reuse practices as local, state, and federal regulations increasingly restrict current biosolids management practices of land application as a soil amendment and landfill alternate daily cover.

E. CMSA, as part of its efforts to diversify its biosolids reuse practices, seeks to utilize the Lystek facility to process a portion of its biosolids to Class A standards.

F. CMSA is willing to haul biosolids to Lystek's treatment facility located at the FSSD facility in Fairfield and guarantee payment to Lystek for each wet ton of biosolids that it processes pursuant to this MOU.

G. In and for the mutual interest of CMSA and Lystek ("Parties"), the Parties wish to coordinate on specific aspects of this project.

NOW, THEREFORE, in consideration of the conditions and promises contained in this MOU, Lystek and CMSA agree as follows:

Agreement

A. **Recitals**. The foregoing recitals are true and correct and incorporated herein by reference and made a part of this MOU.

B. **Effective Date**. The effective date of this MOU (the "Effective Date") shall be the date upon which each of the following has occurred: (i) this MOU is executed by the Parties, (ii) and CMSA receives Notice in accordance with Section D (3) that Lystek has completed construction of the necessary facilities at the FSSD facility to lawfully process CMSA's biosolids.

C. **Responsibilities of the Parties**. The Parties shall have the following responsibilities for processing CMSA's biosolids to Class A Standards:

1. Lystek shall have the following performance responsibilities under this MOU, which it shall perform at its own expense:

    a. Biosolids Processing: Lystek shall receive biosolids from CMSA's designated hauler(s) and process them to EPA 503 Class A Standards.

    b. Biosolids Disposal: Lystek shall be solely responsible for either properly disposing of or beneficially reusing the processed biosolids product or selling it as liquefied fertilizer for agricultural purposes.

    c. Permits: At all times during the Term of this MOU, Lystek shall procure and maintain all the applicable permits, approvals, and agreements from or with the applicable governmental agencies having jurisdiction over Lystek's operations all in accordance with all applicable laws and regulations necessary to receive and process CMSA's biosolids at the FSSD facility, as applicable.

    d. Regulatory Compliance: Lystek shall comply with all federal, state, and local laws, rules, and regulations covering its activities in connection with processing CMSA's biosolids.

    e. Monitoring: Lystek shall be responsible for meeting all monitoring and reporting requirements imposed by all regulatory agencies having jurisdiction over Lystek's operations and the FSSD facility.

    f. Operating Expenses: Lystek shall pay all operating expenses, fees, or charges imposed by regulatory agencies for processing the CMSA's biosolids.

g. Violations: Lystek shall notify CMSA's Representative within twenty-four (24) hours of its receipt of any citation, violation, order, or notice related to its treatment of CMSA's biosolids. Lystek shall send to CMSA's Representative by certified mail a complete copy of any citation, violation, order, or notice including any attachments related in any way to the processing of CMSA's biosolids within five (5) business days of receipt of the citation, violation, order, or notice. Lystek shall promptly provide the CMSA Representative, or designee, with copies of all correspondence and/or information that Lystek sent to the governmental entity or agency that issued the citation, violation, order, or notice. Lystek shall be entirely responsible for any financial penalties, fines, or fees imposed due to its processing facilities' treatment of CMSA's biosolids and/or its site management.

h. Facilities to Handle Receipt of Biosolids from CMSA: Lystek is required to provide adequate space to accommodate the ingress and egress of the trucks and trailers of CMSA biosolids hauling contractor(s), which will not exceed eight (8) feet in width, twelve (12) feet in height, and sixty-two (62) feet in length. Lystek shall also provide water for vehicle clean-up, suitable lighting for nighttime operation, and any additional facilities (portable toilets, hand washing facilities, or equivalent) that may be required by the hauling contractor(s).

i. Biosolids Delivery Hours: The Lystek plant shall be open to receive deliveries of biosolids from CMSA at least twelve (12) hours per day, seven (7) days a week, excluding legal holidays, or other mutually agreed upon hours and days.

j. Invoices: Lystek shall furnish a monthly invoice to CMSA with relevant delivery information (i.e., destination, date, time, and total tonnage). Upon request, CMSA may inspect individual weigh tickets. The billing period shall be from the first to the end of each month. Invoices must be provided to the CMSA Representative, or designee, by the 14th of each succeeding month. Monthly electronic spreadsheets in Excel format detailing arrival date, weight tag number, and net weight must be provided by the above date. Electronic copies cannot substitute for original paper copies for submission of payment.

k. Profit Sharing: Lystek shall notify CMSA under Section D(3) of any sales of liquefied fertilizer for agricultural purposes. When Lystek is able to sell its liquefied fertilizer for more than six dollars ($6) per ton above net operating costs, CMSA shall receive 10% of the profits (net operating costs calculated as transportation, application, and overhead) based on the tonnage CMSA has contributed. Lystek shall provide CMSA with monthly invoices of sales for review.

l. Provision of Annual Summaries to CMSA: Lystek shall provide an annual summary to the CMSA of all monitoring and analytical data as required to complete the CMSA Annual Biosolids Generator's Report for the U.S. Environmental Protection Agency due February 19th of each year. This annual summary shall be posted by January 31st each year and shall be addressed to the CMSA Representative, or designee. The report shall include a statement that the facility has complied with all aspects of 40 C.F.R., Part 503 in the past calendar year.

m. Safety Plan: Lystek shall comply fully with all laws, orders, citations, rules, regulations, standards, and statutes affecting or relating to this MOU or its performance, including, but not limited to those with respect to occupational health and safety. Lystek shall conduct inspections to determine that safe working conditions and equipment exist and accepts sole responsibility for providing a safe place to work for its employees and for CMSA's truck haulers, for adequacy of and required use of all safety equipment, and for full compliance applicable laws, orders, citations, rules, regulations, standards, and statutes. Upon request, Lystek shall make available for CMSA's inspection, its safety plan and records.

n. Emergency Response: Lystek shall provide all necessary emergency and spill response training to its operations personnel. Lystek shall provide training records upon request to CMSA. Lystek shall provide the name of a 24-hour emergency contact person and phone number.

o. Inspections: CMSA personnel shall be permitted to inspect Lystek's site(s) at any time and with reasonable prior notification. Lystek shall maintain and provide copies to CMSA of all records, documents, and papers documenting the disposition, including sales of biosolids handled by Lystek for inspection by authorized local, state, and federal representatives as required by law.

2. CMSA shall have the following performance responsibilities under this MOU, which it shall perform at its own expense:

   a. Deliver Biosolids: CMSA and/or its contract hauler(s) shall deliver biosolids to Lystek's treatment facility located at the FSSD in Fairfield consistently meeting or exceeding the Acceptance Criteria in Exhibit 1. Biosolids that do not meet the Acceptance Criteria may be refused the right to discharge and CMSA will promptly remove the non-compliant biosolids from the Lystek site.

   CMSA will cause to deliver at least one, but no more than six (6), truck loads of biosolids each calendar week during the term of this MOU. In the event that CMSA, or its contract hauler(s), fails to deliver the agreed upon quantities, CMSA will be liable for an operating process fee of $500.00 for each week CMSA does not deliver at least one (1) truck load. This is not a penalty but a liquidated damage based on an assessment of the base operating costs for Lystek to maintain its treatment facility.

With at least 24-hours advance notice to Lystek, CMSA may request that additional deliveries of biosolids be allowed. Lystek and CMSA (and its contract hauler(s)) will work cooperatively to meet the delivery schedule for any additional loads of acceptable biosolids.

b. Comply with Regulations: CMSA and its contract hauler(s) shall comply with all regulations and traffic laws in performance of its responsibilities pursuant to this MOU, including following all posted speed limits while on FSSD's site. CMSA will intervene with its agents or contractors as necessary if problems arise.

c. Guarantee Payment: CMSA shall pay Lystek on a per-wet-ton basis, as measured by Lystek's scale, the weight of CMSA's contracted hauler's truck and trailer less tare weight. The payment will be based on the actual amount of wet tons of biosolids processed at the specified contract unit price per wet ton. Payment of the full invoice amount to Lystek shall be made no later than thirty (30) days after CMSA's receipt and approval of the Lystek invoice. Notice regarding any disputes with an invoice including, but not limited to, its amount shall be made by CMSA within thirty (30) days of its receipt of the Lystek invoice.

Upon the effective date of this agreement, the rate for processing of delivered biosolids to the Lystek treatment facility shall be sixty-eight dollars ($68.00) per wet ton ("Compensation") of biosolids processed by Lystek to Class A standards. The rate of Compensation includes all costs of treating biosolids including, but not limited to, labor and materials, insurance, tools, equipment, licenses, taxes, incidental work, and any other items required for Lystek to perform all of its obligations under this MOU.

A price increase will be effective on July 1st of each year during the term of this MOU and will be calculated using the Consumer Price Index (CPI) as published by the US Bureau of Labor Statistics for the San Francisco area for the prior twelve (12) months.

d. Adjustment of Compensation: In the event that the costs incurred by Lystek to process biosolids at its treatment plant increases as a result of a change in federal or state law, Lystek may make a written request that CMSA adjust the rate, together with documentation supporting the requested increase. In response, CMSA may (1) choose to negotiate an increase in the Compensation to be effective thirty (30) days after the date of the written notice, or (2) terminate this MOU for its convenience under Section D (7) of this MOU.

D. **General Provisions.**

1. Term: The term of this MOU shall be from the effective date through December 31st, 2020.

2. Indemnity: In the performance of this MOU, each Party, its agents, employees, and contractors shall act in an independent capacity and not as officers, employees, or agents of the other Party. Each Party is responsible in proportion to fault for all liability, including, but not limited to, any regulatory violations, personal injury, or property damage that may arise out of this MOU. Each Party expressly agrees to defend, indemnify, and hold harmless the other Party and officers, agents, and employees from and against any and all loss, liability, expense, claims, suits, and damages, including attorney's and experts' fees, to the extent arising out of or resulting from such Party's, its associates', employees', or other agents' negligent acts, errors or omissions, or willful misconduct, in the operation and/or performance of any obligations under this MOU.

3. Notices: Except as otherwise expressly provided herein, any notices given under this MOU shall be effective only if in writing and given by delivering the notice in person, by sending it first class mail or certified mail with a return receipt requested or overnight courier, return receipt requested, with postage prepaid, addressed as follows:

CMSA:	LYSTEK:
Central Marin Sanitation Agency 1301 Andersen Drive San Rafael, CA 94901 Attn: Jason Dow General Manager	Lystek International Ltd 1014 Chadbourne Rd. Fairfield, CA 94534 Attn: James Dunbar General Manager

The foregoing addresses may be changed by written notice. Notices herein shall be deemed given two (2) days after the date when they shall have been mailed if sent by first class, certified or overnight courier, or upon the date personal delivery is made.

4. Invalidity of Any Term Not to Invalidate Entire Memorandum: In the event that any of the terms, covenants, or conditions of this MOU or the application of any such term, covenant, or condition shall be held invalid as to any party by any court of competent jurisdiction, all other terms, covenants, or conditions of this MOU and their application shall not be affected thereby, but shall remain in full force and effect unless any such court holds that those provisions are not separable from all other provisions of this MOU.

5. Use of Name; Marketing: Excluding a simple statement or acknowledgement of this Agreement between the Parties, neither Party shall use the name, marks, or logo of the other Party in any planned advertisement, promotional material, press release, or other planned publicity or marketing materials, in any form or media, with regard to the subject matter of this Agreement and sale of liquefied fertilizer from CMSA's biosolids, without the prior written approval of the other Party.

6. Good Faith: Each Party shall use its best efforts and work wholeheartedly and in good faith for the expedited completion of the objectives of this MOU and the satisfactory performance of its terms.

7. Termination for Convenience: Either party may terminate this MOU for convenience and without cause at any time by giving the other Party ninety (90) days written notice of such termination. In the event of termination, Lystek shall not be obligated to further perform any activities described in this MOU. In the event of termination, (1) CMSA will pay Lystek for services performed pursuant to this MOU up to the date of termination; and Lystek will complete any work previously funded by the CMSA to the satisfaction of CMSA. In no event will CMSA be liable for costs incurred by Lystek after receipt of a notice of termination.

8. Amendment: The Parties may agree to modify the terms of this MOU by written agreement as authorized by the governing boards of both Parties.

9. Assignment: Neither this MOU nor any duties or obligations hereunder may be assigned or delegated unless first approved by all Parties by written instrument executed and approved in the same manner as this MOU.

10. Dispute Resolution: The Parties shall make good faith efforts to resolve disputes or disagreements arising from this MOU via meet and confer. If a dispute or disagreement arises, the Parties shall meet and confer within ten (10) calendar days of receiving written notification from the other Party describing the dispute and shall thereafter schedule and participate in further meetings if appropriate, in an effort to resolve the dispute or disagreement.

11. Governing Law: This MOU is made under and shall be governed by the laws of the State of California.

IN WITNESS WHEREOF, the Parties have executed this Memorandum of Understanding by their duly authorized representatives as of the day and year indicated on the first page of this MOU.

CENTRAL MARIN SANITATION AGENCY	LYSTEK INTERNATIONAL LIMITED
By: ______________	By: ______________
Jason Dow, P.E. General Manager	James Dunbar, P.E. General Manager
Dated: 9/14/16	Dated: SEPT. 14, 2016

Exhibit 1 to the
MEMORANDUM OF UNDERSTANDING
BETWEEN
CENTRAL MARIN SANITATION AGENCY (CMSA),
AND
LYSTEK INTERNATIONAL LIMITED (LYSTEK)
FOR TREATMENT OF WASTEWATER BIOSOLIDS

<u>Acceptance Criteria</u>

1. Annual Quantity: minimum of one (1) truck load each calendar week and no more than six (6) loads per week; additional amounts to be agreed upon in advance in writing.
2. Solids Content between 23% and 27%; regular variances outside of this acceptance range will require a price adjustment to be agreed upon between the Parties.
3. Grit concentration no more than 2%.
4. Biosolids shall meet or exceed EPA 503 Class B quality and shall be free of contaminants that may impair Lystek's ability to produce a Class A biofertilizer as intended in this agreement.

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM NO. 6
BIOSOLIDS DEWATERING

FINAL
October 2018

2700 YGNACIO VALLEY ROAD, SUITE 300 • WALNUT CREEK, CALIFORNIA 94598 • P. 925-932-1710 • F. 925-930-0208

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM
NO. 6
BIOSOLIDS DEWATERING

TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF FIGURES

BIOSOLIDS DEWATERING

1.0 INTRODUCTION

This technical memorandum summarizes the findings from the biosolids dewatering alternatives analysis for the Wastewater Treatment Plant (WWTP) at the Central Marin Sanitation Agency (Agency). The purpose of this analysis is to assist the Agency in determining whether the Agency should continue maintaining the existing centrifuges, replace them with new centrifuges, or install a different dewatering technology. The analysis of the existing centrifuges includes review of the performance history, maintenance records, and the manufacturer's condition assessment report. The other dewatering technologies to be evaluated are rotary fan presses and screw presses.

This analysis includes an evaluation of both economic and non-economic parameters and a life cycle cost comparison for four (4) alternatives. The economic factors include capital costs and O&M costs (power, chemicals, labor, maintenance, truck hauling, and disposal). Other factors evaluated include space requirements and the equipment's ability to meet the solids specifications that may be required in potential partnerships between the Agency and regional biosolids processing facilities.

2.0 SUMMARY OF KEY FINDINGS

The key findings are:

- Alternative 1 - Rehab Centrifuges has the lowest life cycle cost as it is significantly less capital intensive than installing new equipment. A disadvantage of this alternative is that the Agency will not be able to capitalize on recent innovations or advancements in dewatering technology or energy efficiency. In addition, as the Agency increases system loads by importing more organic material, the existing units will require longer operation per day than currently practiced. This increase in operating hours is acceptable to the Agency. The total project cost for this alternative is estimated to be $331,000, with a present worth of $20,952,000.

- Alternative 2 - New Centrifuges have the highest score in the non-economic evaluation. Although they have a higher capital cost than Alternative 1, they scored more favorably because the centrifuges have a larger capacity and are the only alternative able to accommodate future loads within an 8-hour operating shift. The total project cost for this alternative is estimated to be $3,203,000, with a present worth of $23,401,000.

- Alternative 3 - The total project cost for this alternative is estimated to be $3,408,000, with a present worth of $25,463,000. Screw Presses are not recommended for the following reasons:
  - Screw press size and capacity limitations make this equipment impractical for installation in the existing Solids Handling Building. Only one manufacturer (Huber) was identified that would fit in the existing building, and even then, there is insufficient space to install a redundant unit.
  - Screw presses have lower electrical and maintenance costs than centrifuges, yet their overall operating costs are higher as they do not produce cake solids as dry as centrifuges, resulting in significantly higher hauling and disposal costs.
  - Lower percentage cake solids are acceptable for regional biosolids disposal options like Lystek, but will increase the cost of transportation to regional facilities, therefore reducing cost effectiveness.

- Alternative 4 - The total project cost for this alternative is estimated to be $4,589,000, with a present worth of $27,268,000. Rotary Fan Presses are not recommended for the following reasons:
  - There are relatively few installations similar in size to the Agency (>10 mgd).
  - Optimal performance with rotary fan presses has typically been achieved only with fibrous, easy-to-dewater solids. Sludge that contains significant levels of secondary sludge, and constituents like food waste that make sludge more difficult to dewater have more significant negative impacts on rotary fan presses than other equipment.
  - Rotary fan presses have lower electrical and maintenance costs than centrifuges, yet their overall operating costs are higher as they do not produce cake solids as dry as centrifuges, resulting in significantly higher hauling and disposal costs.
  - Due to lower cake solids, it may not be as cost-effective for the Agency to explore Class A or regional biosolids disposal options being considered by various Bay Area agencies.

3.0 BACKGROUND

3.1 Existing Treatment Facilities

The Agency's WWTP was designed in 1981 with an average dry weather flow (ADWF) capacity of 10.0 million gallons per day (mgd) and a corresponding sustained peak secondary treatment capacity of 30.0 mgd. The WWTP consists of preliminary treatment (headworks with screening and grit removal), primary treatment, secondary treatment (biotowers, activated sludge, and secondary clarification), disinfection, and dechlorination.

Solids handling includes waste activated sludge thickening, anaerobic digestion, biosolids dewatering, and cogeneration fueled with biogas.

The dewatering process removes water from digested biosolids. The primary purpose of sludge dewatering is to reduce the volume and weight of the digested biosolids. This makes the biosolids easier and less expensive to transport and prepare for further processing or use/disposal. Biosolids dewatering is currently accomplished by three centrifuges located in the Solids Handling Building, which were installed in 2002 as replacements to older centrifuges. Each centrifuge is associated with one hopper and the units are unable to switch between hoppers. On average, two of the centrifuges are in operation approximately 9 hours per day, seven days per week at 60 gallons per minute (gpm). Table 6.1 summarizes the original specified design criteria for the existing centrifuge dewatering process. The cake is currently hauled offsite and either land applied at Sonoma or Solano or used as alternative daily cover at the Lystek testing facility located at the Redwood Landfill. In 2016, the Agency also started delivering cake to the Fairfield Suisun Sewer District.

Table 6.1 Existing Biosolids Dewatering Centrifuge Design Criteria[1]
2017 Facilities Master Plan
Central Marin Sanitation Agency

Biosolids Dewatering Equipment	
Number (Duty + Standby)	2+1
Type	Decanter Centrifuge
Manufacturer	Centrisys
Model	CS18-4
Operating Hours per day	8-12
Main Drive	Constant speed
Main Drive Motor, hp ea	40
Hydraulic Backdrive Motor, hp ea	10
Bowl Size, in	18
Volumetric Feed Capacity, gpm ea	75
Solids Feed, lb/hr ea	1,125
Total Solids Feed, % solids	2-3
Volatile Solids Feed, % solids	65-70
Cake Dryness, % solids	24-26
Polymer Usage, active lbs/dry ton	15
Polymer Type[2]	Polydyne Clarifloc - WE-1196

Notes:
(1) Original design criteria based on Specification Section 11364 from 2001 Centrifuge Replacement Project.
(2) Polymer originally specified was Polydyne Clarifloc NW-117. This polymer has since changed to type noted.

Table 6.2 summarizes the land application and disposal sites for biosolids in 2014, 2015, 2016, and six months in 2017.

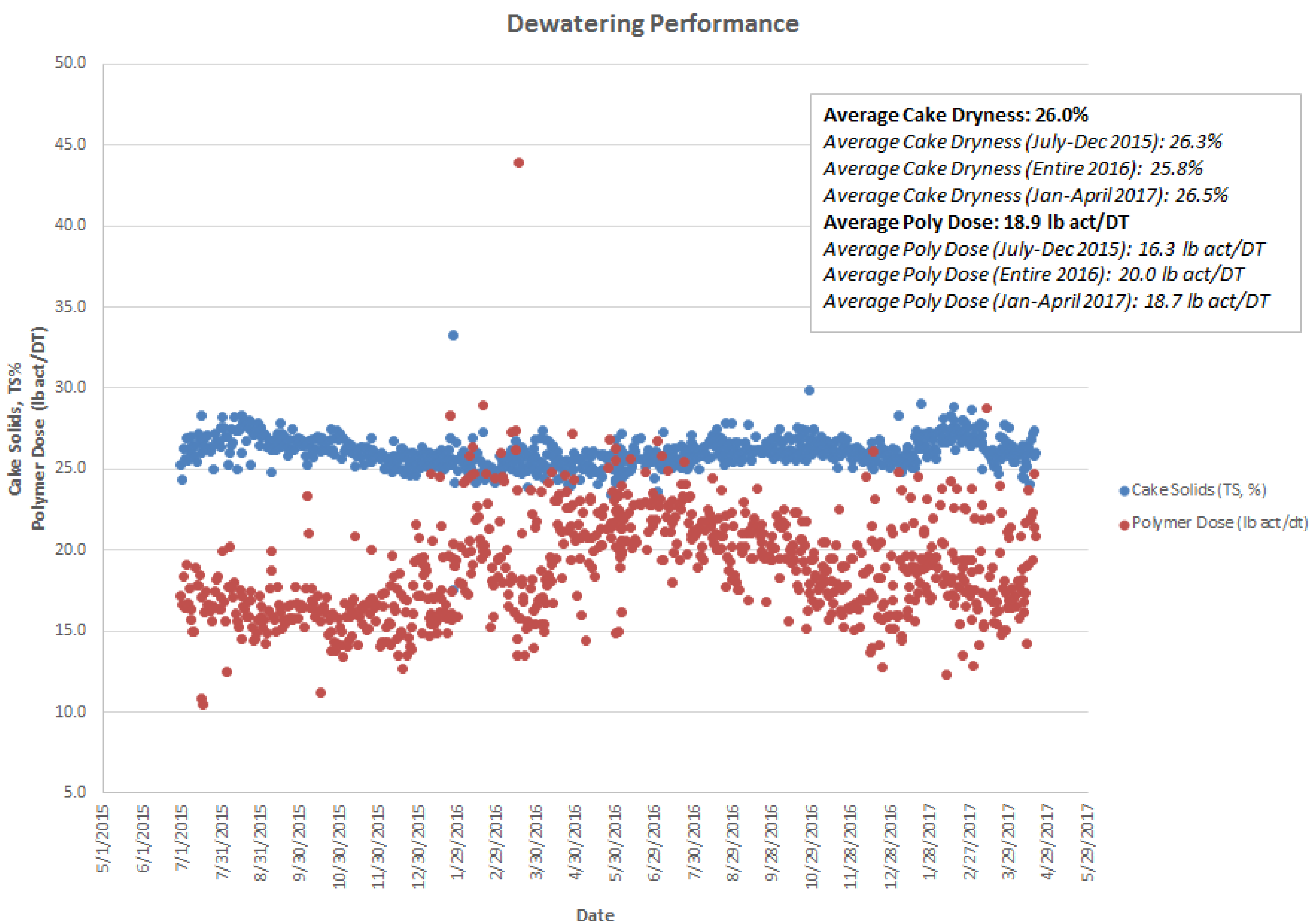
Table 6.2 Biosolids Management[1]
2017 Facilities Master Plan
Central Marin Sanitation Agency

	2014	2015	2016	2017[2]
Land Application[3], wet tons	2,070	2,273	2,135	368
Redwood Landfill, wet tons	3,863	3,608	4,185	2,056
Dos Palos Compost, wet tons	-	18	13	-
Lystek, wet tons	-	-	371	935
Total	**5,933**	**5,899**	**4,461**	**3,358**

Notes:
(1) Per Agency daily biosolids production data.
(2) January 1 through June 30, 2017.
(3) Land application by Synagro at Solano County or Sonoma County.

3.2 Performance History

The centrifuges have performed reasonably well producing an average cake dryness between 24 percent and 26 percent solids based on data from 2015 and 2016. The Agency currently targets 25 percent solids as a Key Performance Indicator, and that value seems reasonable for the plant. Polymer consumption has been higher than originally specified, which may be due to a number of factors, including, but not limited to, less organics through the headworks screening process, increases in cellulosic materials in the digesters, centrifuge age and performance, or process changes that have impacted digested sludge characteristics. Staff has continued to optimize the system to produce the driest cake possible with the lowest polymer consumption. Centrisys, the centrifuge manufacturer, also visited the site in mid-2016 and advised staff on optimization measures. Since these efforts, staff has noted an improvement in polymer consumption as discussed during Progress Meeting No. 3. Figure 6.1 summarizes the cake dryness and polymer dosage between July 2015 and April 2017, as determined from the plant data provided to date. The data show that there was a slight decrease in cake dryness in 2016 (25.8%) compared to 2015 (26.3%), but changes made by staff in the second half of 2016 have resulted in an improvement to 26.5 percent in 2017. Similarly, the increase in polymer dose apparent in 2016 (20.0 lb act/DT) was reduced in 2017 to 18.7 lb act/DT.



EXISTING CENTRIFUGE DEWATERING PERFORMANCE

FIGURE 6.1

CENTRAL MARIN SANITATION AGENCY

2017 FACILITIES MASTER PLAN

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3.3 Maintenance History

The centrifuges were originally installed in 2002, and have required repairs, refurbishment, and replacement parts on a routine basis. Purchase orders indicate that $193,071 in repair work has been required since December 2011. Table 6.3 summarizes the repair history and costs since December 2011. Major rebuilds of the rotating assemblies and Rotodiffs cost between $20,000 to $40,000 per unit and require shipment of the units to Centrisys for the required work. Upgrades of existing programmable logic controllers (PLCs) were completed during this timeframe, and likely represent one-time expenses that will not be incurred again. Other than these maintenance items, the centrifuges themselves and their component parts were inspected by Centrisys in June 2016 and found to be in generally good condition with relatively minor maintenance required, including removal of struvite buildup.

Table 6.3 Existing Centrifuge Repair History
2017 Facilities Master Plan
Central Marin Sanitation Agency

Date	Description	Cost
12/27/2011	Refurbish CEN 3 rotating assembly	$20,710.00
2/13/2013	Refurbish CEN 2 rotating assembly and Rotodiff	$37,321.75
9/7/2013	Refurbish CEN 1 rotating assembly and Rotodiff	$37,384.85
9/27/2013	Centrifuge replacement parts (bearing, o-rings, etc)	$976.89
4/25/2014	Centrifuge replacement parts (actuator, seals, gear pump, etc.)	$4,563.18
11/21/2014	Centrifuge 1 PLC Upgrade	$34,499.39
4/21/2015	Centrifuge replacement parts (misc.)	$10,520.10
5/11/2015	Centrifuge 2 and 3 PLC Upgrade	$42,589.13
4/6/2016	Centrifuge Performance Evaluation	$2,050.00
4/18/2016	Centrifuge feed tube	$2,455.79
	Total	**$193,071.08**

Notes:
(1) Costs are from repair quotes and purchase orders provided by the Agency.

There is also noted corrosion on components of the biosolids hoppers. Such corrosion can be attributed to moisture, hydrogen sulfide, or other corrosive gases in the truck loading area and may signify inadequate ventilation. This corrosion could also be exacerbated by overflows of a single hopper when only one centrifuge is in service. The condition assessment in Technical Memorandum No. 1 recommends upgrades for the hopper units with a single hopper and mechanical cake discharge system within the next 3-5 years, or alternatively, modifications that allow distribution of sludge cake among all three hoppers when only one centrifuge is in service.

3.4 Manufacturer's Condition Assessment Report

Centrisys investigated the units on May 29, 2016 and provided a report with the following findings:

- The three centrifuges were in generally good condition with no noticeable damage.
- There was some struvite buildup, but sludge is considered "normal" (as opposed to abrasive).
- The main drive belts, Rotodiff hose, and oil levels were all acceptable.
- Change out of lube lines and fittings for main bearing lubrication system was recommended.
- Bearings were replaced in September 2013.
- Some wear was present on discharge ports.
- A circuit breaker trip for Centrifuge #3 needed to be addressed.

4.0 EVALUATION BASIS AND SIZING

This section establishes the planning level sizing basis for the dewatering analysis. Two scenarios were considered including the maximum anticipated load during the planning horizon, and the ultimate buildout condition.

The planning horizon is 15 years and the load will depend on growth in the service area, which impacts the amount of sludge generated at the WWTP, and the amount of fats, oils, and grease (FOG) and food waste (FW) that is imported to the anaerobic digesters. To assess growth in the service area, three approaches were considered: (1) biosolids hauling and disposal records; (2) Bay Area/Marin County population projections; and (3) historical influent TSS loading to the WWTP. Table 6.4 summarizes the anticipated annual increase based on each approach.

While historical primary sludge and TWAS quantities have not increased in the last few years, some increase is expected based on growth in the service area. Influent loading to the WWTP has increased 2 to 3 percent a year in the last 5 years, however this increase has not resulted in any measurable increase in primary sludge and TWAS quantities. Population projections suggest a modest growth of 0.5 percent. For planning purposes, it was decided to use an annual growth rate and associated annual sludge production increase of 1.5 percent.

Table 6.4	**Service Area Growth 2017 Facilities Master Plan Central Marin Sanitation Agency**	
Approach	**Finding**	**Impact to Sludge Generated at WWTP**
Historical Primary Solids and TWAS Quantities	Last 8 years have shown no long-term increase in primary and secondary solids production.	None, no increase shown
Marin County Population Projections	Very little growth projected, approximately 0.5% a year for Marin County.	0.5% annual increase
Influent TSS Loading to WWTP	Last 5 years averaged 2-3% increase each year.	2-3% annual increase

While the anaerobic digesters have additional capacity to accommodate the projected increase in sludge production, it is important to quantify because industry experience suggests there are practical limits to how much FOG and FW can be imported. Published research indicates that the maximum amount of FOG and FW that can be imported is approximately 30 percent of the total digester feed by volume or on a volatile solids (VS) mass basis (Appleton, R.A. and T. Rauch-Williams. "Co-Digestion of Organic Waste: Addressing Operational Side Effects." WE&RF, 2017; Prabhu, M. and S. Mutnuri. "Anaerobic co-digestion of sewage sludge and food waste." Waste Management & Research. 2016, Vol. 34(4) pp. 307-315.).

Records of the recent digester feed characteristics at the plant provided to Carollo in the 2017-3-25 OWRF Weekly document showed that the organic slurry comprised approximately 31 percent of total digester feed on a VS basis cumulatively from January through March 2017. Since the plant is already operating above the 30 percent value published for co-digestion and digester operations have remained stable, it is assumed that the microorganisms within the digesters are accustomed to the feedstock characteristics and could potentially accommodate a higher percentage of organic slurry. Hence, to estimate a conservative load on the dewatering system and allow for equipment sizing, it was assumed that the digesters could accommodate a feedstock comprised of approximately 35 percent organic slurry by volume (equivalent to 38 percent of digester feed on a volatile solids basis).

This quantity of future organic feedstock relative to municipal sludge in digester feed is higher than published values, but was used in this analysis for two reasons. First, it provides for a conservative but realistic way to accommodate the associated load on dewatering and subsequently, size the required equipment. Second, the plant's digesters have microorganisms that are already accustomed to feedstock that slightly exceeds the published values. As long as additional feedstock is introduced slowly, it is possible that the microorganisms would be able to accommodate it.

It should be noted that this percentage is based the best available information to date and the presumption that the microbiology will be able to handle it. However, it should be field tested to confirm. If possible, the plant should track loading rates based on chemical oxygen demand (COD) rather than volatile solids. This allows for a more accurate carbon balance that encompasses all organics fed to the digester and identifies the methane yield for specific feedstocks. This would be in addition to more standard monitoring parameters like volatile fatty acids (VFAs), alkalinity, and methane/digester gas production, all of which are used to monitor digester health. Food waste digestion facilities in central Europe monitor feedstock COD and control digester feed in a way that maintains healthy digester operating parameters like VFA-to-Alkalinity ratios and expected digester gas production. The volumetric and VS-based percent values noted above represent the digester feed parameters that have been tracked historically in the United States at operating co-digestion facilities.

Based on the anticipated growth rate of 1.5 percent a year, this volumetric and VS-based percent criteria will limit how much FOG and FW can be imported to the digesters in the planning horizon, and will help establish the dewatering capacity needed. The ultimate buildout condition reflects additional increases in sludge and imported FOG and FW so that the digesters are operating at their minimum hydraulic and maximum organic loading limits.

Table 6.5 summarizes the sludge, FOG, and FW quantities and digester operating conditions for the current conditions (2015-2016) and the two scenarios considered. The values presented represent the data provided for this time period. More recent operations could differ from these values, including increases in feedstock accepted at the plant and changes in TWAS concentration. Increases in feedstock are assumed for the future scenarios relative to the 2015-2016 period. The impacts of potentially thicker TWAS are addressed within the table notes.

Table 6.5 Daily Average Digester Feed
2017 Facilities Master Plan
Central Marin Sanitation Agency

	2015 - 2016 Average	Planning Horizon (2032) (1)	Ultimate Buildout (2)
Primary Sludge (PS)			
gal/day	28,795	36,000	50,330
% TS	4.4	4.4	4.4
TS, lb/d	10,509	13,139	18,369
% VS	85	85	85
VS, lb/d	8,888	11,112	15,536
Thickened WAS (TWAS)(3)			
gal/day	19,736	24,674	34,496

Table 6.5 Daily Average Digester Feed 2017 Facilities Master Plan Central Marin Sanitation Agency			
	2015 - 2016 Average	**Planning Horizon (2032) (1)**	**Ultimate Buildout (2)**
% TS	5.6	5.6	5.6
TS, lb/d	9,163	11,148	16,019
% VS	84	84	84
VS, lb/d	7,709	9,638	13,475
Total PS+TWAS, gal/day			
gal/day	48,530	60,674	84,826
% TS	4.9	4.9	4.9
TS, lb/d	19,673	24,597	34,388
% VS	84	84	84
VS, lb/d	16,598	20,751	29,011
Fats, Oils, and Grease (FOG)			
gal/day(4)	9,113	28,973(5)	40,506(5)
% TS	3.2	3.2	3.2
TS, lb/d	2,408	7,138	9,979
% VS	93	93	93
VS, lb/d	2,245	7,656	10,703
Food Waste (FW)			
wet tons/day	4.85	15.42(5)	21.56(5)
gal/day	1,163	3,698(5)	5,170(5)
% TS	21.1	21.1	21.1
TS, lb/d	2,047	6,508	8,258
% VS	92	92	92
VS, lb/d	1,858	5,907	9,099
Total FOG+FW			
gal/day	10,276	32,671(5,6)	45,676(5,6)
% TS	5.2	5.2	5.2
TS, lb/d	4,455	14,164	19,802
% VS	92	92	92
VS, lb/d	4,102	13,045	18,238
Total Digester Feed			
gal/day	58,806	93,345	130,502
% TS	4.9	5.0	5.0
TS, lb/d	24,128	38,761	54,190

Table 6.5 Daily Average Digester Feed 2017 Facilities Master Plan Central Marin Sanitation Agency			
	2015 - 2016 Average	**Planning Horizon (2032) (1)**	**Ultimate Buildout (2)**
% VS	86	87	87
VS, lb/d	20,701	33,796	47,249
FOG+FW (% of total digester feed volume)	**17%**	**35%**	**35%**
FOG+FW (% of total digester feed volatile solids)	**20%**	**38%**	**38%**
Digester HRT, days (7)	**33.2**	**20.9**	**15.0**
Digester Loading, lb VS/cf/d (8)	**0.08**	**0.13**	**0.18**
Percent of Total Digester Capacity Used in Scenario	44%	72%	100%

Notes:

(1) Based on projected sludge loading increase of 1.5% per year and limiting FOG and FW to 35% of total digester feed (by volume) and approximately 38% on a volatile solids basis.
(2) Based on operating digester at hydraulic and organic loading limits (15 day HRT and 0.18 lb VS/cf/d. Will require 75 percent increase in sludge generated at WWTP and 400% increase in imported FOG and FW from the 2015-2016 values presented.
(3) TWAS concentration is based on data provided for 2015-2016. If thicker material is produced in the future, the volumetric load on the digester from municipal sludge would decrease but the solids load would remain unchanged. Digester capacity would then be limited by solids loading rate rather than digester feed volume. Due to the limitation on solids loading, increasing the TWAS concentration is not expected to significantly impact the amount of organics that the Agency could feed to the digesters beyond what is already projected. In addition, digester mixing effectiveness may be hampered at thicker digestate concentrations and could require modifications.
(4) Based on daily average over a full 365-day year. Feedstock is not currently delivered every day..
(5) Based on maintaining same ratio of FOG to FW as practiced within the 2015-2016 period.
(6) This volume exceeds the current Organic Waste Receiving Facility vault capacity and would necessitate a capacity increase to accommodate it.
(7) Minimum HRT of 15 days recommended.
(8) Maximum loading of 0.18 lb VS/cf/d recommended.

The planning horizon reflects a 25 percent increase in sludge generated at the WWTP based on growth in the service area, and a 300 percent increase in imported FOG and FW relative to the 2015-2016 values. The ultimate buildout condition reflects a 75 percent increase in sludge generated at the WWTP and 400 percent increase in imported FOG and FW relative to the 2015-2016 values. The ultimate condition is expected to occur well beyond this Master Plan's planning horizon and is not recommended for this analysis.

Table 6.6 summarizes the dewatering criteria based on the planning horizon and the anticipated digester performance. The required equipment capacity will depend on the hours of operation. The Agency has indicated that operating more than 8 hours a day would be acceptable, however, continuous operation was not desired since the Agency prefers to only dewater during hours when plant staff are onsite. The analysis is based on meeting a target of 8 to 12 hours of operation 7 days a week. It should be noted that due to space and capacity limitations, some of the alternatives do require operation more than 8 hours a day.

Table 6.6 Biosolids Dewatering Design Criteria
2017 Facilities Master Plan
Central Marin Sanitation Agency

Digester Feed	
gal/day	93,345
% TS	5.0
TS, lb/d	38,761
% VS	87
VS, lb/d	33,796
Assumed Volatile Solids Reduction	
%	72 (1)
lb/d	24,191
Digested Sludge / Dewatering Feed	
gal/day	93,345
% TS	1.87
TS, lb/d	14,570
% VS	66
VS, lb/d	9,605
Target Dewatering Operating Time	
Operating Hours per Day(2)	8 to 12
Operating Days per Week	7
Target Dewatering Feed Conditions (3)	
Total Sludge Flow, gpm	194
Total Sludge Load, lb/hr	1,821

Notes:

(1) Based on 60% VS reduction of PS and TWAS and 90% VS reduction of FOG and FW.
(2) Noted value is a target, but Agency has indicated that exceeding 8 to 12 hours/day is acceptable as long as equipment is not required to operate continuously 24 hours/day for 7 days/week.
(3) Based on noted operating hours per day and days per week. Values do not represent capacities per unit, but rather total processing capacity required for the noted operational conditions. Capacity per unit will vary based on the number of operational units.

5.0 ALTERNATIVES

This section summarizes the technology alternatives for the dewatering process. There are several technologies available on the market for municipal sludge, FOG, and food waste dewatering, including belt filter presses, centrifuges, screw presses, and rotary fan presses.

Belt filter presses are a widely used technology in the industry, but they were eliminated from consideration because they require too large a footprint to fit within the existing building. In addition, they have a higher odor potential, and require greater operator attention and maintenance than the other options considered.

Centrifuges are currently utilized by the Agency for dewatering and have performed well. However, it is energy-intensive compared to other technologies, and the aging units have relatively high maintenance costs. Therefore, alternative dewatering technologies which can fit into the existing Solids Handling Building, meet the biosolids dewatering requirements, and require less power consumption and maintenance were also evaluated. In addition to looking at new technologies for the dewatering process, this evaluation also considers the feasibility of continual refurbishment of the existing centrifuges to maintain consistent and reliable performance for the foreseeable future. The following alternatives were evaluated:

- Alternative 1 - Rehab Existing Centrifuges.
- Alternative 2 - New Centrifuges.
- Alternative 3 - Screw Presses.
- Alternative 4 - Rotary Fan Presses.

Budget proposals and sizing recommendations were solicited from technology suppliers for the evaluation. The number of duty and standby units for each alternative was based on the building size/layout, equipment capacity, and maintenance of existing level of redundancy. Equipment like centrifuges can be provided with larger capacity per unit, which allows for fewer units to be installed. However, those same units are larger, heavier, and more power intensive than smaller units installed in greater quantity. Smaller units fit the existing facility and associated structural and electrical constraints better. In addition, there is less loss in capacity if a smaller unit is down for service compared to a larger unit. There have been significant improvements in some centrifuge manufacturer's power consumption requirements, so if existing units were replaced with units of similar capacity, power savings could potentially be achieved. However, if the existing units were replaced with larger capacity units, the power consumption of the larger units may be the same or more than existing equipment. In addition, not all centrifuge manufacturers have achieved similar levels of power savings, so any reduction in power consumption would be related to the specific unit to be installed.

5.1 Alternative 1 - Rehab Existing Centrifuges

The cost to rehabilitate the existing centrifuges to "like new" status is significantly less than the cost to purchase new centrifuges. The technology for Centrisys centrifuges has remained relatively stable since the existing centrifuges were originally installed. The current centrifuges already perform relatively well for the feed sludge at the plant, so it is not expected that new centrifuges would offer significant increases in performance. Technology improvements in other manufacturers' centrifuges such as Alfa Laval or Westfalia have primarily focused on power reduction.

The existing units can handle current loads within a 9 hour operating day and were found to be in generally good condition by Centrisys. However, the existing centrifuges have capacity limits that would require operating more than 9 hours per day to handle increased sludge, FOG, and FW loading during the planning horizon. While longer operating hours are acceptable to the Agency, operating the existing centrifuges for longer operating hours will likely result in increased maintenance and shorter overall equipment life. In reality, refurbishment of the existing units will eventually lead to diminishing returns as equipment ages beyond the ability to rehabilitate and repair. Eventually, the equipment will need to be replaced, but the current good condition of the units could allow them to remain feasible options for the next 5 to 10 years. In addition, the controls have been upgraded, as noted in Table 6.3, and have the latest generation of PLC and backdrive controllers, which means the controls should be serviceable for that same timeframe.

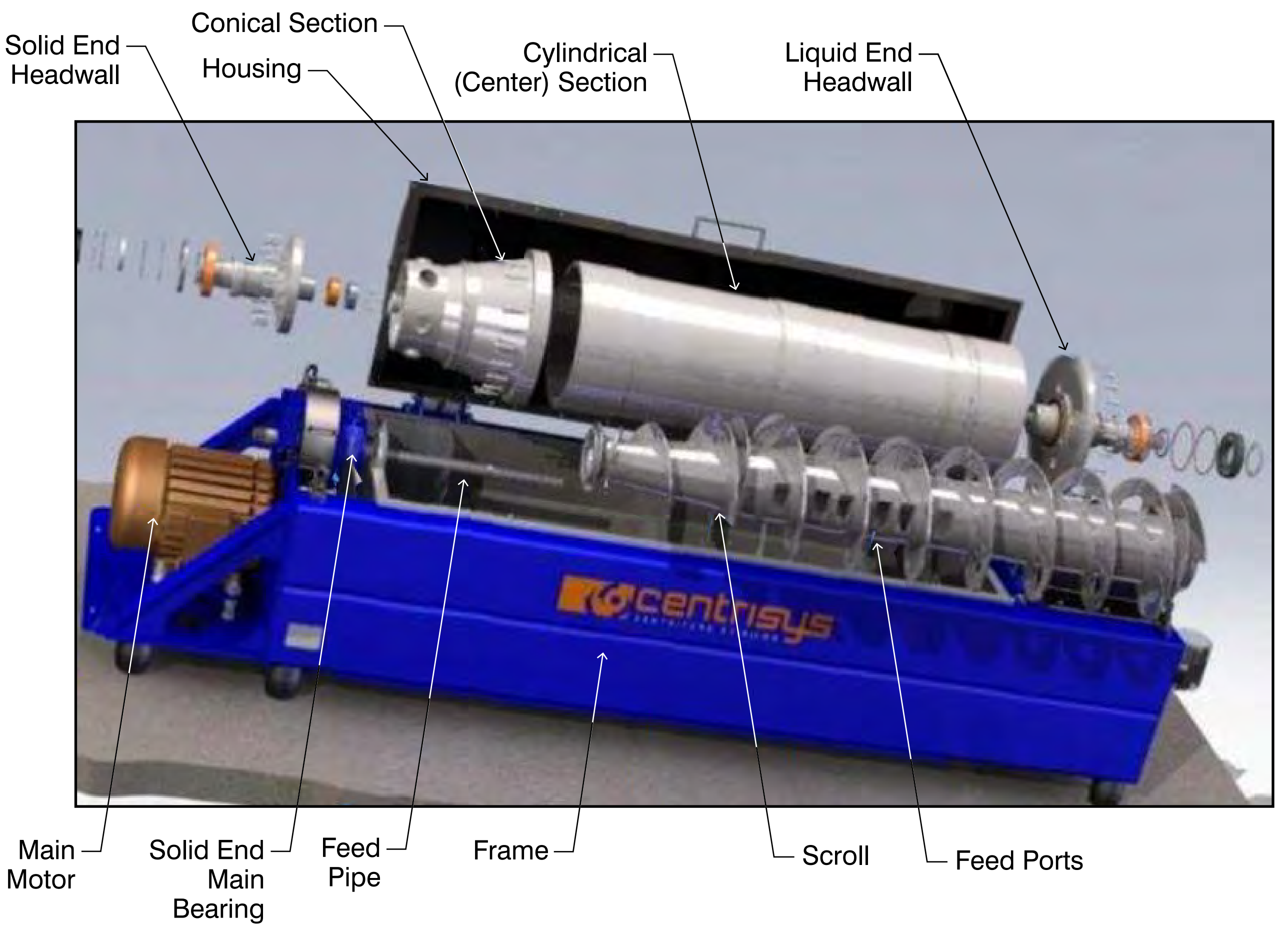
5.2 Alternative 2 - New Centrifuges

New centrifuges would be similar to existing units in basic operation. Centrifuges can achieve the highest cake solids of the technologies considered, up to 28-percent for easy-to-dewater anaerobically digested sludges that contain significantly more primary sludge than secondary. Increased proportions of secondary sludge, volatile solids, and more recently, food waste, can reduce dewaterability such that cake dryness decreases by several percentage points. However, even for these relatively difficult to dewater sludges, centrifuges typically produce the driest cake possible across the technologies considered. Centrifuges also have a relatively high level of solids capture (95 to 98 percent) compared to screw presses. Due to their enclosed configuration, centrifuges, similar to screw presses, contain odors well. The expected polymer dosage is higher for centrifuges as compared to rotary fan presses, but side-by-side pilot tests have shown that screw presses can require the same or greater polymer than centrifuges. Noise levels will be greater with a centrifuge compared to a screw press or rotary fan press. Sound attenuation panels on the walls in the centrifuge area can be used to reduce sound levels within the centrifuge room. The high rotating speed also produces significant vibrations that must be accommodated in structural design. Vibration isolators provided with the centrifuges typically dampen vibrations such that only a fraction of the dynamic load is imparted to the surrounding structure. Centrifuges also require more power to operate than any other technology, and are fitted with large motors that must be accommodated by the electrical system. Figure 6.2 presents a cut-away of a centrifuge.

Operator oversight can be minimized with typical operations and control features provided by manufacturers. Instrumentation and controls systems allow some functions to be automated and monitored by a manufacturer-designed monitoring and control system including variable frequency drives, probes, and controller. The instrumentation and controls allow for the dewatering operations to be mostly automated, minimizing operator oversight. The typical operations control features provided by the manufacturers are capable of controlling the complete dewatering system including the polymer system, sludge feed pump, washwater flow, and discharge conveyor. Unattended operation is possible, though not practiced by some facilities that prefer some level of operator oversight for the high-speed units.

Centrifuge manufacturers established in the United States include Centrisys Corporation, Alfa Laval Inc., GEA Westfalia Separator Group GmbH, and Andritz AG. Many other centrifuge manufacturers, like Flottweg, have been supplying centrifuges in Europe and other markets for a number of years, but they have not yet established a large installation base in the United States. Manufacturers' units differ in some design features. Centrisyis utilizes hydraulic backdrives whereas other manufacturers use electric drives. Other differences include types of main bearing lubrication, extent/type of abrasion protection, and power reduction features.

For this alternative, it was assumed a different manufacturer would be considered such as Alfa Laval or Westfalia which offer more energy-efficient units than the Agency's existing Centrisys units. However, the Agency would prefer to install units that closely match existing piping and conduit routing if possible. Figure 6.3 presents a site plan of this alternative which shows three new centrifuges sized to accommodate planning horizon loads within an 8-hour operating shift. There is sufficient room in the existing building to accommodate the larger capacity units.



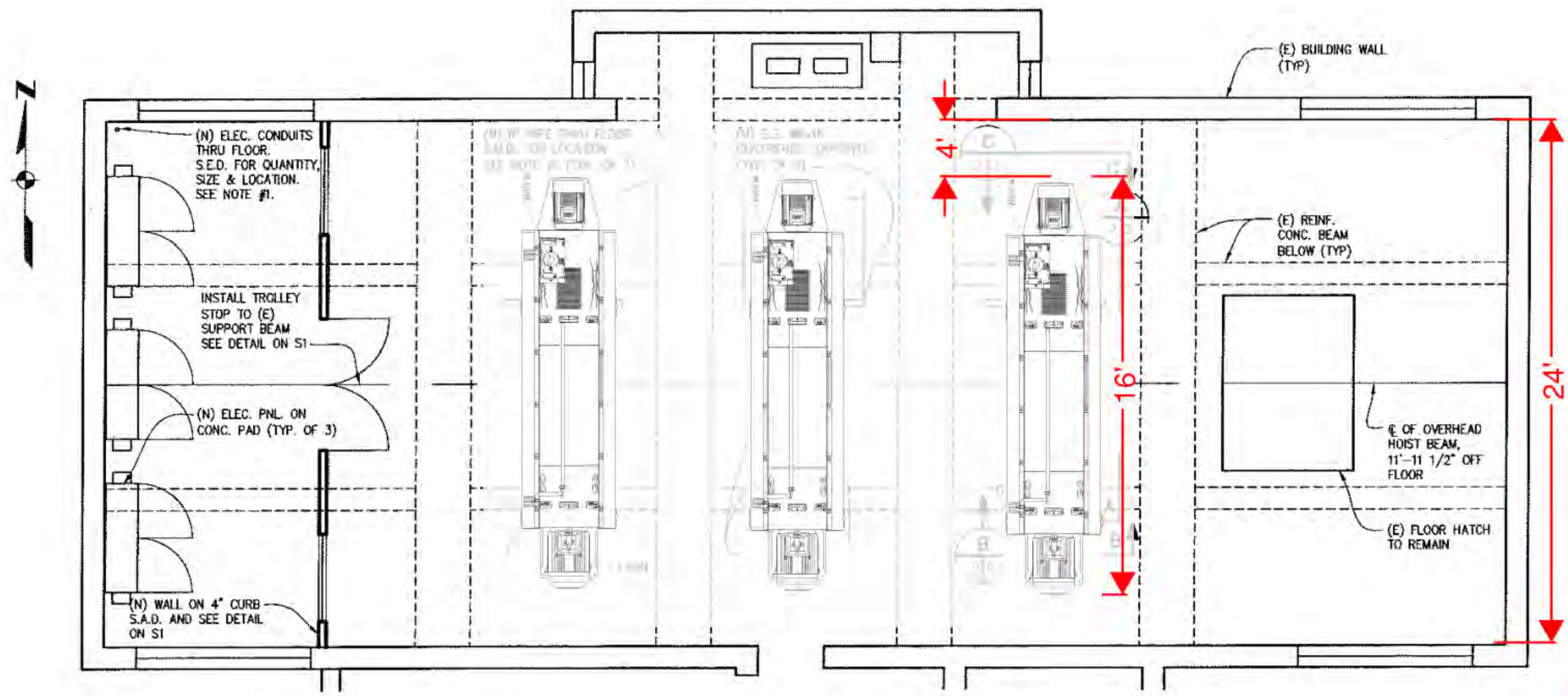
Courtesy of Centrisys

Photo of the Agency's existing Centrisys Centrifuge, Model CS18-4

TYPICAL DEWATERING CENTRIFUGE

FIGURE 6.2

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN



Courtesy of Alfa Laval

ALTERNATIVE 2
NEW CENTRIFUGE LAYOUT

FIGURE 6.3

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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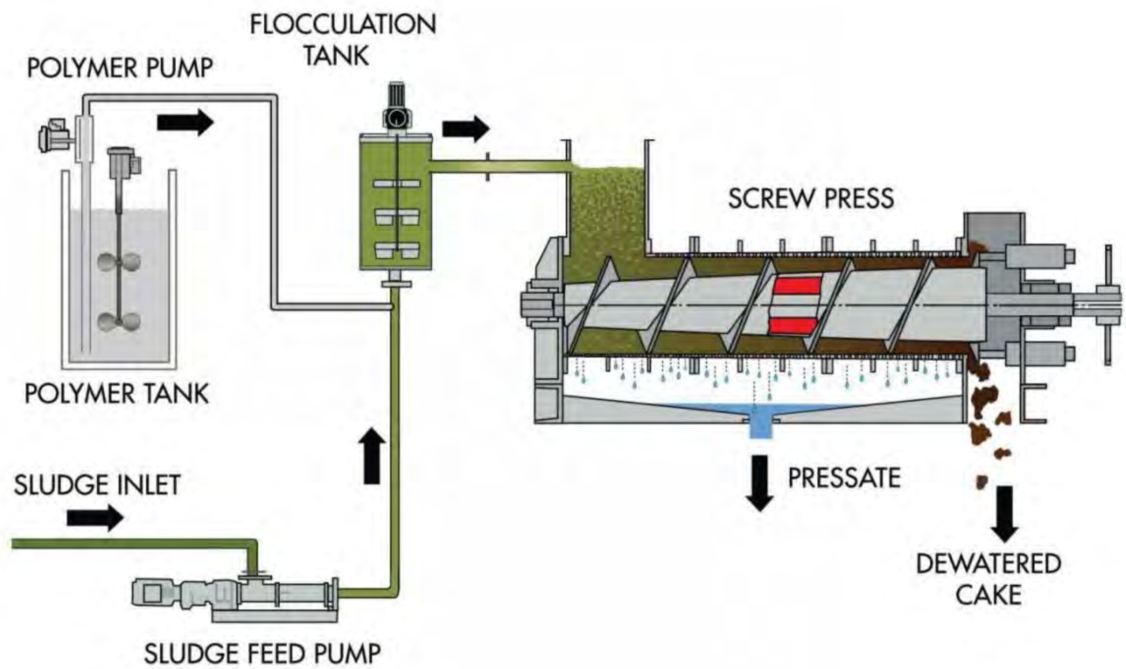
5.3 Alternative 3 - Screw Presses

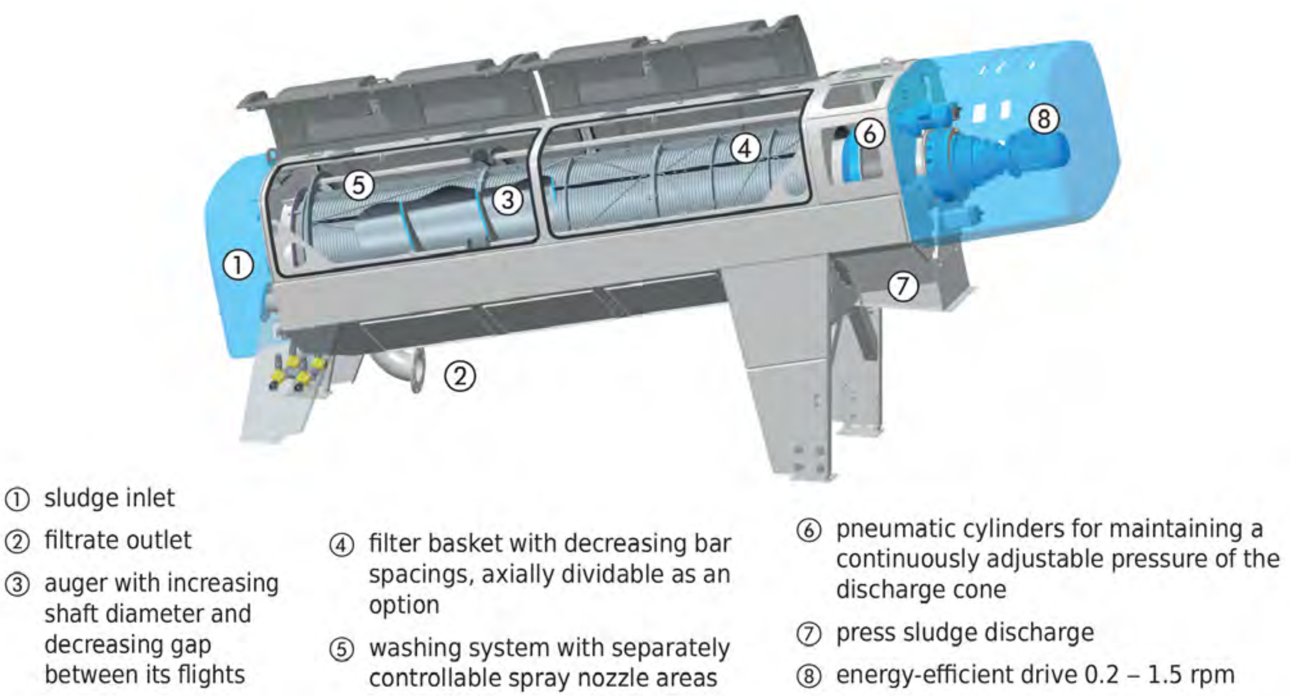
A screw press system is a sludge dewatering technology that is typically operated continuously. Feed solids are dewatered by a combination of gravity drainage, at the inlet of the screw, and pressure, which is created by conveying the material along a rotating shaft toward the outlet as the interior size of the equipment decreases. Solids are conditioned with polymer and loaded into unit, where they pass through a continually decreasing volume due to an enlarging center cone screw. This increases the pressure along the length of the screw press, and forces the free water in the solids through the external screen. The separated water (pressate) is collected and discharged at the bottom of the screw press and returned to the liquid treatment process. The dewatered cake is discharged at the end of the screw press and conveyed for ultimate use and disposal. Figure 6.4 shows a schematic diagram and drawing of a screw press.

The screw press is gaining popularity in some municipal wastewater treatment plants due to its slow speed and mechanical simplicity, which allow it to be operated virtually unattended. Because of their slow speed, they do not present the same noise and vibration considerations that centrifuges do. Screw presses typically achieve cake dryness several percentage points wetter than a centrifuge on the same sludge. Screw presses also have a relatively low level of solids capture (less than 95 percent). Due to their enclosed configuration, screw presses, similar to centrifuges, contain odors well. The expected polymer dosage required is similar to or greater than centrifuges. This equipment has capacity limitations that necessitate installation of more units than centrifuges for the same processing capacity requirement and operating time.

Screw press manufactures established in the United States include Huber Technology, Inc. and FKC Co., Ltd. Other manufacturers like Schwing Bioset, Ishigaki, and Andritz also produce screw presses but have significantly fewer installations in the United States than Huber or FKC. Similarly, a unit called a volute press is manufactured and supplied by PWTech, but this technology also has relatively few installations. Between Huber and FKC, the unit design differs significantly. The most significant differences include an inclined installation for Huber versus a flat horizontal installation for FKC, the type of pressure cone used to create back pressure, type of screw speed control, and overall size of unit. Screw presses are relatively limited in capacity so they represent less processing capacity than centrifuges over the same operating time. FKC units are quite large and typically require significant area for installation.



Courtesy of FKC



Courtesy of Huber

TYPICAL SCREW PRESS

FIGURE 6.4

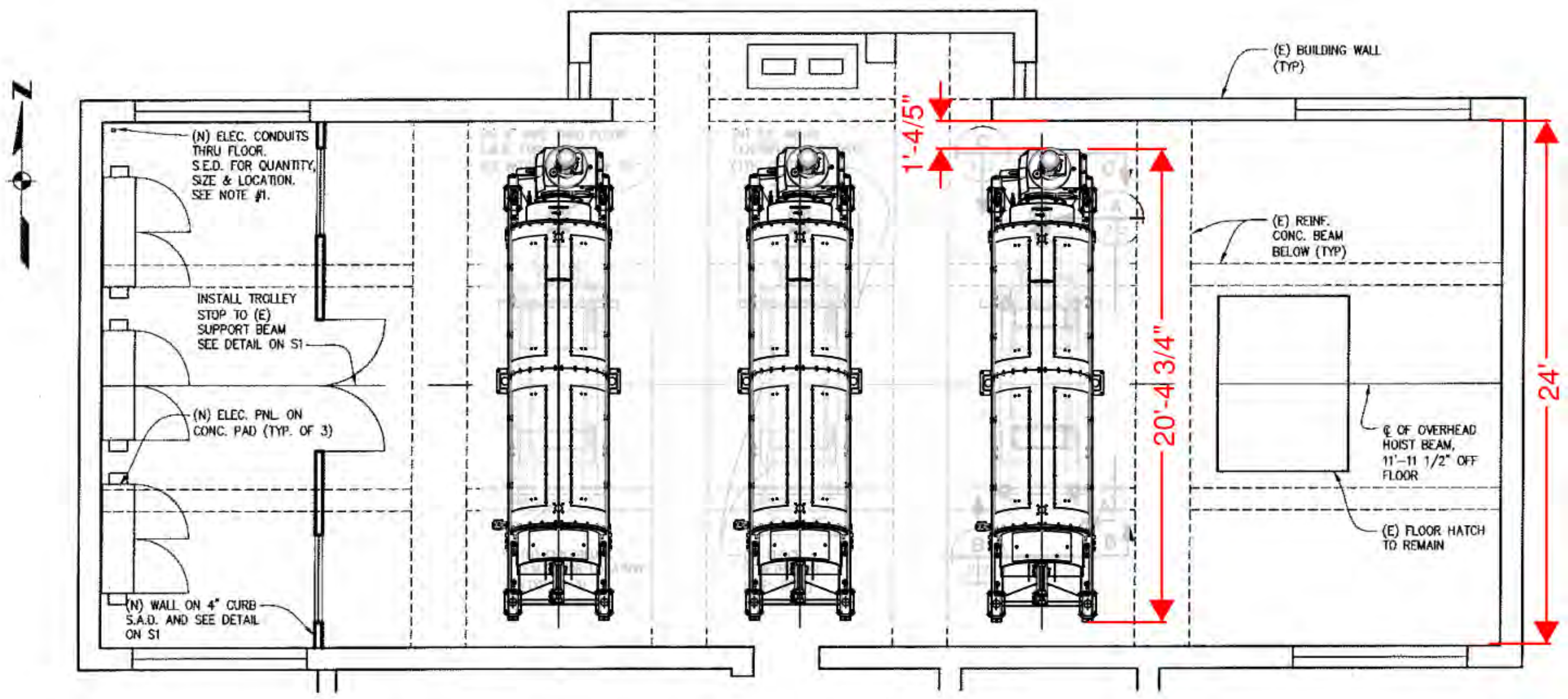
The screw presses from FKC require more space than those from Huber and would limit access around each screw press required for maintenance, equipment pullout, etc. The screw presses from Huber are more compact but three screw presses would not fit without compromising access around the equipment, so this approach is likely not feasible. Two Huber screw presses would fit within the space if the units were oriented perpendicular to existing equipment, but this would give up some redundancy and operational flexibility.

Since the orientation of the screw presses will need to be perpendicular to existing equipment, it will require modification to the existing floor and other structures in the existing Solids Handling Building. One option for installation would be to ship the units pre-assembled, then disassemble the units on-site in pieces less than 5 tons to facilitate the use of the existing bridge crane to place the units on the required elevated supports, and reassemble the units in-place. Because of the more involved installation process, higher cost was assumed for installation of the screw presses. The existing bridge crane is of sufficient size for the maintenance of any of the new equipment as it has capacity to lift the heaviest component of any unit.

Since the inlet and outlet geometry will be different than the existing centrifuges, the screw presses will require some adaptations to fit in with the existing chutes and hoppers. Figure 6.5 illustrates a preliminary layout for Huber screw presses with 2 duty and 1 standby, showing that there is not enough room in the Solids Handling Building for a redundant screw press unit. Figure 6.6 illustrates a preliminary layout for Huber screw presses with 2 duty and 0 standby, showing the larger clearance around the equipment. Figure 6.7 shows a preliminary layout for FKC screw presses with 2 duty and 0 standby, showing the larger size compared to Huber.

5.4 Alternative 4 - Rotary Fan Presses

The rotary fan press is a relatively new sludge dewatering technology. The rotary fan press operates using the low differential pressure between the incoming sludge and the outgoing sludge cake combined with the very slow (< 1 rpm) rotational motion of the filter screens to advance the sludge through the press. Before entering the low-pressure zone, solids are dosed with polymer and fed into a channel bound by screens on each side. As the conditioned sludge enters the annular space between the two wedge wire filter screens, a pressure differential develops within the press and the liquid portion of the sludge seeks the path of least resistance through the filter screens. The remaining solids are collected inside the two filter screens traveling toward the solids discharge of the press. At the discharge of the press an adjustable restrictor arm slows down the solids, forming a cake plug. Cake accumulates against the outlet gate, and the motion of the screens squeezes out additional water. The cake is continuously released through the pressure-controlled outlet and conveyed for ultimate use and disposal. Filtrate generated from both pressure zones is collected and returned to the liquid treatment process. Figure 6.8 presents a cut away of a typical rotary fan press module.

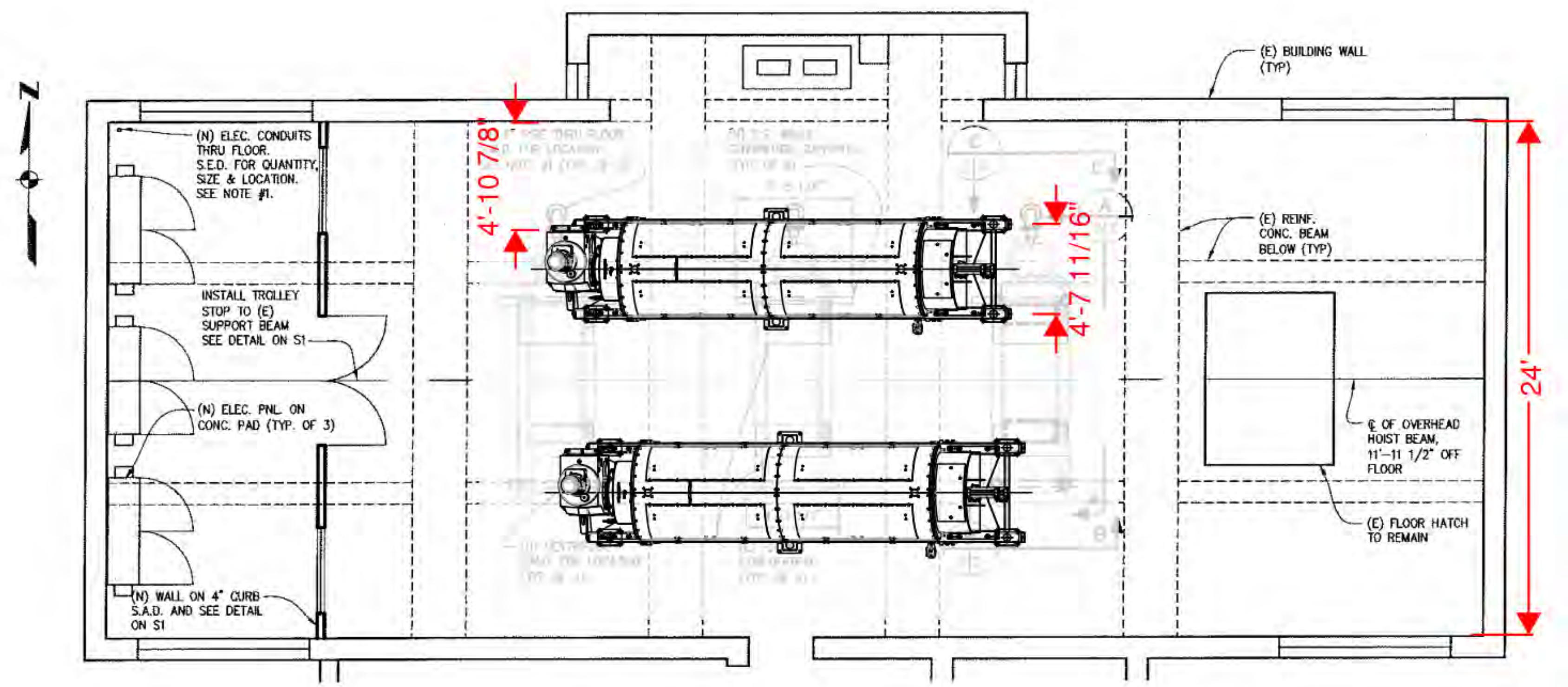


Courtesy of Huber

ALTERNATIVE 3
HUBER SCREW PRESS LAYOUT
WITH 2 DUTY AND 1 STANDBY UNITS

FIGURE 6.5

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

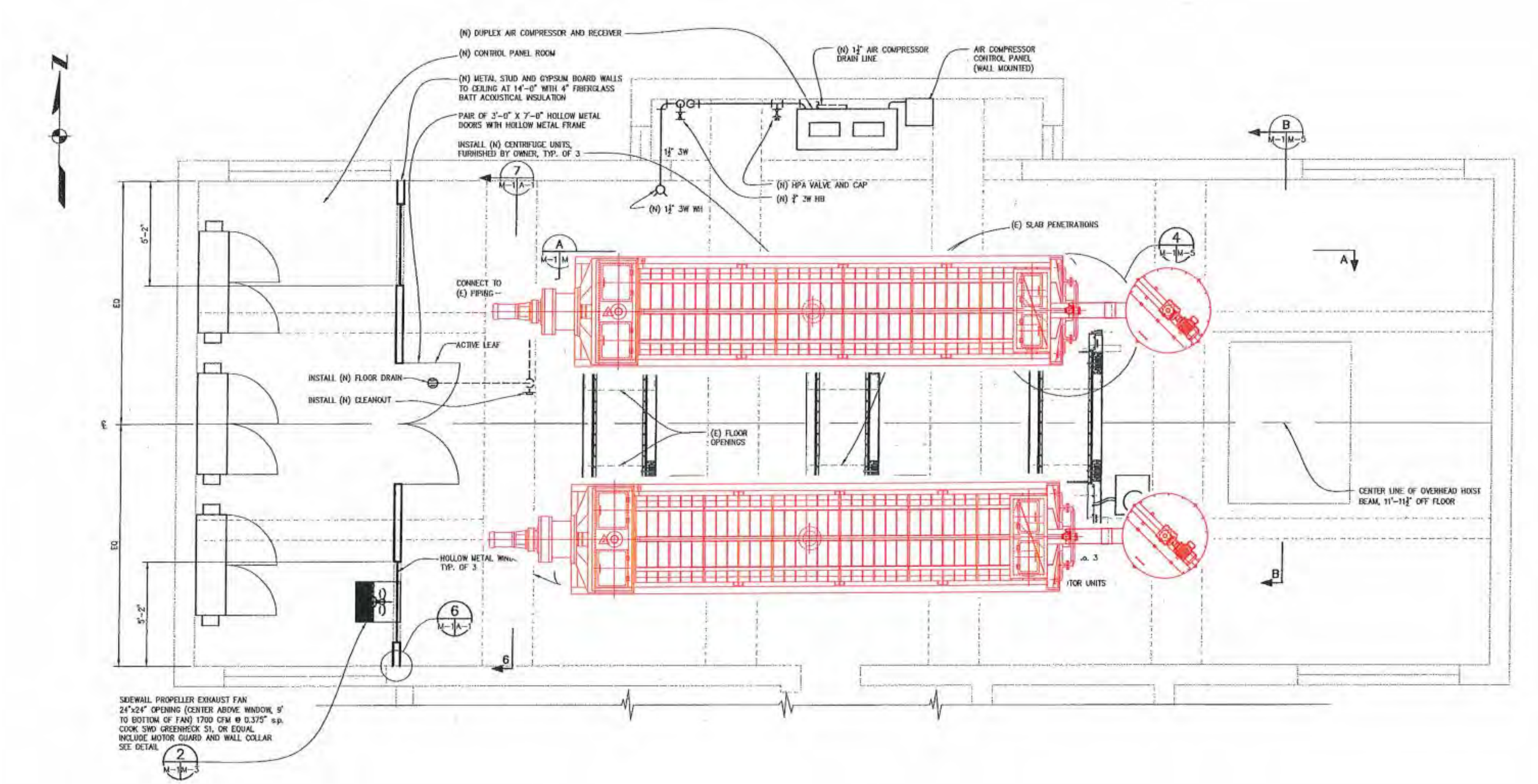


Courtesy of Huber

ALTERNATIVE 3
HUBER SCREW PRESS LAYOUT
WITH 2 DUTY AND 0 STANDBY UNITS

FIGURE 6.6

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN



Courtesy of FKC

ALTERNATIVE 3
FKC SCREW PRESS LAYOUT
WITH 2 DUTY AND 0 STANDBY UNITS

FIGURE 6.7

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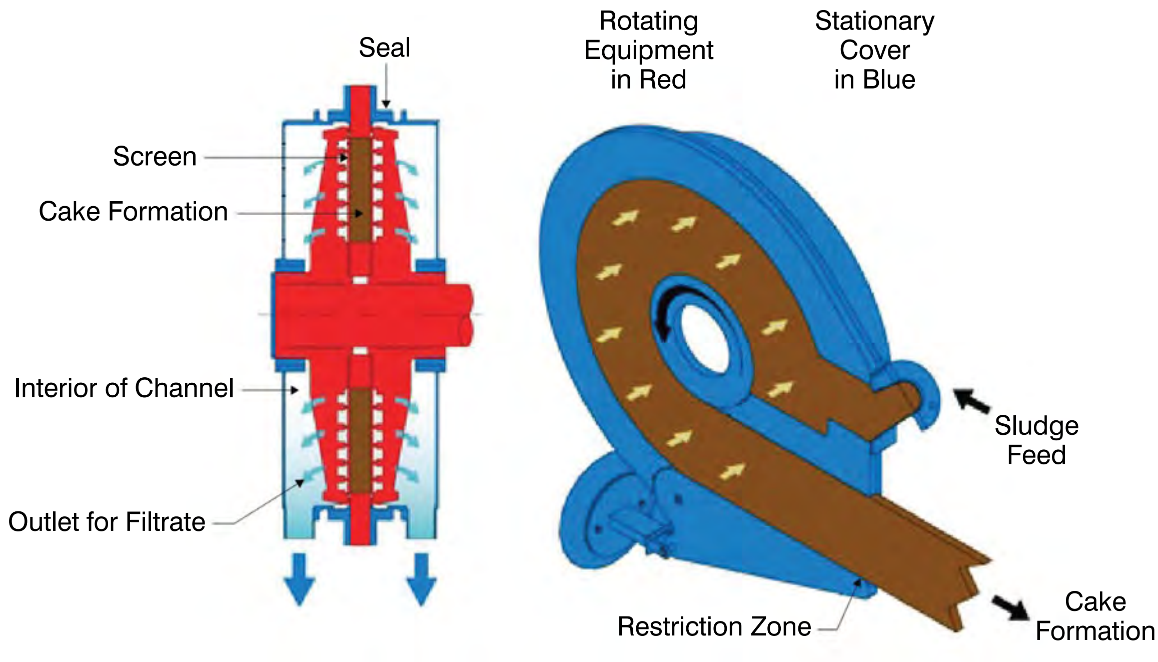
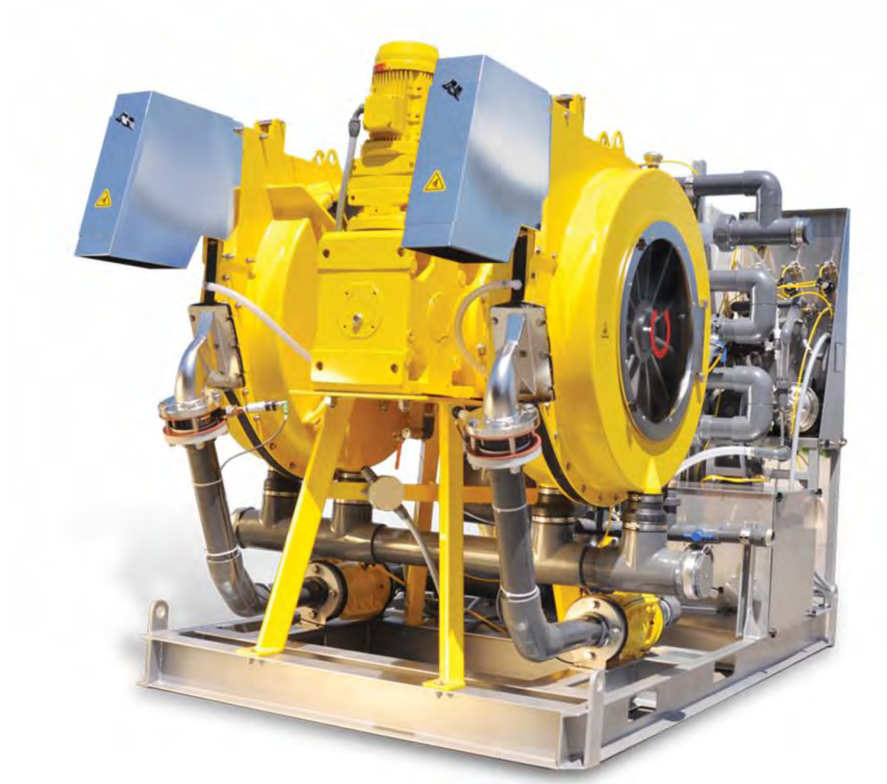


Courtesy of Fournier Industries



Courtesy of Prime Solutions, Inc.

TYPICAL ROTARY FAN PRESS

FIGURE 6.8

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Rotary fan press manufacturers include Prime Solutions Inc. and Fournier Industries. Prime Solutions, Inc. is based out of Otsego, Michigan and has installations in at wastewater treatment plants in the United States. Fournier Industries is based out of Thetford Mines, Quebec, Canada. Rotary fan presses are gaining attention from wastewater agencies seeking enclosed dewatering equipment with a small footprint, modular configuration, and lower power consumption than centrifuges. The number of installations is limited, but based on side-by-side pilot testing at other facilities, rotary fan presses can produce cake dryness similar to screw presses but require less polymer. Performance for these presses is best for highly fibrous sludges (paper and pump industrial sludge or municipal primary sludge) that are relatively easy to dewater. Rotary fan presses also have similar solids capture (less than 95 percent) as screw presses. This equipment has capacity limitations that necessitate installation of more modules than centrifuges for the same processing capacity requirement and operating hours.

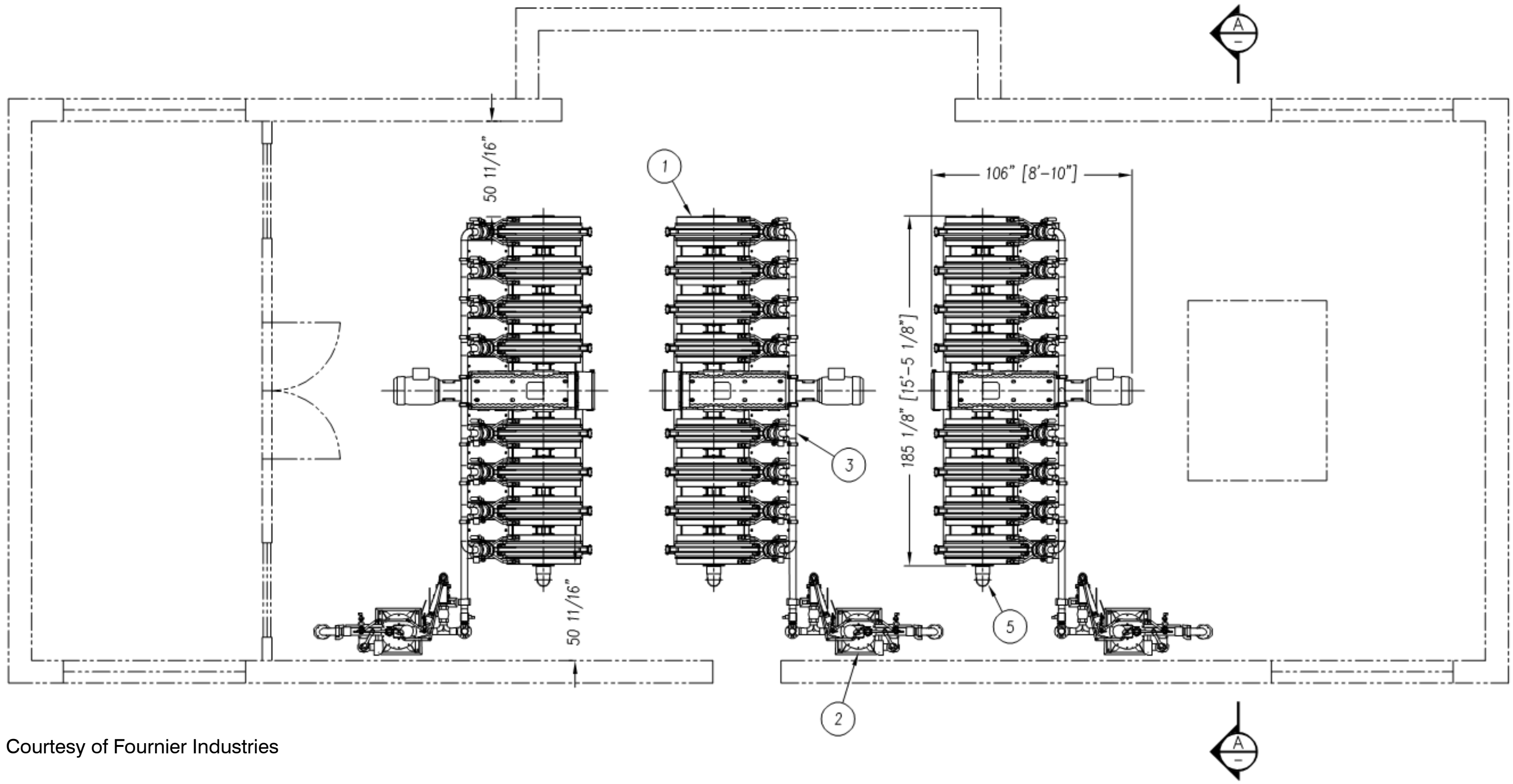
Since the inlet and outlet geometry will be different than the existing centrifuges, the rotary fan presses will require some adaptations to fit in with the existing chutes and hoppers. Figure 6.9 is a layout of the rotary fan press equipment in the Solids Handling Building.

6.0 ALTERNATIVES COMPARISON

This section summarizes the alternatives evaluation for the dewatering process.

6.1 Economic

Table 6.7 summarizes the equipment sizing, anticipated performance, and results of the life cycle cost comparison for the alternatives. The present worth analysis was based on a 15-year lifecycle cost and includes capital costs and annual O&M costs including power, maintenance, and labor costs. Capital costs reflect an April 2017 ENR of 10688 and are based on vendor proposals with allowances for mechanical, structural, and electrical improvements. Unit costs for estimating O&M are based on unit pricing and current sludge disposal costs provided by the Agency. Detailed capital and O&M costs are included in Appendix A.



Courtesy of Fournier Industries

ALTERNATIVE 4
ROTARY FAN PRESS LAYOUT

FIGURE 6.9

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Table 6.7 Present Worth Analysis of Dewatering Alternatives
2017 Facilities Master Plan
Central Marin Sanitation Agency

	Alt. 1 Rehab Centrifuges	**Alt. 2 New Centrifuges**	**Alt. 3 Screw Presses**	**Alt. 4 Rotary Fan Presses**
Digested Sludge Feed, gpd	93,345	93,345	93,345	93,345
Digested Sludge Feed, ppd	14,570	14,570	14,570	14,570
Sludge Feed Thickness, Percent Solids	1.73	1.73	1.73	1.73
Number of Units, duty + standby	2 + 1	2 + 1	2 + 0	2 + 1
Manufacturer and Model	Centrisys CS18-4	Alfa Laval G3 75	Huber Ros3Q800	Fournier 8-900/8000CV
Maximum/Recommended for Evaluation Hydraulic Capacity, gpm per Unit (Peak / Average)	100 / 75	135 / 100	57 / 40	86 / 72
Peak Solids Capacity, pph per Unit	840	840	714	744
Hours of Operation per Day at Build Out / Days of Operation per Week[(1)]	**10.4 / 7**	**7.8 / 7**	**19.4 / 7**	**10.8 / 7**
Estimated Polymer Dosage, active lbs/dry ton[(2)]	20	20	20	18
Estimated Dewatered Cake, Percent Solids[(3)]	24	24	20	20
Horsepower, hp per Unit	50	60	4.0	16
Unit Equipment Cost, each	$40,000[(4)]	$300,000	$332,000	$331,000
Project Cost[(5)]	$331,000	$3,203,000	$3,408,000	$4,589,000
Annual O&M Cost in 15 years[(6)]	$1,761,000	$1,729,000	$1,901,000	$1,946,000
Power Cost	$49,000	$44,000	$5,000	$12,000
Polymer Cost	$265,000	$265,000	$265,000	$239,000
Hauling and Disposal Cost	$1,319,000	$1,319,000	$1,583,000	$1,583,000
Labor Cost	$83,000	$55,000	$28,000	$83,000
Maintenance Cost	$45,000	$45,000	$20,000	$30,000
Present Worth of O&M Costs[(7)]	$20,621,000	$20,198,000	$22,055,00	$22,679,000
Present Worth[(7)]	**$20,952,000**	**$23,401,000**	**$25,463,000**	**$27,268,000**

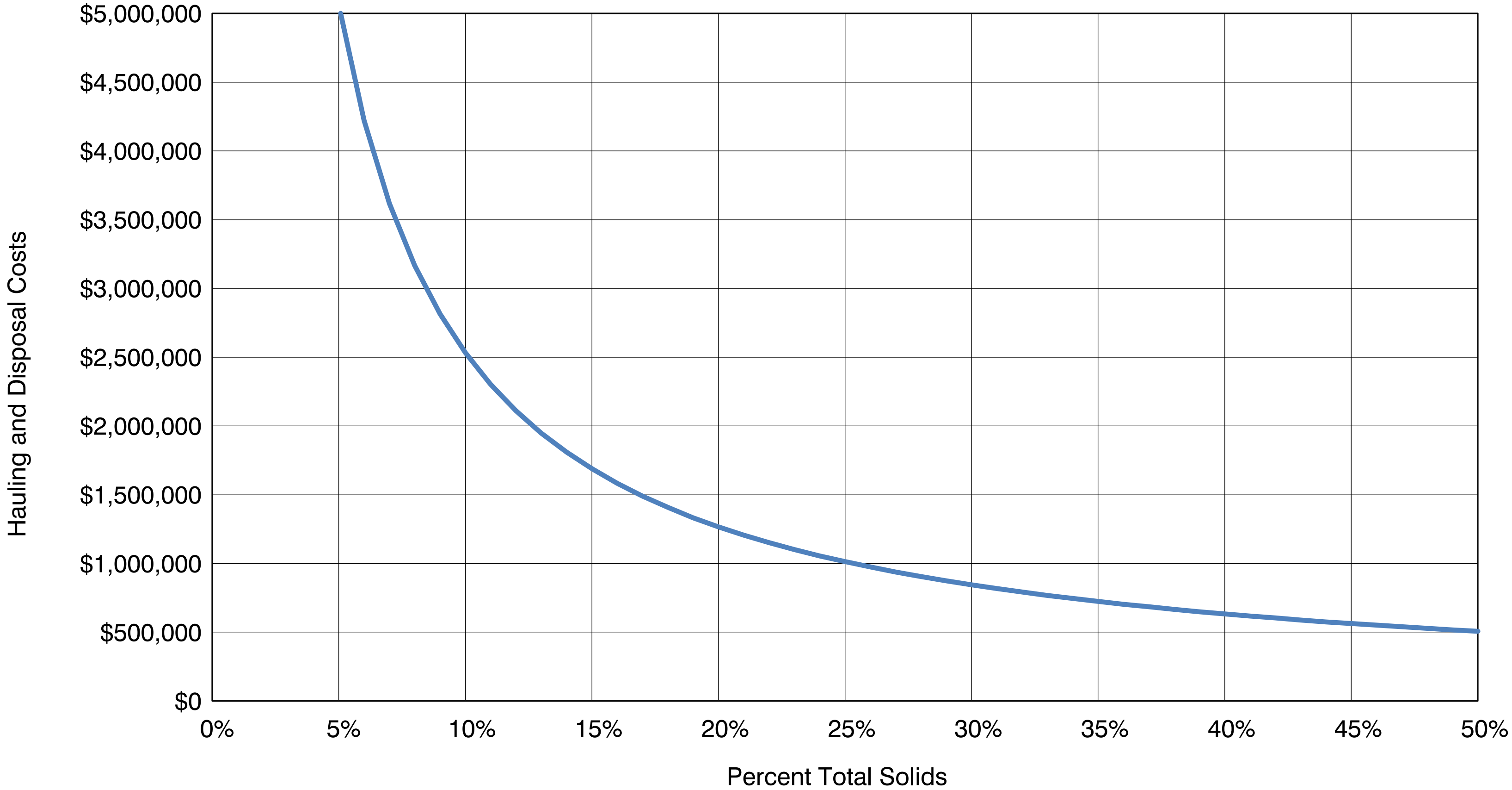
Notes:

(1) Hours of operation based on either hydraulic capacity or solids handling capacity, whichever is longer duration.
(2) Both polymer and cake values for the screw press and rotary fan press are based on relative performance of this equipment in published pilot tests at other facilities that investigated performance of centrifuges, screw presses, and rotary fan presses.
(3) There will likely be some degradation in dewatering performance for all technologies as the percentage of imported organics is increased to the digesters.
(4) Cost for refurbishment.
(5) Project costs for new units are based on April 2017 ENR of 10668 and include 30 percent allowance for estimating contingency and 35 percent allowance for engineering, legal, administration, and permitting.
(6) O&M costs include power ($0.17/kWh), chemicals ($1.05/active lbs), hauling ($8.57/wet ton), and disposal ($34.42/wet ton). Hauling and disposal costs assume 35% land application and 65% landfill. Labor costs based on $157,000/year including benefits. Maintenance costs are based on 5% of equipment costs for centrifuges and 3% for screw presses and rotary fan presses.
(7) Present Worth is total project cost plus present worth of annual O&M costs. Annual O&M costs were converted to present worth based on 3 percent inflation rate, 6 percent discount rate, and 15-year analysis period.

The centrifuge alternatives (1 and 2) have the lowest present worth cost. Although a centrifuge system would consume more power and require more operator attention and maintenance, it would achieve higher percent cake solids, which reduces hauling and disposal costs compared to the alternatives. The lower hauling and disposal costs for centrifuges offsets the slightly higher power and maintenance costs compared to the other technologies. Figure 6.10 illustrates how the percent total solids impacts the costs of hauling and disposal, while Figure 6.11 illustrates how hauling and disposal costs compare to other operations and maintenance costs.

The new centrifuges are able to operate for the fewest hours per day at the required loading. The Agency's preference is to operate the biosolids dewatering process 8 to 12 hours per day, 7 days per week. Due to space limitations, the screw presses that can fit into the existing building do not have enough capacity and must be run for significantly more than 12 hours per day. However, unattended operation of screw presses is more common and more feasible than unattended operation of centrifuges.

Redundancy for the current centrifuge system is provided by having two operating units and one standby unit. There is not enough room in the Solids Handling Building for a fully redundant screw press unit. While this may be acceptable for a short period of time, it limits operator flexibility and the ability to manage planned (or unplanned) downtime and maintenance.



HAULING AND DISPOSAL COSTS VS. PERCENT TOTAL SOLIDS

FIGURE 6.10

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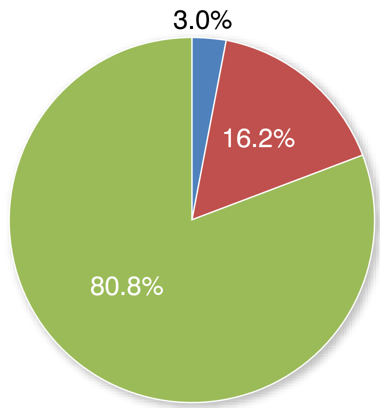
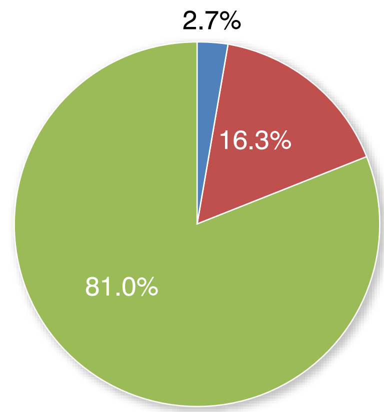
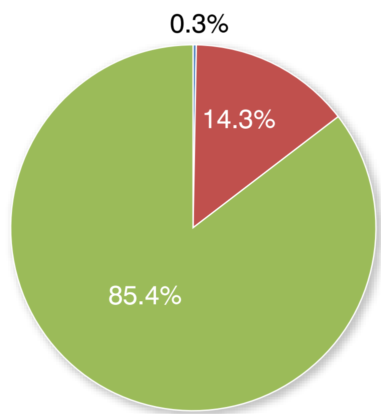
Alternative 1 – Rehab Centrifuges



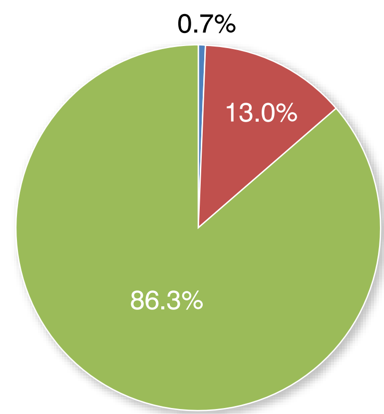
Alternative 2 – New Centrifuges



Alternative 3 – Screw Presses



Alternative 4 – Rotary Fan Presses



LEGEND

- Power Cost
- Polymer Cost
- Hauling and Disposal Cost

HAULING AND DISPOSAL COSTS
AS A PERCENTAGE OF O&M COSTS

FIGURE 6.11

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6.2 Non-Economic

The non-economic evaluation is based on several criteria. The criteria have been reviewed with the Agency to identify relative importance, and weighting factor were developed accordingly. Table 6.8 summarizes the non-economic analysis and key advantages and disadvantages of the dewatering technologies considered. For each criteria, a score of +1, 0, or -1 is given to each alternative, which reflects that the alternative is well aligned, neutral, or not aligned with that specific criteria. The score for each criteria is multiplied by the weighting factor, and the sum total is provided on the bottom. The higher the overall score, the better it is aligned with criteria valued by the Agency.

The goal for a dewatering system is to consistently provide efficient dewatering and solids capture. Efficient solids capture is defined as collecting a high percentage of dry solids in the dewatered cake. The centrifuge is expected to achieve higher cake percent solids, and thus higher centrate quality, as compared to a screw press or rotary fan press.

Another key factor is the ability to operate continuously for extended periods of time without breakdowns. While centrifuges, screw presses, and rotary fan presses are reliable pieces of equipment, the screw press fares better in this comparison due to its significantly lower operating speeds than centrifuges and greater history of installations than rotary fan presses.

Operations and maintenance considerations include the level of automation and control, ease of startup and shutdown, equipment accessibility, and ease of maintenance. The operational goal for the dewatering equipment is to minimize operational difficulties and maintenance downtime. All the technologies can be installed with high levels of automation. The centrifuge has a relatively more complex startup/shutdown cycle compared to the other technologies due to its higher operating speeds and greater amount of controls required.

A screw press system is a simpler dewatering system than the centrifuges with fewer mechanical components that can utilize unattended operation and requires less O&M attention. Screw presses are estimated to have a lower electrical costs and maintenance costs. However, the screw presses do not produce cake solids as high as centrifuges nor do they allow for the same amount of redundancy.

Rotary fan presses produce cake solids similar to screw presses, but are more compact, thus allowing redundancy similar to the centrifuges. Rotary Fan presses have less polymer consumption than screw presses or centrifuges.

Table 6.8 Evaluation Summary of Dewatering Alternatives
2017 Facilities Master Plan
Central Marin Sanitation Agency

Evaluation Criteria	Weight	Alt. 1 Rehab Centrifuges	Alt. 2 New Centrifuges	Alt. 3 Screw Presses	Alt. 4 Rotary Fan Presses	Comments
Cake Dryness	5	+1	+1	-1	-1	Centrifuges have the highest cake solids concentration and solids capture.
Redundancy with Least Equipment	4	0	0	-1	0	Screw presses offer no redundancy due to the building size constraints
Present Worth Costs	4	+1	0	-1	-1	While screw presses and rotary fan presses have lower power and maintenance costs, centrifuges have lower overall present worth due to lower hauling and disposal
Polymer consumption	3	-1	-1	-1	+1	Rotary Fan presses have lower polymer consumption than screw presses or centrifuges
Proven technology	3	+1	+1	+1	-1	Centrifuges and screw presses are widely used, while rotary fan presses have few installations similar in size to CMSA (>10 mgd)
Automate	3	0	0	0	0	All processes can have the speed, biosolids feed, and polymer dosage automated
Capacity limitation	3	0	+1	-1	0	New centrifuges will provide the greatest capacity, while screw press capacity is significantly limited due to the building size constraints and the number of units required
Maintenance	3	-1	-1	+1	+1	Screw presses and fan presses require less O&M attention and have fewer mechanical parts than centrifuges

Table 6.8 Evaluation Summary of Dewatering Alternatives
2017 Facilities Master Plan
Central Marin Sanitation Agency

Evaluation Criteria	Weight	Alt. 1 Rehab Centrifuges	Alt. 2 New Centrifuges	Alt. 3 Screw Presses	Alt. 4 Rotary Fan Presses	Comments
Structural Modifications	2	0	0	-1	-1	Screw presses and fan presses will likely require modifications to the existing structure
Odor control	2	0	0	0	0	All processes are enclosed and foul air is easily captured and treated.
Staff familiarity	2	+1	+1	-1	-1	Staff has experience using and maintaining centrifuges
Unmanned Operation	1	-1	-1	+1	0	Screw press allow for unmanned operation, while centrifuges require significant operator attention for startup and shutdown
Compatibility with regional biosolids to energy projects	1	+1	+1	-1	-1	B2E projects such as Lystek (already complete), or SCFI require sludge at concentrations ranging from 12 to 16 percent. Other technologies in development such as gasification or pyrolysis benefit from receiving a higher concentration of cake. Centrifuges offer the most flexibility as they deliver the driest cake, and can be adjusted to produce a wetter cake if needed.
Noise	1	-1	-1	+1	+1	Centrifuges generate significant noise and require sound attenuation
Total Score (Higher is Better)		**7**	**6**	**-13**	**-10**	

Notes:
(1) Legend: +1 Better; 0 Neutral; -1 Worse.

Centrifuges are able to achieve a relatively high cake solids of 24 to 26 percent, which lowers the hauling and disposal costs and keeps overall O&M cost lower. In addition, the Agency has experience using and maintaining centrifuges. If biosolids drying is considered for future biosolids disposal to produce Class A biosolids, or if gasification or pyrolysis is being considered for sludge disposal, producing a higher cake concentration as is produced by the centrifuge will be beneficial. However, cake transferred to Lystek at the Fairfield Suisun facility only requires cake dryness of 16-percent, which should be achievable by any of the three technologies. However, the lower cake dryness and associated increase in water weight will increase hauling costs. Currently, the Agency is delivering two loads of biosolids per week to Lystek and this will likely increase in the future.

7.0 CAKE HOPPER IMPROVEMENTS

Regardless of the chosen technology, consideration should be given to revising the conveyance of the cake into and out of the hoppers to prevent overflows of a single hopper when only one unit is in service. The hopper system could be revised to spread sludge cake between the three hoppers when only one dewatering unit is in service or allow all three hoppers to be used with each dewatering unit. This could be achieved by upgrading the hopper units with a single hopper with a live bottom.

A live bottom hopper has a multiple screw feeder located on the bottom of the bin that can meter residuals to trucks or dumpsters below. The live bottom can utilize multiple discharge points with slide gates to aid in distributing solids. This allows the storage bin below to be loaded evenly to better utilize the storage volume. See Figure 6.12 for an example of a live bottom hopper. Costs for modifications to the hoppers were not developed in this TM, but could range from $1 to $2 million dollars for a unit sufficiently sized for the Agency.

The addition of a truck scale system could simplify truck loading by opening/closing gates once setpoint weights are reached for each truck. However, such a system would have to be installed within the existing truck loading bay and this would be a complex sequencing task, with significant structural and electrical elements for required excavation and load cell integration. A scale located external to the loading bay could be installed more easily and would provide a weight readout for filled trucks, but would not provide benefits during the truck loading process itself. The addition of a scale within the truck loading facility would add significantly more cost to the estimated $1 to $2 million for hopper modifications.

Courtesy of KWS Environmental

EXAMPLE OF LIVE BOTTOM HOPPER

FIGURE 6.12

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APPENDIX A – PROJECT COST ESTIMATES

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	6 - BIOSOLIDS DETWATERING	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR MARCH 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	7/28/2017
PROJECT ID :		**PREPARED BY :**	RRH
TITLE :	Alternate 1 - Rehab Centrifuges	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Rehab Existing Centrifuges**					
	Rehab Centrisys CS18-4 Centrifgues	3	EA	$48,000	$144,000	
	Total					$144,000
	SUBTOTAL					**$144,000**
2	**Allowances**					
	Structural Allowance	0	LS	$0	$0	
	Mechanical Allowance	0	LS	$0	$0	
	EI&C Allowance (% of installed equipment cost)	0%	%		$0	
	Total					$0
	SUBTOTAL					**$144,000**
	Estimating Contingency	30%	%			$43,200
	SUBTOTAL					**$187,200**
	Sales Tax on 50% of Subtotal Above	9.00%	%			$8,500
	SUBTOTAL					**$195,700**
	General Conditions, Contractor Overhead, & Profit	25%	%			$49,000
	CONSTRUCTION COST SUBTOTAL					**$244,700**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35%	%			$86,000
	PROJECT COST					**$331,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	6 - BIOSOLIDS DETWATERING	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR MARCH 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	7/28/2017
PROJECT ID :		**PREPARED BY :**	RRH
TITLE :	Alternate 2 - New Centrifuges	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**New Centrifuges**					
	Centrifuges Alfa Laval G3 75	3	EA	$360,000	$1,080,000	
	Total					$1,080,000
	SUBTOTAL					**$1,080,000**
2	**Allowances**					
	Structural Allowance	0	LS	$0	$0	
	Mechanical Allowance	1	LS	$100,000	$100,000	
	EI&C Allowance (% of installed equipment cost)	20%	%		$216,000	
	Total					$316,000
	SUBTOTAL					**$1,396,000**
	Estimating Contingency	30%	%			$418,800
	SUBTOTAL					**$1,814,800**
	Sales Tax on 50% of Subtotal Above	9.00%	%			$81,700
	SUBTOTAL					**$1,896,500**
	General Conditions, Contractor Overhead, & Profit	25%	%			$475,000
	CONSTRUCTION COST SUBTOTAL					**$2,371,500**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35%	%			$831,000
	PROJECT COST					**$3,203,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

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2017 FACILITIES MASTER PLAN

TASK :	6 - BIOSOLIDS DETWATERING	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR MARCH 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	7/28/2017
PROJECT ID :		**PREPARED BY :**	RRH
TITLE :	Alternate 3 - Screw Presses	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Screw Presses**					
	Screw Presses Huber Ros3Q800	2	EA	$431,600	$863,200	
	Total					$863,200
	SUBTOTAL					**$863,200**
2	**Allowances**					
	Structural Allowance	1	LS	$300,000	$300,000	
	Mechanical Allowance	1	LS	$150,000	$150,000	
	EI&C Allowance (% of installed equipment cost)	20%	%		$172,640	
	Total					$622,600
	SUBTOTAL					**$1,485,800**
	Estimating Contingency	30%	%			$445,800
	SUBTOTAL					**$1,931,600**
	Sales Tax on 50% of Subtotal Above	9.00%	%			$87,000
	SUBTOTAL					**$2,018,600**
	General Conditions, Contractor Overhead, & Profit	25%	%			$505,000
	CONSTRUCTION COST SUBTOTAL					**$2,523,600**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35%	%			$884,000
	PROJECT COST					**$3,408,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	6 - BIOSOLIDS DETWATERING	**LOCATION FACTOR :**	1.24
JOB # :	10405A.00	**SF ENR MARCH 2017 :**	11609
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	7/28/2017
PROJECT ID :		**PREPARED BY :**	RRH
TITLE :	Alternate 4 - Rotary Fan Presses	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Rotary Fan Presses**					
	Rotary Fan Press Fournier 8-900/8000CV	3	EA	$430,898	$1,292,700	
	Total					$1,292,700
	SUBTOTAL					**$1,292,700**
2	**Allowances**					
	Structural Allowance	1	LS	$300,000	$300,000	
	Mechanical Allowance	1	LS	$150,000	$150,000	
	EI&C Allowance (% of installed equipment cost)	20%	%		$258,540	
	Total					$708,500
	SUBTOTAL					**$2,001,200**
	Estimating Contingency	30%	%			$600,400
	SUBTOTAL					**$2,601,600**
	Sales Tax on 50% of Subtotal Above	9.00%	%			$117,100
	SUBTOTAL					**$2,718,700**
	General Conditions, Contractor Overhead, & Profit	25%	%			$680,000
	CONSTRUCTION COST SUBTOTAL					**$3,398,700**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35%	%			$1,190,000
	PROJECT COST					**$4,589,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

APPENDIX B – PRESENT WORTH COST ANALYSIS

Present Worth Cost Analysis

Year of analysis	**2017**	Period	**15**	yrs	**2032**
Escalation rate	**3.00%**	Power Cost	**$0.17**	/kWh	
Discount rate	**6.00%**	Polymer Cost	**$1.80**	$/active lb	
Growth rate	**1.50%**	Hauling Cost	**$8.57**	$/wet ton	
		Disposal Cost	**$34.42**	$/wet ton	

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Dewatering Feed Solids, lbs/hr	1,345	1,365	1,386	1,406	1,428	1,449	1,471	1,493	1,515	1,538	1,561	1,584	1,608	1,632	1,657	1,682
Dewatering Feed Solids, dry tons/year	5,891	5,979	6,069	6,160	6,253	6,346	6,442	6,538	6,636	6,736	6,837	6,939	7,044	7,149	7,256	7,365
Dewatering Feed Volumetric, gpm	156	158	161	163	166	168	171	173	176	178	181	184	187	189	192	195
Project Cost																
Centrifuges Rehab	**$331,000**															
Centrifuges Replace	**$3,203,000**															
Screw Presses	**$3,408,000**															
Rotarty Fan Presses	**$4,589,000**															
Power Cost																
Centrifuges Rehab	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355	$49,355
Centrifuges Replace	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420	$44,420
Screw Presses	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330	$5,330
Rotarty Fan Presses	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845	$11,845
Polymer Cost																
Centrifuges Rehab	$212,080	$215,261	$218,490	$221,767	$225,094	$228,470	$231,897	$235,375	$238,906	$242,490	$246,127	$249,819	$253,566	$257,370	$261,230	$265,149
Centrifuges Replace	$212,080	$215,261	$218,490	$221,767	$225,094	$228,470	$231,897	$235,375	$238,906	$242,490	$246,127	$249,819	$253,566	$257,370	$261,230	$265,149
Screw Presses	$212,080	$215,261	$218,490	$221,767	$225,094	$228,470	$231,897	$235,375	$238,906	$242,490	$246,127	$249,819	$253,566	$257,370	$261,230	$265,149
Rotarty Fan Presses	$190,872	$193,735	$196,641	$199,590	$202,584	$205,623	$208,707	$211,838	$215,015	$218,241	$221,514	$224,837	$228,210	$231,633	$235,107	$238,634
Hauling and Disposal Cost																
Centrifuges Rehab	$1,055,232	$1,071,061	$1,087,127	$1,103,434	$1,119,985	$1,136,785	$1,153,837	$1,171,144	$1,188,711	$1,206,542	$1,224,640	$1,243,010	$1,261,655	$1,280,580	$1,299,788	$1,319,285
Centrifuges Replace	$1,055,232	$1,071,061	$1,087,127	$1,103,434	$1,119,985	$1,136,785	$1,153,837	$1,171,144	$1,188,711	$1,206,542	$1,224,640	$1,243,010	$1,261,655	$1,280,580	$1,299,788	$1,319,285
Screw Presses	$1,266,279	$1,285,273	$1,304,552	$1,324,120	$1,343,982	$1,364,142	$1,384,604	$1,405,373	$1,426,454	$1,447,850	$1,469,568	$1,491,612	$1,513,986	$1,536,696	$1,559,746	$1,583,142
Rotarty Fan Presses	$1,266,279	$1,285,273	$1,304,552	$1,324,120	$1,343,982	$1,364,142	$1,384,604	$1,405,373	$1,426,454	$1,447,850	$1,469,568	$1,491,612	$1,513,986	$1,536,696	$1,559,746	$1,583,142
Labor Cost																
Centrifuges Rehab	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651
Centrifuges Replace	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101	$55,101
Screw Presses	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550	$27,550
Rotarty Fan Presses	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651	$82,651
Ongoing Maintenance Cost																
Centrifuges Rehab	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000
Centrifuges Replace	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000
Screw Presses	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920	$19,920
Rotarty Fan Presses	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831	$29,831
Annual Cost																
Centrifuges Rehab	$1,444,319	$1,463,328	$1,482,623	$1,502,207	$1,522,085	$1,542,262	$1,562,740	$1,583,526	$1,604,624	$1,626,039	$1,647,774	$1,669,836	$1,692,228	$1,714,956	$1,738,026	$1,761,441
Centrifuges Replace	$1,411,833	$1,430,842	$1,450,137	$1,469,721	$1,489,599	$1,509,776	$1,530,254	$1,551,040	$1,572,138	$1,593,553	$1,615,288	$1,637,349	$1,659,742	$1,682,470	$1,705,539	$1,728,955
Screw Presses	$1,531,159	$1,553,335	$1,575,843	$1,598,688	$1,621,876	$1,645,413	$1,669,302	$1,693,549	$1,718,161	$1,743,141	$1,768,496	$1,794,231	$1,820,353	$1,846,866	$1,873,777	$1,901,092
Rotarty Fan Presses	$1,581,478	$1,603,336	$1,625,521	$1,648,039	$1,670,894	$1,694,093	$1,717,639	$1,741,539	$1,765,797	$1,790,419	$1,815,411	$1,840,777	$1,866,524	$1,892,656	$1,919,181	$1,946,104
Total Cost																
Centrifuges Rehab	$1,775,319	$1,463,328	$1,482,623	$1,502,207	$1,522,085	$1,542,262	$1,562,740	$1,583,526	$1,604,624	$1,626,039	$1,647,774	$1,669,836	$1,692,228	$1,714,956	$1,738,026	$1,761,441
Centrifuges Replace	$4,614,833	$1,430,842	$1,450,137	$1,469,721	$1,489,599	$1,509,776	$1,530,254	$1,551,040	$1,572,138	$1,593,553	$1,615,288	$1,637,349	$1,659,742	$1,682,470	$1,705,539	$1,728,955
Screw Presses	$4,939,159	$1,553,335	$1,575,843	$1,598,688	$1,621,876	$1,645,413	$1,669,302	$1,693,549	$1,718,161	$1,743,141	$1,768,496	$1,794,231	$1,820,353	$1,846,866	$1,873,777	$1,901,092
Rotarty Fan Presses	$6,170,478	$1,603,336	$1,625,521	$1,648,039	$1,670,894	$1,694,093	$1,717,639	$1,741,539	$1,765,797	$1,790,419	$1,815,411	$1,840,777	$1,866,524	$1,892,656	$1,919,181	$1,946,104

Present Worth Cost Analysis

Year of analysis	**2017**	Period	**15**	yrs	**2032**
Escalation rate	**3.00%**	Power Cost	**$0.17**	/kWh	
Discount rate	**6.00%**	Polymer Cost	**$1.80**	$/active lb	
Growth rate	**1.50%**	Hauling Cost	**$8.57**	$/wet ton	
		Disposal Cost	**$34.42**	$/wet ton	

Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Total Cost Inflated																
Centrifuges Rehab	$1,775,319	$1,507,228	$1,572,915	$1,641,503	$1,713,121	$1,787,904	$1,865,994	$1,947,538	$2,032,690	$2,121,611	$2,214,470	$2,311,443	$2,412,712	$2,518,471	$2,628,920	$2,744,267
Centrifuges Replace	$4,614,833	$1,473,768	$1,538,451	$1,606,004	$1,676,557	$1,750,244	$1,827,204	$1,907,584	$1,991,538	$2,079,225	$2,170,812	$2,266,475	$2,366,395	$2,470,764	$2,579,781	$2,693,655
Screw Presses	$4,939,159	$1,599,935	$1,671,811	$1,746,930	$1,825,436	$1,907,484	$1,993,234	$2,082,852	$2,176,514	$2,274,404	$2,376,711	$2,483,636	$2,595,388	$2,712,185	$2,834,256	$2,961,839
Rotarty Fan Presses	$6,170,478	$1,651,436	$1,724,515	$1,800,856	$1,880,606	$1,963,918	$2,050,951	$2,141,873	$2,236,859	$2,336,091	$2,439,760	$2,548,066	$2,661,216	$2,779,430	$2,902,934	$3,031,967
Present Value																
Centrifuges Rehab	$1,775,319	$1,421,913	$1,399,889	$1,378,237	$1,356,952	$1,336,026	$1,315,452	$1,295,224	$1,275,335	$1,255,779	$1,236,549	$1,217,639	$1,199,044	$1,180,758	$1,162,774	$1,145,087
Centrifuges Replace	$4,614,833	$1,390,347	$1,369,216	$1,348,432	$1,327,990	$1,307,884	$1,288,107	$1,268,652	$1,249,515	$1,230,690	$1,212,170	$1,193,951	$1,176,026	$1,158,391	$1,141,040	$1,123,968
Screw Presses	$4,939,159	$1,509,372	$1,487,906	$1,466,756	$1,445,916	$1,425,383	$1,405,151	$1,385,216	$1,365,572	$1,346,216	$1,327,143	$1,308,348	$1,289,828	$1,271,578	$1,253,594	$1,235,872
Rotarty Fan Presses	$6,170,478	$1,557,958	$1,534,812	$1,512,034	$1,489,616	$1,467,554	$1,445,840	$1,424,468	$1,403,433	$1,382,729	$1,362,349	$1,342,289	$1,322,543	$1,303,105	$1,283,971	$1,265,134
Net Present Value																
Centrifuges Rehab	$20,951,976															
Centrifuges Replace	$23,401,211															
Screw Presses	$25,463,012															
Rotarty Fan Presses	$27,268,313															
Net Present Value of O&M Costs																
Centrifuges Rehab	$20,620,976															
Centrifuges Replace	$20,198,211															
Screw Presses	$22,055,012															
Rotarty Fan Presses	$22,679,313															

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM NO. 7
BLENDING REDUCTION ALTERNATIVES ANALYSIS

FINAL
October 2018

2700 YGNACIO VALLEY ROAD, SUITE 300 • WALNUT CREEK, CALIFORNIA 94598 • P. 925.932.1710 • F. 925.930.0208

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM
NO. 7
BLENDING REDUCTION ALTERNATIVES ANALYSIS

TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF FIGURES

BLENDING REDUCTION ALTERNATIVES ANALYSIS

1.0 INTRODUCTION

This technical memorandum summarizes an evaluation of wet weather storage and treatment alternatives to reduce the frequency, duration, and volume of wet weather blending events at the Central Marin Sanitation Agency (Agency) Wastewater Treatment Plant (WWTP).

2.0 SUMMARY OF KEY FINDINGS

The key findings are:

- Two (2) primary effluent storage alternatives were evaluated:
  - Alternative S-1, which converts the existing effluent pond for temporary storage of primary effluent, has a project cost of $10.6 million in 2016 dollars and up to 38 percent reduction in blending volume. While this is the lowest-cost storage alternative, disadvantages include lost use of the effluent storage pond during wet weather events and risk of odors in a developed area.
  - Alternative S-2, which adds a new 3.0 million gallon (MG) underground storage tank, is significantly more costly at $29.8 million and only results in 21 percent reduction in blending volume. However, it offers less risk of odors, more flexibility to implement daily flow equalization, and better use of space on the site.

- Five (5) treatment alternatives were evaluated:
  - Alternative T-1, which proposes no new treatment facilities, would have no additional project cost and would not achieve significant blending reductions.
  - Alternative T-2, which includes optimization of existing facilities, has a total project cost of $11.4 million to achieve a 39 percent reduction in blending volume. The main advantage is cost-effectiveness, especially if the optimization occurs on a phased schedule. The main disadvantage is that construction would need to occur over at least two separate dry weather seasons because only two secondary clarifiers could be modified per dry season.
  - Alternative T-3, which includes expanding existing secondary treatment facilities, has a total project cost of $55.0 million to achieve a 63 percent reduction in blending volume. This alternative improves overall process reliability year-round and the new facilities could be used for nutrient removal if needed in the future. However, the expanded facilities must be in service continuously during the wet weather season, which would result in additional

and significant operating costs. The expanded facilities also require significant space, which would result in significantly reduced capacity of the effluent storage pond.

- Alternative T-4, which includes modifying secondary treatment facilities to operate the biotowers and activated sludge systems in parallel, has a total project cost of $28.9 million and 87 percent reduction in blending volume. The main advantage is blending reduction. The main disadvantage is that no facilities are currently in existence employing ballasted flocculation as a clarifier following trickling filters, so the technology is experimental. Other disadvantages include lost use of the effluent storage pond, high cost, and expensive additional facilities constructed for use during less than 3 percent of the year (on average).
- The remaining treatment alternatives, T-5 and T-6, achieve 95 and 100 percent reductions in blending volume, respectively. However, project costs are very high, ranging from $72.6 to $303 million.

3.0 BACKGROUND

3.1 Treatment Facilities

The Agency's WWTP was designed in 1981 with an average dry weather flow capacity of 10.0 mgd and a corresponding sustained peak secondary treatment capacity of 30.0 mgd for the biotower/activated sludge system. In order to handle the significant wet weather flows from the tributary agencies (San Rafael Sanitation District, Sanitary District No. 1 of Marin County, Sanitary District No. 2 of Marin County, and the City of Larkspur), the design primary capacity was 90 mgd. A blending channel was provided to convey primary effluent flows greater than the sustained peak secondary treatment capacity of 30.0 mgd to a point downstream of the secondary clarifiers where the excess primary effluent and secondary effluent are blended before effluent disinfection.

The original design approach included effluent disposal by gravity through an offshore outfall and diffusers. A 4.0 MG effluent storage pond, with a maximum depth of 8 feet and minimum freeboard of 3 feet, was included to handle concurrent peak flow and high tide events by storing final effluent until the tide elevation dropped, increasing the hydraulic capacity of the outfall and diffusers. Subsequently, the effluent storage pond volume was increased to 6.2 MG, with a freeboard of 1 foot, to provide additional storage capacity.

The Wet Weather Improvements Project (WWIP) was completed in May 2010 to handle increasing wet weather flows from the satellite collection agencies. Treatment plant expansions and modifications included new mechanical equipment for the Aerated Grit Chamber 3, two new primary clarifiers to increase the primary treatment capacity to 125 mgd, polymer storage and feed facilities to increase primary clarifier performance when ferric chloride (from existing storage and feed facilities) was added during peak flow events, two new chlorine contact tanks to increase the disinfection capacity to 125 mgd, and a new 155 mgd effluent pumping station to increase disposal capacity during concurrent peak flow and high tide events. Motorized operators were installed on existing aeration tank gates so that changing the aeration tanks to a sludge reaeration configuration could be made through the SCADA system if necessary during wet weather events. Additionally, the volume of the effluent storage pond was increased again to 7.0 MG by increasing the height and side slope of the pond berm.

3.2 Historical Blending Events

The number, duration, and volume of blending events that have occurred over the past three water years (October 1, 2013 through September 30, 2016) was obtained from the Agency website, which summarizes the information submitted to the Regional Board. These data are summarized in Appendix A. During this three-year period, there were 27 blending events with a total duration of 413 hours and a total volume of 279 MG. The individual blending event metrics, together with influent flow rate hydrographs provided by the Agency, were used to estimate reductions in blending volume and event frequency for the primary effluent storage and secondary treatment alternatives discussed below.

4.0 PRIMARY EFFLUENT STORAGE ALTERNATIVES

This section presents two on-site primary effluent storage alternatives to reduce the frequency, duration, and volume of wet weather blending events. The major components comprising each alternative and the proposed operating strategy are described.

4.1 S-1 – Convert Existing Effluent Storage Pond

Alternative S-1 provides on-site storage of primary effluent in the modified effluent storage pond. When wastewater flows exceed 30 mgd, primary effluent would be diverted to the converted effluent storage pond. With a freeboard of 1 foot, 6.3 MG of storage would be available. The stored primary effluent would be pumped back to the existing liquid treatment train as wastewater flows recede below 30 mgd following a wet weather event. This approach would eliminate blending for those peak flow events where the total volume of excess primary effluent is 6.3 MG or less and would reduce the blended primary effluent volume for all other peak flow events.

This storage alternative would reduce blended primary effluent volumes by approximately 38 percent, based on an analysis of reported blending events over the past three wet-weather seasons.

The major components of this storage alternative include:

- Primary Effluent Diversion Box. This hydraulic control structure would be adjacent to the primary effluent channel and would contain a downward opening weir gate that would divert flows by gravity through a new pipeline to the effluent storage pond. A sump pump would be provided in the diversion box to empty this structure after each use.

- Effluent Storage Pond Modifications. This includes a new inlet structure, concrete floor lining, wash-down monitors, and floating mechanical surface aerators. The proposed modifications would allow Agency staff to aerate the wastewater while it is being stored and to clean the pond after each use to minimize the risk of odors. The tank would be cleaned after a storage event to prepare it to handle the next event. A number of wash-down monitors would be provided for operators to flush settled solids and other debris from the pond to minimize odors when the pond is empty. The solids and other debris would be conveyed by the Pond Drain Pump Station.

- Pond Drain Pump Station. This pump station would convey stored primary effluent to the primary effluent channel after the wet weather event ends and plant influent flows recede. All stored primary effluent would then receive full secondary treatment. The pump station would have a minimum 6.3 mgd capacity so that the pond could be emptied within one day.

4.2 S-2 – Install New Below-Grade Storage Tank

Alternative S-2 would provide on-site storage of up to 3 MG of primary effluent in a below-grade storage tank. When wastewater flows exceed 30 mgd, primary effluent would be diverted to the storage tank. The new storage tank facilities would be located below the Corporation Yard. The stored primary effluent would be pumped back to the existing liquid treatment train as wastewater flows recede below 30 mgd following a wet weather event. This approach would eliminate blending for those peak flow events where the volume of excess primary effluent is 3.0 MG or less and would reduce the blended primary effluent volume for all other peak flow events.

This storage alternative would reduce blended primary effluent volumes by approximately 21 percent, based on an analysis of plant flow data over the past three wet-weather seasons.

The major components of this storage alternative include:

- Primary Effluent Diversion Box. This is the same as what was described for Alternative S-1.

- Primary Effluent Storage Tank. This includes a buried, pile supported, concrete storage tank that would need to be nearly 30 feet deep so that 3 MG of storage can be located below the Corporation Yard. The facility would include wash-down monitors, ventilation, and odor control. The tank would be cleaned after a storage event to prepare it to handle the next event. An automatic tipping trough-type basin cleaning system could be used to flush settled solids and other debris to the Tank Drain Pump station.

- Tank Drain Pump Station. This is the same as what was described for Alternative S-1 except that the pump station capacity would be 3 mgd.

5.0 TREATMENT ALTERNATIVES

This section presents five treatment alternatives to reduce the frequency, duration, and volume of wet weather blending events. The major components comprising each alternative and the proposed operating strategy are described. Process flow diagrams are also provided for each alternative.

5.1 T-1 – Maintain Existing Secondary Treatment

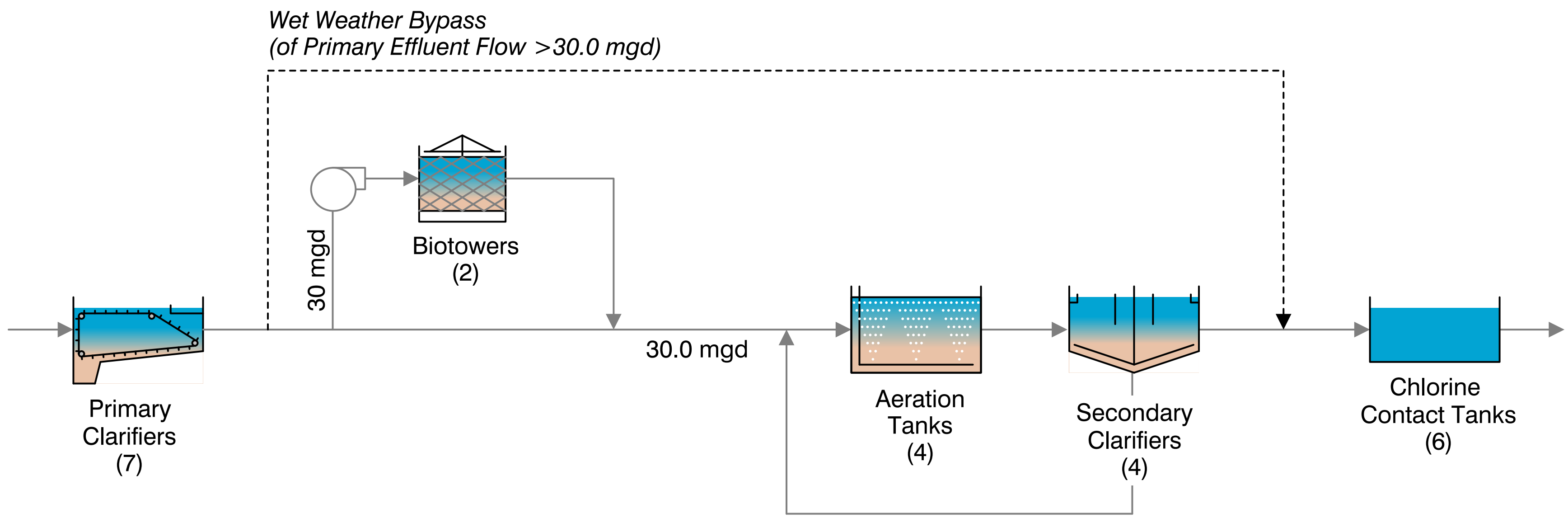
Alternative T-1 would maintain the existing secondary treatment facilities, which have a design peak sustained treatment capacity of 30 mgd. Figure 7.1 shows a process flow diagram of the existing secondary treatment facilities consisting of two biotowers, four aeration tanks, four secondary clarifiers, and ancillary equipment. Primary effluent flows greater than 30 mgd are routed around the secondary treatment facilities and are blended with secondary effluent before disinfection.

5.2 T-2 – Optimize Existing Secondary Treatment

Alternative T-2 would increase the sustained peak secondary treatment capacity to 37.5 mgd by optimizing the existing secondary treatment facilities, as shown in Figure 7.2.

This treatment alternative is based on modifying existing secondary facilities for reliable treatment up to a maximum secondary clarifier surface overflow rate (SOR) of 1,200 gal/d-sq. ft. This approach would eliminate blending for those peak flow events where the plant flow rate is 37.5 mgd or less and would reduce the blended primary effluent volume for all other peak flow events.

This treatment alternative would reduce blended primary effluent volumes by approximately 39 percent, based on an analysis of plant flow data over the past three wet-weather seasons.



ALTERNATIVE T-1 PROCESS FLOW DIAGRAM MAINTAIN EXISTING SECONDARY TREATMENT

FIGURE 7.1

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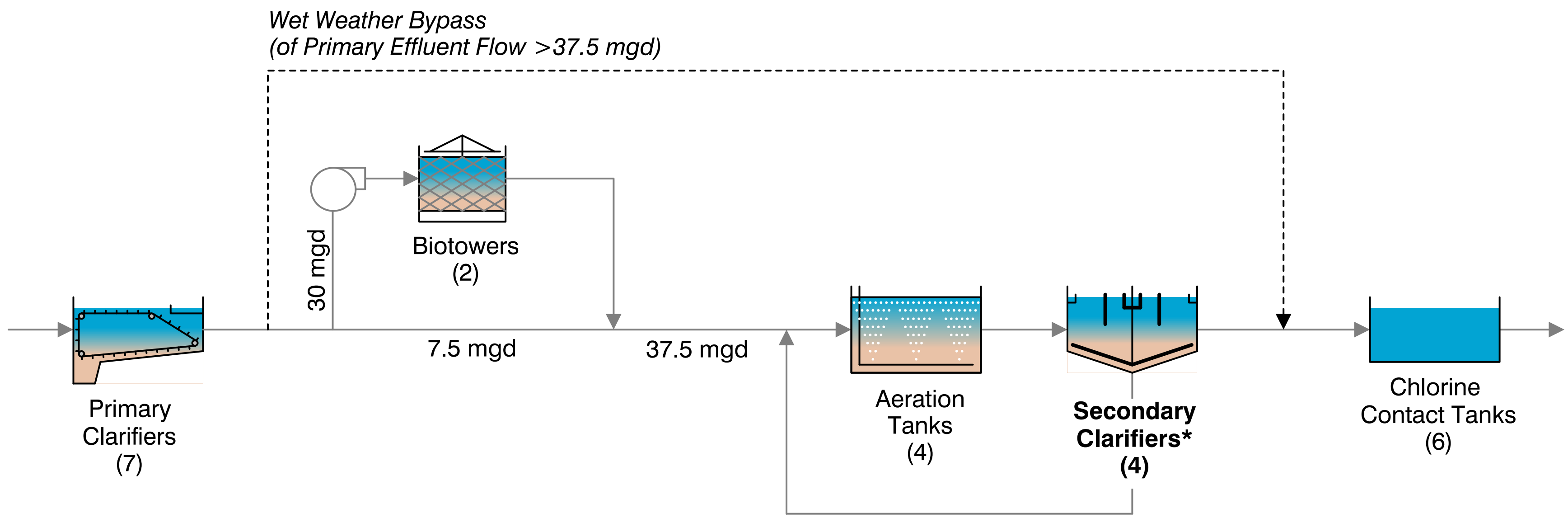

NOTE:

* Rehabilitate with new mechanisms and associated RAS pumping and piping modifications to improve performance.

ALTERNATIVE T-2
PROCESS FLOW DIAGRAM
OPTIMIZE SECONDARY TREATMENT

FIGURE 7.2

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

carollo

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The major components of this alternative include:

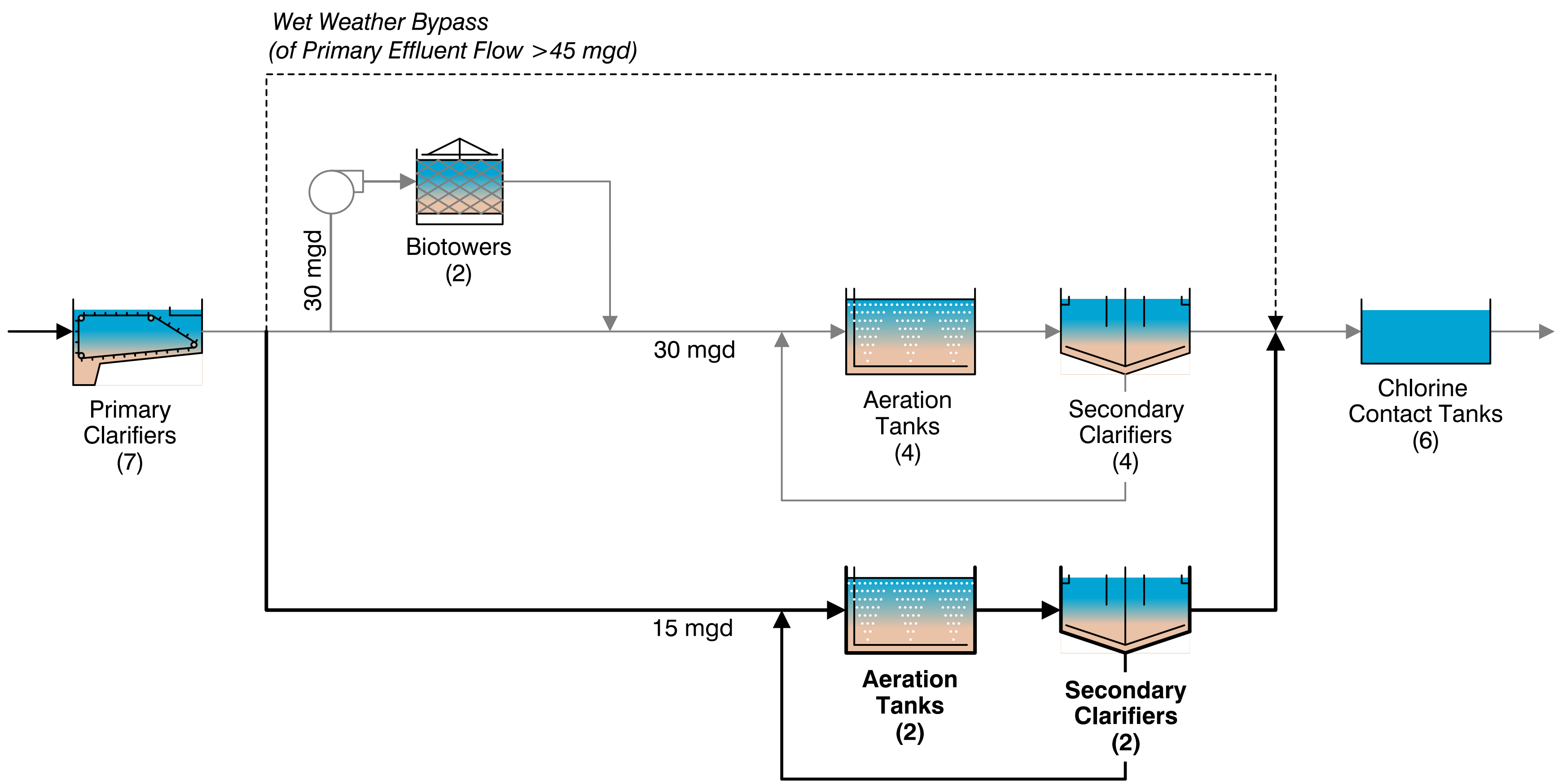
- Secondary Clarifier Rehabilitation. The existing clarifier mechanisms that utilize an "organ pipe"-type sludge suction removal mechanism in each clarifier would be replaced with a new clarifier mechanism that uses a suction tube-type mechanism to optimize clarifier performance and provide better sludge removal. The new mechanisms would maintain the existing center-feed configuration. Demolition of the existing mechanisms would include removal of the rake arms, surface skimmer, feedwell, return sludge control box, center column, drive unit, and bridge. The new mechanisms would include a center column, a single rotating sludge suction arm (and opposing counterweight), surface skimmer, drive unit, and bridge. A series of fixed orifices, with varying diameter, would be provided in the rotating sludge suction arm for settled sludge removal. Each mechanism would also include two additional components to optimize clarifier performance. First, an energy dissipating inlet (EDI) would reduce the clarifier inlet velocity out of the center column ports and balance flow distribution within the clarifier to minimize hydraulic short circuiting. Second, a circular flocculation baffle, with a diameter of approximately 33 feet and extending approximately 5 feet below the water surface, would provide additional mixed liquor flocculation to optimize sludge settleability.

- New RAS Pumps and Piping Modifications. The existing return activated sludge (RAS) pumps would be replaced with higher-capacity pumps to maintain effective clarifier performance at the higher sustained peak secondary flows. The existing RAS piping in the secondary clarifiers pump room would be modified so the inlet (suction side) of the existing RAS pumps is connected directly to the rotating suction arm. The existing waste activated sludge (WAS) piping would be modified so the inlet of the existing WAS pumps is connected directly to the modified RAS pump inlet piping. These modifications would improve control of return sludge pumping and activated sludge system solids residence time (SRT).

This alternative does not include modifications to the existing biotowers. Up to 30.0 mgd of primary effluent would be treated by the biotowers during peak flow events; so, up to 7.5 mgd of primary effluent would flow past the biofilters and be combined with the biofilter effluent upstream of the aeration tanks during peak flow events.

5.3 T-3 – Expand Existing Secondary Treatment

Alternative T-3 would increase the sustained peak secondary treatment capacity to 45.0 mgd by expanding the existing activated sludge facilities, as shown in Figure 7.3.



ALTERNATIVE T-3
PROCESS FLOW DIAGRAM
EXPAND EXISTING SECONDARY TREATMENT

FIGURE 7.3

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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This treatment alternative is based on constructing new aeration tanks, secondary clarifiers, and appurtenant facilities to increase the sustained peak secondary treatment capacity by 50 percent. This approach would eliminate blending for those peak flow events where the plant flow rate is 45.0 mgd or less and would reduce the blended primary effluent volume for all other peak flow events.

This treatment alternative would reduce blended primary effluent volumes by approximately 63 percent, based on an analysis of plant flow data over the past three wet-weather seasons.

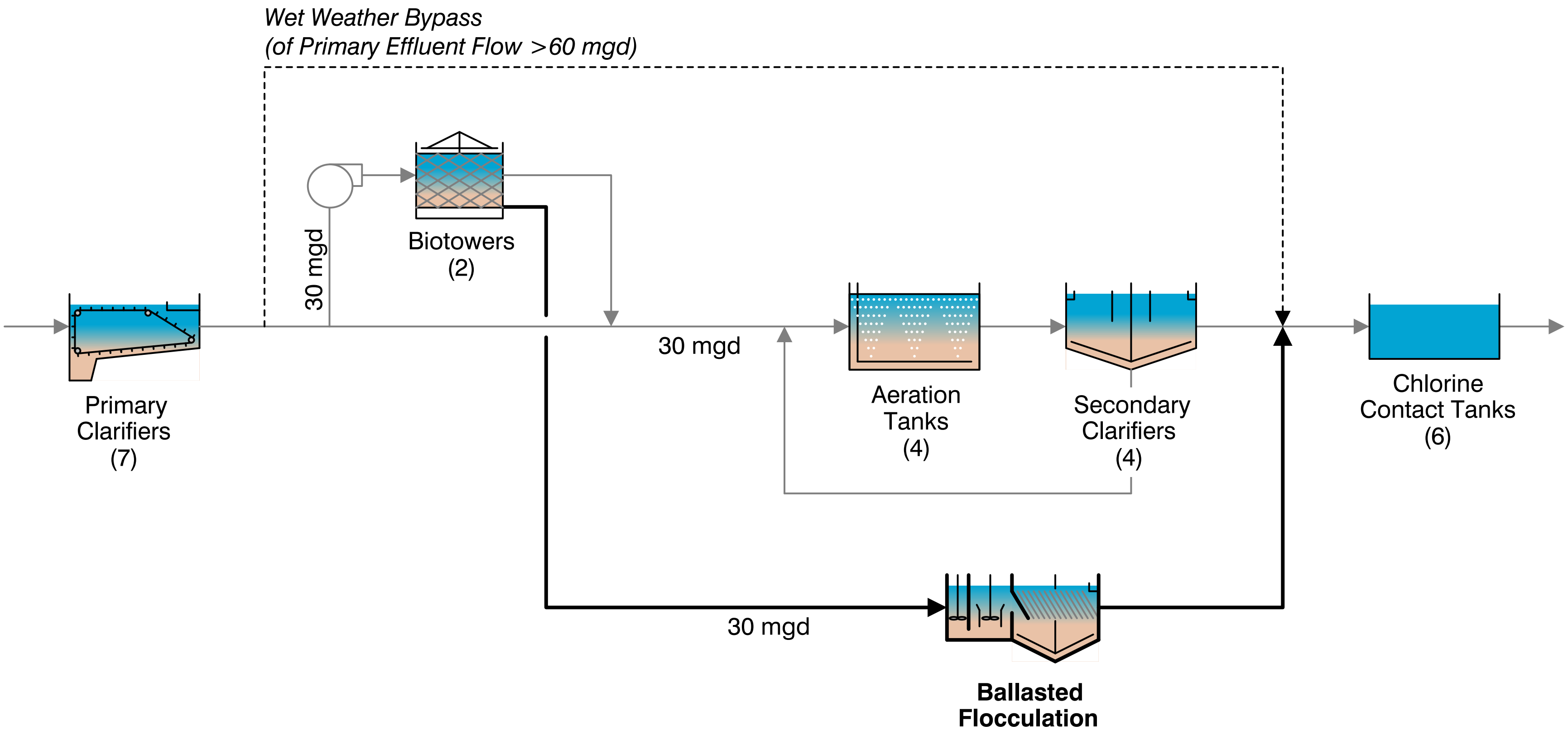
The major components of this alternative include:

- Primary Effluent Diversion Box. This is the same as what was described for Storage Alternatives S-1 and S-2.
- Aeration Tanks. This includes two (2) new aeration tanks, each with a volume of 0.313 MG. The aeration tanks would include diffusers.
- Secondary Clarifiers. This includes two (2) new 100 ft. diameter secondary clarifiers.
- Blower Building. A new blower building with blowers to supply process aeration for the new aeration tanks. If there is sufficient space in the existing blower building, it may be possible to locate new blowers there instead of in a new building.
- Sludge Pumping. Return sludge and waste sludge pumps would be needed to move settled sludge to the aeration basins and thickening facilities.

The new aeration tanks and secondary clarifiers would be located north of the existing tanks and clarifiers and would occupy a significant portion of the existing effluent storage basin. The new activated sludge treatment facilities would be operated continuously during the wet weather season so the secondary treatment capacity is available when a wet weather event occurs.

5.4 T-4 – Convert Biotowers and Activated Sludge to Run in Parallel

Alternative T-4 would increase the sustained peak secondary treatment capacity to 60.0 mgd by modifying the existing secondary treatment facilities to operate the biotowers and activated sludge systems in parallel during peak flow events, as shown in Figure 7.4.



ALTERNATIVE T-4
PROCESS FLOW DIAGRAM
CONVERT BIOTOWERS AND ACTIVATED SLUDGE TO RUN IN PARALLEL

FIGURE 7.4

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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This treatment alternative is based on constructing a new 30.0 mgd ballasted flocculation system to clarify the biotower effluent; the existing activated sludge system would not be modified. This approach would eliminate blending for those peak flow events where the plant flow rate is 60.0 mgd or less and would reduce the blended primary effluent volume for all other peak flow events.

This treatment alternative would reduce blended primary effluent volumes by approximately 87 percent, based on an analysis of plant flow data over the past three wet-weather seasons.

The major components of this alternative include:

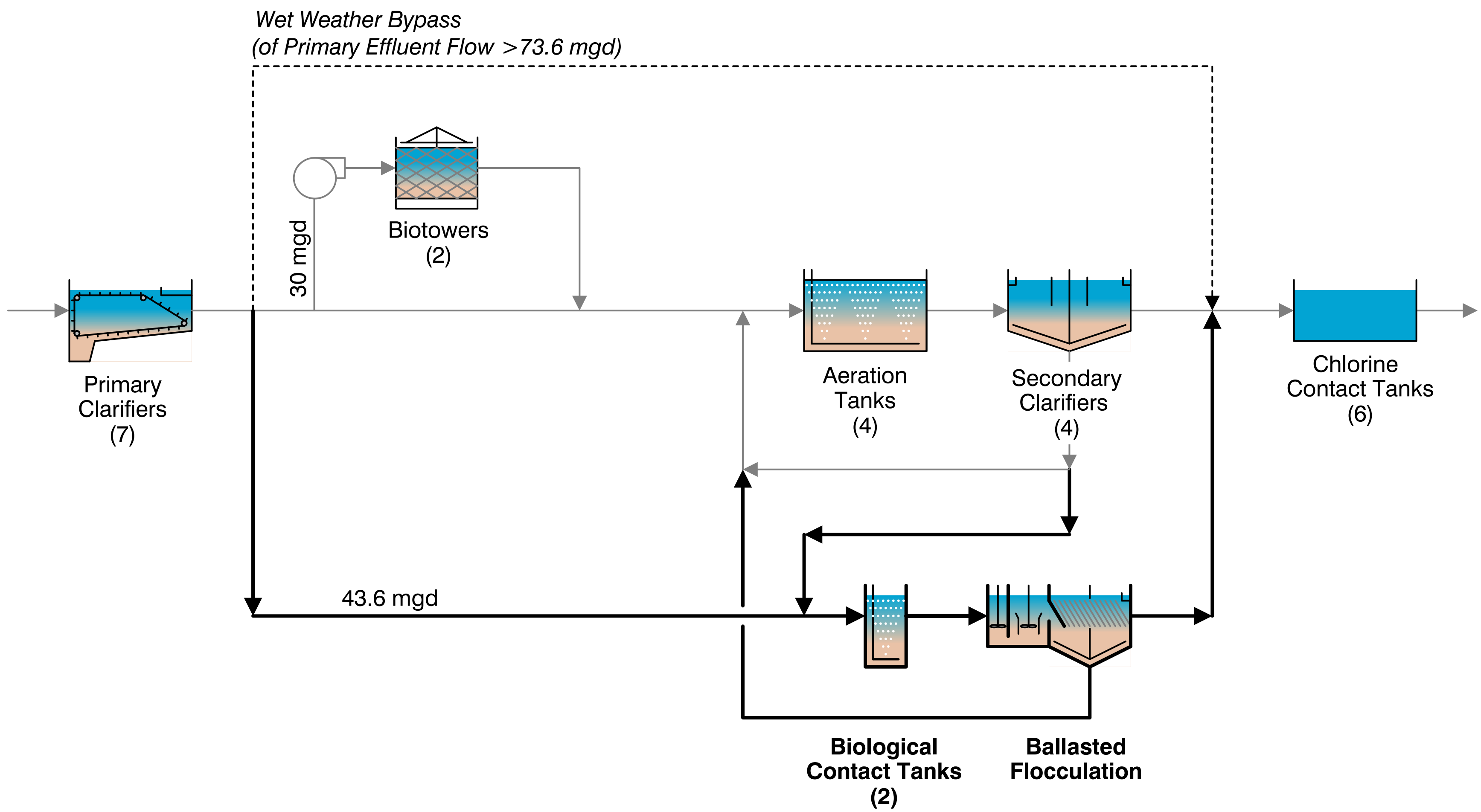
- Biotower Effluent Diversion. If the plant flow rate exceeded 30 mgd, the two existing biotowers would be isolated from the aeration tanks by closing the existing 48-in diameter effluent valve for each biotower and opening a new biotower effluent valve to direct the flow through a new pipeline line to the ballasted flocculation treatment system. The existing and new effluent valves would be motorized and operated through the SCADA system.

- Ballasted Flocculation. A 30 mgd ballasted flocculation system would remove solids in the biotower effluent. Ballasted flocculation, like secondary sedimentation, removes solids through settling. A difference, however, is that with ballasted flocculation, microsand is added for effective solids settling at high surface overflow rates. The settled solids (including microsand) are pumped to a cyclone to separate the primary effluent/return activated sludge solids from the microsand. The ability to operate at much higher overflow rates than conventional secondary clarifiers results in ballasted flocculation having a much smaller footprint. Chemical storage and feed systems are also included in this system to aid in settling.

- Return Sludge Pumps. After microsand is removed from the settled sludge, the latter is pumped back to the activated sludge process.

5.5 T-5 – Install New High-Rate Biological Treatment with Ballasted Flocculation

Alternative T-5 would increase the sustained peak secondary treatment capacity to 73.6 mgd by constructing a new 43.6 mgd high-rate biological treatment system to operate in parallel with existing secondary treatment facilities during peak flow events, as shown on Figure 7.5.



ALTERNATIVE T-5
PROCESS FLOW DIAGRAM
INSTALL NEW HIGH-RATE BIOLOGICAL TREATMENT WITH BALLASTED FLOCCULATION

FIGURE 7.5

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

This approach would eliminate blending for those peak flow events where the plant flow rate is 73.6 mgd or less and would reduce the blended primary effluent volume for all other peak flow events.

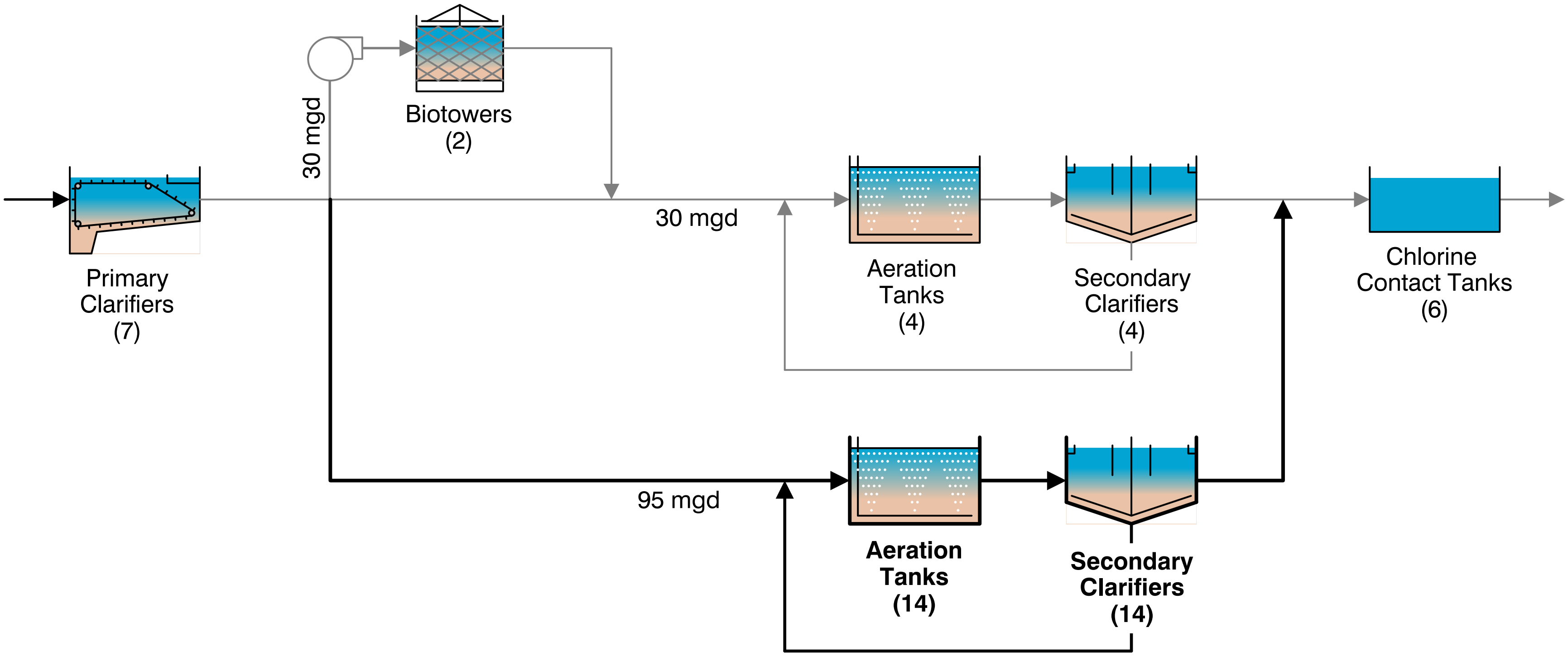
This treatment alternative is based on reducing blended primary effluent volumes by approximately 95 percent, based on an analysis of plant flow data over the past three wet-weather seasons.

The major components of this alternative include:

- Primary Effluent Diversion Box. This is the same as what was described for previous alternatives.
- Biological Contact (Aeration) Tanks. This includes two (2) new 0.454 MG biological contact (aeration) tanks. Biological contact tanks are small aeration tanks that provide biological treatment and help flocculate primary effluent solids for effective settling. The contact tank effluent would flow to the new ballasted flocculation system. The biological contact tanks would be placed in service when needed by diverting a portion of the return activated sludge (RAS) from the existing activated sludge system to the biological contact tanks. Sufficient RAS would be diverted to maintain a minimum suspended solids concentration of at least 1,000 mg/L in the biological contact tanks for effective performance.
- Ballasted Flocculation. This is the same as what was described for T-3 except its capacity would be 43.6 mgd.
- Blower Building. A new blower building with blowers to supply process aeration for the new biological contact tanks. If there is sufficient space in the existing blower building, it may be possible to locate new blowers there instead of in a new building.
- Return Sludge Pumps. After microsand is removed from the settled sludge, the latter is pumped back to the activated sludge process.

5.6 T-6 – Install Conventional Treatment for Blending Elimination

Alternative T-6 would increase the sustained peak secondary treatment capacity to 125 mgd by constructing 95 mgd of additional aeration tanks, secondary clarifiers, and associated aeration air blowers, return sludge pumps, and waste sludge pumps as shown on Figure 7.6.



ALTERNATIVE T-6
PROCESS FLOW DIAGRAM
INSTALL CONVENTIONAL TREATMENT
FOR BLENDING ELIMINATION

FIGURE 7.6

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2017 FACILITIES MASTER PLAN

This treatment alternative is based on elimination of any primary effluent blending events by setting the sustained peak secondary treatment capacity equal to the existing primary effluent capacity of 125 mgd.

6.0 ALTERNATIVE COMPARISON

Table 7.1 summarizes the project cost and the advantages and disadvantages for the primary effluent storage alternatives. Table 7.2 presents a summary of the treatment alternatives. Detailed project costs are provided in Appendix B.

Table 7.1 Primary Effluent Storage Alternatives Comparison 2017 Facilities Master Plan Central Marin Sanitation Agency		
Item	**Alternative S-1** **Convert Existing Effluent Storage Pond**	**Alternative S-2** **Install New Below Grade Storage Tank**
Storage Volume, MG	6.3	3.0
Estimated Annual Blending Volume Reduction(1) % MG	 38% 35.5	 21% 19.6
Average Annual Number of Blending Events(1)	4.5	6.1
Total Project Cost, in millions(2)	\$10.6	\$29.8
Advantages	• Leverages existing assets and is cost-effective relative to other storage alternative. • Provides opportunity to equalize diurnal flows, loads, and power usage at the WWTP during dry weather.	• Efficient use of Corporation Yard for both process use and vehicle storage. • Provides opportunity for equalization of diurnal flows, loads, and power usage at the WWTP. • Risk of odors better managed through foul air collection and engineered odor control system.
Disadvantages	• Higher risk of odors when in use. • Lose effluent storage pond use during wet weather events • Lose space that could have been allocated for other Agency needs such as addressing nutrients or other potential future regulations.	• Not cost-effective relative to other storage alternative. • Tank would be located in a known layer of deep Bay Mud,

Notes:

(1) Annual average of 93.0 MG with 9 events per year based on reported blending events over the past three water years (2013/14, 2014/15, and 2015/16).

(2) Based on October 2016 SF ENR of 11,578 and includes 30 percent allowance for estimating contingencies and 35 percent allowance for engineering, legal, administration, and permitting.

Table 7.2 Treatment Alternatives Comparison
2017 Facilities Master Plan
Central Marin Sanitation Agency

Item	Alternative T-1 Maintain Existing Secondary Treatment	Alternative T-2 Optimize Existing Secondary Treatment	Alternative T-3 Expand Existing Secondary Treatment	Alternative T-4 Convert Biotowers and Activated Sludge to Run in Parallel	Alternative T-5 Install New High-Rate Biological Treatment With Ballasted Flocculation	Alternative T-6 Install Conventional Treatment for Blending Elimination
Secondary Treatment Wet Weather Capacity, mgd	30.0	37.5	45.0	60.0	73.6	125
Estimated Annual Blending Volume Reduction(1) % MG	 0 0	 39% 35.8	 63% 58.3	 86% 80.5	 95% 89.1	 100% 93.0
Average Annual Number of Blending Events(1)	9.0	7.4	6.1	4.1	2.5	0.0
Total Project Cost, in millions(2)	$0	$11.4	$55.0	$28.9	$72.6	$303
Advantages	• No additional project cost.	• Leverages existing assets and is cost-effective relative to other treatment alternatives. • Improves overall process reliability year-round. • Utilizes existing technologies. • Replaces assets that would need to be replaced in the future.	• Improves overall process reliability year-round. • Utilizes existing technologies. • New facilities can be used for nutrient removal if needed in the future.	• Leverages existing assets. • Significant reduction in blending volume but not average blending days.	• Significant reduction in blending volume.	• Eliminates all primary effluent bypass up to 125 mgd.
Disadvantages	• No additional blending reductions.	• Construction must occur during dry weather over multiple years because only two secondary clarifiers can be modified per dry weather season.	• Expanded facilities must be in use during wet weather, which means process will be more susceptible to nitrifying. • Not cost-effective compared to other treatment alternatives. • Lose existing effluent storage pond • Large footprint means Agency loses space that could have been allocated for other needs such as potential future regulations. • Expensive additional facilities constructed for use during less than 3 percent of the year (on average).	• No facilities are currently in existence employing ballasted flocculation as a clarifier following trickling filters, so the technology is experimental. • Requires significant operational change to accommodate wet weather events. • Ballasted flocculation requires coagulant and polymer. • Lost use of effluent storage pond. • Expensive additional facilities constructed for use during less than 3 percent of the year (on average).	• Limited experience with this process configuration. Only 2 full scale facilities currently in service with 3rd in design. • Maintaining adequate biological inventory for contact tanks means process will be more susceptible to nitrifying. • Ballasted flocculation requires coagulant and polymer. • Not cost effective.	• Additional land may be needed to site new facilities. • Maintaining adequate biological inventory for contact tanks means process will be more susceptible to nitrifying. • Not cost effective.

Notes:
(1) Annual average of 93.0 MG with 9 events per year based on reported blending events over the past three water years (2013/14, 2014/15, and 2015/16).
(2) Based on October 2016 SF ENR of 11578 and includes 30 percent allowance for estimating contingencies and 35 percent allowance for engineering, legal, administration, and permitting.

APPENDIX A – CMSA BLENDING EVENT DATA

CENTRAL MARIN SANITATION AGENCY

SEARCH

Home
About Us
Virtual Tour
Live Webcams
Agency Newsletters
Health & Environment
Awards
Financial Information
Governing Board
Documents

COMMUNITY
Services
Local Events
Fun & Learning

BUSINESS AREA
Employment
Contracting with CMSA
Permits
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Links

BLENDING HISTORY

Health & Environment | Pollution Prevention | Laboratory Monitoring | Green Business | Blending

Home » Protecting Public Health & The Environment » Blending History

During wet weather, stormwater and groundwater inflow and infiltration into the sanitary sewer collection system causes high wastewater flows to the treatment plant.

During these conditions, CMSA blends chemically enhanced primary-treated effluent from the primary clarifiers with fully-treated effluent from the secondary clarifiers prior to chlorination, dechlorination, and discharge into the Central San Francisco Bay.

Recent Blending Events with Approximate Time Period and Volume

	Start	End	Volume (Million Gal.)
1	March 14, 2016 - 16:29	March 14, 2016 - 22:34	0.6
2	March 12, 2016 - 14:10	March 14, 2016 - 13:42	24.44
3	March 10, 2016 - 12:27	March 12, 2016 - 01:10	22.87
4	March 7, 2016 - 15:11	March 7, 2016 - 16:24	0.07
	March 6, 2016 - 18:05	March 7, 2016 - 15:14	11.74
5	March 6, 2016 - 07:31	March 6, 2016 - 12:17	0.37
6	March 5, 2016 - 19:36	March 6, 2016 - 04:38	6.21
7	January 19, 2016 - 05:22	January 20, 2016 - 00:13	18.72
8	January 17, 2016 - 17:29	January 18, 2016 - 15:07	14.99
9	January 6, 2016 - 21:46	January 6, 2016 - 23:17	0.06
10	January 6, 2016 - 19:40	January 6, 2016 - 20:49	0.05
11	January 6, 2016 - 05:49	January 6, 2016 - 15:09	4.33
12	January 5, 2016 - 03:50	January 5, 2016 - 13:36	3.3
13	December 21, 2015 - 17:01	December 21, 2015 - 20:07	0.3
14	February 8, 2015 - 09:52	February 8, 2015 - 16:06	3.22
15	December 20, 2014 - 08:45	December 20, 2014 - 12:49	0.43
16	December 19, 2014 - 04:33	December 20, 2014 - 02:13	17.02
17	December 18, 2014 - 06:54	December 18, 2014 - 11:31	0.34
18	December 17, 2014 - 19:59	December 17, 2014 - 22:09	0.15
19	December 17, 2014 - 06:24	December 17, 2014 - 15:11	1.33
	December 15, 2014 - 05:38	December 17, 2014 - 06:28	39.97
20	December 12, 2014 - 20:09	December 12, 2014 - 20:42	0.06
21	December 11, 2014 - 08:13	December 12, 2014 - 19:27	40.05

22	December 6, 2014 - 02:16	December 6, 2014 - 06:34	1.41
23	December 4, 2014 - 10:01	December 4, 2014 - 11:40	0.08
24	December 3, 2014 - 03:46	December 3, 2014 - 14:59	8.41
25	February 28, 2014 - 03:35	February 28, 2014 - 16:25	5.52
26	February 26, 2014 - 20:35	February 26, 2014 - 23:09	0.46
27	February 7, 2014 - 19:30	February 10, 2014 - 04:00	52.9

TOTAL: 279.4

APPENDIX B – PROJECT COST ESTIMATES

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	7 - BLENDING REDUCTION ALTERNATIVE ANALYSIS	**LOCATION FACTOR :**	1.15
JOB # :	10405A.00	**SF ENR OCTOBER 2016 :**	11578
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	11/30/2016
ALT. # :	S-1	**PREPARED BY :**	DBH
ALT. :	Convert Existing Effluent Storage Pond	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Primary Effluent Diversion Box**					
	Primary Effluent Diversion Box	1	LS	$140,000	$140,000	
	Primary Effluent Diversion Pipe	250	LF	$1,100	$275,000	
	Total					$415,000
2	**Effluent Storage Pond Modifications**					
	Reinforced Concrete Slab	3200	CY	$530	$1,696,000	
	Outlet Structure	1	LS	$150,000	$150,000	
	Floating Aerators	1	LS	$400,000	$400,000	
	Total					$2,246,000
3	**Pond Drain Pump Station**					
	7 MGD Pump Station & Return Pipe	1	LS	$750,000	$750,000	
	Total					$750,000
	SUBTOTAL					**$3,411,000**
4	**Allowances**					
	Process Mechanical Allowance	5	%		$171,000	
	Yard Piping & Site Civil Allowance	5	%		$171,000	
	EIC Allowance	20	%		$682,000	
	Coating/Painting Allowance	5	%		$171,000	
	Total					$1,195,000
	SUBTOTAL					**$4,606,000**
	Estimating Contingency	30	%			$1,382,000
	SUBTOTAL					**$5,988,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$277,000
	SUBTOTAL					**$6,265,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$1,566,000
	CONSTRUCTION COST SUBTOTAL					**$7,831,000**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35	%			$2,741,000
	PROJECT COST					**$10,572,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

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TASK :	7 - BLENDING REDUCTION ALTERNATIVE ANALYSIS	**LOCATION FACTOR :**	1.15
JOB # :	10405A.00	**SF ENR OCTOBER 2016 :**	11578
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	11/30/2016
ALT. # :	S-2	**PREPARED BY :**	DBH
ALT. :	Install New Below-Grade Storage Tank	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Primary Effluent Diversion Box**					
	Primary Effluent Diversion Box	1	LS	$140,000	$140,000	
	Primary Effluent Diversion Pipe	300	LF	$600	$180,000	
	Total					$320,000
2	**Primary Effluent Storage Tank**					
	Concrete Piles or Piers	1	LS	$2,300,000	$2,300,000	
	Below-Grade Concrete Tank	1	LS	$3,800,000	$3,800,000	
	Below-Grade Tank Earthwork & Shoring	1	LS	$2,250,000	$2,250,000	
	Ventilation	1	LS	$250,000	$250,000	
	Odor Control Treatment System	1	LS	$300,000	$300,000	
	Total					$8,900,000
3	**Tank Drain Pump Station**					
	3 MGD Pump Station & Return Pipe	1	LS	$400,000	$400,000	
	Total					$400,000
	SUBTOTAL					**$9,620,000**
4	**Allowances**					
	Process Mechanical Allowance	5	%		$481,000	
	Yard Piping & Site Civil Allowance	5	%		$481,000	
	EIC Allowance	20	%		$1,924,000	
	Coating/Painting Allowance	5	%		$481,000	
	Total					$3,367,000
	SUBTOTAL					**$12,987,000**
	Estimating Contingency	30	%			$3,896,000
	SUBTOTAL					**$16,883,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$781,000
	SUBTOTAL					**$17,664,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$4,416,000
	CONSTRUCTION COST SUBTOTAL					**$22,080,000**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35	%			$7,728,000
	PROJECT COST					**$29,808,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

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TASK :	7 - BLENDING REDUCTION ALTERNATIVE ANALYSIS	**LOCATION FACTOR :**	1.15
JOB # :	10405A.00	**SF ENR OCTOBER 2016 :**	11578
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	11/30/2016
ALT. # :	T-2	**PREPARED BY :**	DBH
ALT. :	Optimize Existing Secondary Treatment	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Secondary Clarifier**					
	Tow-Bro Clarifier Mechanisms, 100 ft. dia., 304SS	4	EA	$500,000	$2,000,000	
	Demolition	1	LS	$125,000	$125,000	
	Sheet Piling	4	EA	$150,000	$600,000	
	Center Column Foundation	4	EA	$125,000	$500,000	
	Total					$3,225,000
2	**RAS Pumping and Piping Modifications**					
	RAS Pumps	6	EA	$37,500	$225,000	
	RAS Piping Modifications	1	LS	$100,000	$100,000	
	Total					$325,000
	SUBTOTAL					**$3,550,000**
3	**Allowances**					
	Process Mechanical Allowance	10	%		$355,000	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$710,000	
	Coating/Painting Allowance	10	%		$355,000	
	Total					$1,420,000
	SUBTOTAL					**$4,970,000**
	Estimating Contingency	30	%			$1,491,000
	SUBTOTAL					**$6,461,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$299,000
	SUBTOTAL					**$6,760,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$1,690,000
	CONSTRUCTION COST SUBTOTAL					**$8,450,000**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35	%			$2,958,000
	PROJECT COST					**$11,408,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

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TASK :	7 - BLENDING REDUCTION ALTERNATIVE ANALYSIS	**LOCATION FACTOR :**	1.15
JOB # :	10405A.00	**SF ENR OCTOBER 2016 :**	11578
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	11/30/2016
ALT. # :	T-3	**PREPARED BY :**	DBH
ALT. :	Expand Existing Secondary Treatment	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Primary Effluent Diversion Box**					
	Primary Effluent Diversion Box	1	LS	$140,000	$140,000	
	Primary Effluent Diversion Pipe	350	LF	$800	$280,000	
	Total					$420,000
2	**Aeration Tanks**					
	Aeration Basins 2x, 42,000 ft^3 each	1	LS	$3,071,000	$3,071,000	
	Concrete Piles or Piers	1	LS	$750,000	$750,000	
	Mixed Liquor Pipe	200	LF	$800	$160,000	
	Total					$3,981,000
3	**Secondary Clarifiers**					
	Secondary Clarifiers 2x, 100 ft diameter	2	EA	$3,000,000	$6,000,000	
	Concrete Piles or Piers	1	LS	$2,000,000	$2,000,000	
	Secondary Effluent Pipe	280	LF	$800	$224,000	
	Total					$8,224,000
4	**Blower Building**					
	New Blower Building	1	LS	$3,000,000	$3,000,000	
	Total					$3,000,000
5	**Sludge Pumping**					
	RAS/WAS Pump Station & Pipeline	1	LS	$1,500,000	$1,500,000	
	Total					$1,500,000
	SUBTOTAL					**$17,125,000**
6	**Allowances**					
	Process Mechanical Allowance	5	%		$856,000	
	Yard Piping & Site Civil Allowance	10	%		$1,713,000	
	EIC Allowance	20	%		$3,425,000	
	Coating/Painting Allowance	5	%		$856,000	
	Total					$6,850,000
	SUBTOTAL					**$23,975,000**
	Estimating Contingency	30	%			$7,193,000

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2017 FACILITIES MASTER PLAN

TASK : 7 - BLENDING REDUCTION ALTERNATIVE ANALYSIS
JOB # : 10405A.00
LOCATION : San Rafael, CA
ALT. # : T-3
ALT. : Expand Existing Secondary Treatment

LOCATION FACTOR : 1.15
SF ENR OCTOBER 2016 : 11578
ESTIMATE PREPARATION DATE : 11/30/2016
PREPARED BY : DBH
REVIEWED BY : AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	SUBTOTAL					**$31,168,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$1,442,000
	SUBTOTAL					**$32,610,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$8,153,000
	CONSTRUCTION COST SUBTOTAL					**$40,763,000**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35	%			$14,267,000
	PROJECT COST					**$55,030,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

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2017 FACILITIES MASTER PLAN

TASK :	7 - BLENDING REDUCTION ALTERNATIVE ANALYSIS	**LOCATION FACTOR :**	1.15
JOB # :	10405A.00	**SF ENR OCTOBER 2016 :**	11578
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	11/30/2016
ALT. # :	T-4	**PREPARED BY :**	DBH
ALT. :	Convert Biotowers and Activated Sludge to Run in Parallel	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Biotower Effluent Diversion**					
	Biotower Effluent Diversion Pipe	510	LF	$600	$306,000	
	Total					$306,000
2	**Ballasted Flocculation**					
	Ballasted Flocculation/Sedimentation Unit, 30 mgd	1	LS	$7,230,000	$7,230,000	
	Concrete Piles or Piers	1	LS	$530,000	$530,000	
	Secondary Effluent Pipe	250	LF	$1,000	$250,000	
	Total					$8,010,000
3	**Return Sludge Pumps**					
	Return Sludge Pump Station & Pipeline	1	LS	$1,000,000	$1,000,000	
	Total					$1,000,000
	SUBTOTAL					**$9,316,000**
4	**Allowances**					
	Process Mechanical Allowance	5	%		$466,000	
	Yard Piping & Site Civil Allowance	5	%		$466,000	
	EIC Allowance	20	%		$1,863,000	
	Coating/Painting Allowance	5	%		$466,000	
	Total					$3,261,000
	SUBTOTAL					**$12,577,000**
	Estimating Contingency	30	%			$3,773,000
	SUBTOTAL					**$16,350,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$756,000
	SUBTOTAL					**$17,106,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$4,277,000
	CONSTRUCTION COST SUBTOTAL					**$21,383,000**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35	%			$7,484,000
	PROJECT COST					**$28,867,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

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TASK :	7 - BLENDING REDUCTION ALTERNATIVE ANALYSIS	**LOCATION FACTOR :**	1.15
JOB # :	10405A.00	**SF ENR OCTOBER 2016 :**	11578
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	11/30/2016
ALT. # :	T-5	**PREPARED BY :**	DBH
ALT. :	Install New High-Rate Biological Treatment with Ballasted Flocculation	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Primary Effluent Diversion Box**					
	Primary Effluent Diversion Box	1	LS	$140,000	$140,000	
	Primary Effluent Diversion Pipe	650	LF	$1,300	$845,000	
	Total					$985,000
2	**Biological Contact (Aeration) Tanks**					
	Activated Sludge Feed Pipeline	300	LF	$550	$165,000	
	Biological Contact Tanks 2x, 61,000 ft^3 each	1	LS	$3,934,000	$3,934,000	
	Concrete Piles or Piers	1	SF	$1,025,000	$1,025,000	
	Biological Contact Tank Effluent Pipe	200	LF	$1,300	$260,000	
	Total					$5,384,000
3	**Ballasted Flocculation**					
	Ballasted Flocculation System, 43.6 mgd	1	LS	$9,279,000	$9,279,000	
	Concrete Piles or Piers	1	LS	$670,000	$670,000	
	Chemical Feed System	1	LS	$1,000,000	$1,000,000	
	Total					$10,949,000
4	**Blower Building**					
	New Blower Building	1	LS	$3,000,000	$3,000,000	
	Total					$3,000,000
5	**Return Sludge Pumps**					
	Settled Sludge Pump Station & Pipeline	1	LS	$1,500,000	$1,500,000	
	Total					$1,500,000
	SUBTOTAL					**$21,818,000**
6	**Allowances**					
	Process Mechanical Allowance	10	%		$2,182,000	
	Yard Piping & Site Civil Allowance	10	%		$2,182,000	
	EIC Allowance	20	%		$4,364,000	
	Coating/Painting Allowance	5	%		$1,091,000	
	Total					$9,819,000
	SUBTOTAL					**$31,637,000**

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CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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ALT. :	Install New High-Rate Biological Treatment with Ballasted Flocculation	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	Estimating Contingency	30	%			$9,491,000
	SUBTOTAL					**$41,128,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$1,902,000
	SUBTOTAL					**$43,030,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$10,758,000
	CONSTRUCTION COST SUBTOTAL					**$53,788,000**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35	%			$18,826,000
	PROJECT COST					**$72,614,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	7 - BLENDING REDUCTION ALTERNATIVE ANALYSIS	**LOCATION FACTOR :**	1.15
JOB # :	10405A.00	**SF ENR OCTOBER 2016 :**	11578
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	11/30/2016
ALT. # :	T-6	**PREPARED BY :**	DBH
ALT. :	Install Conventional Treatment for Blending Elimination	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Primary Effluent Diversion Box**					
	Primary Effluent Diversion Box	1	LS	$140,000	$140,000	
	Primary Effluent Diversion Pipe	350	LF	$1,800	$630,000	
	Total					$770,000
2	**Aeration Tanks**					
	Activated Sludge Feed Pipeline	300	LF	$550	$165,000	
	Aeration Basins 14x	1	LS	$21,500,000	$21,500,000	
	Concrete Piles or Piers	1	LS	$5,250,000	$5,250,000	
	Mixed Liquor Pipe	200	LF	$1,800	$360,000	
	Total					$27,110,000
3	**Secondary Clarifiers**					
	Secondary Clarifiers, 100 ft diameter	14	EA	$3,000,000	$42,000,000	
	Concrete Piles or Piers	1	LS	$10,000,000	$10,000,000	
	Secondary Effluent Pipe	280	LF	$1,800	$504,000	
	Total					$52,504,000
4	**Blower Building**					
	New Blower Building	1	LS	$5,000,000	$5,000,000	
	Total					$5,000,000
5	**Sludge Pumping**					
	RAS/WAS Pump Stations & Pipelines	1	LS	$9,000,000	$9,000,000	
	Total					$9,000,000
	SUBTOTAL					**$94,384,000**
6	**Allowances**					
	Process Mechanical Allowance	5	%		$4,719,000	
	Yard Piping & Site Civil Allowance	10	%		$9,438,000	
	EIC Allowance	20	%		$18,877,000	
	Coating/Painting Allowance	5	%		$4,719,000	
	Total					$37,753,000
	SUBTOTAL					**$132,137,000**

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	7 - BLENDING REDUCTION ALTERNATIVE ANALYSIS	**LOCATION FACTOR :**	1.15
JOB # :	10405A.00	**SF ENR OCTOBER 2016 :**	11578
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	11/30/2016
ALT. # :	T-6	**PREPARED BY :**	DBH
ALT. :	Install Conventional Treatment for Blending Elimination	**REVIEWED BY :**	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	Estimating Contingency	30	%			$39,641,000
	SUBTOTAL					**$171,778,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$7,945,000
	SUBTOTAL					**$179,723,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$44,931,000
	CONSTRUCTION COST SUBTOTAL					**$224,654,000**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35	%			$78,629,000
	PROJECT COST					**$303,283,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM NO. 8
SECONDARY TREATMENT EVALUATION

FINAL
October 2018

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CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM
NO. 8
SECONDARY TREATMENT EVALUATION

TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF FIGURES

SECONDARY TREATMENT EVALUATION

1.0 INTRODUCTION

This technical memorandum (TM) summarizes an evaluation of secondary treatment operations and performance at the Central Marin Sanitation Agency (Agency) Wastewater Treatment Plant (WWTP). The main purpose of this TM is to identify efficient secondary treatment operating strategies for dry and wet weather conditions. The evaluation considers the number of biotowers, aeration tanks, and secondary clarifiers that are in service as well as pumping strategies and their impacts on plant performance, effluent quality, and power usage. This evaluation is based on compliance with the current final effluent discharge permit, which includes limits for total suspended solids (TSS) and carbonaceous biochemical oxygen demand (cBOD). It does not consider secondary treatment modifications and/or new facilities that may be required to comply with potential future nutrient limits, which will be addressed in Technical Memorandum (TM) No. 4, Nutrient Removal Evaluation. This TM also includes recommended capital improvements that will benefit secondary treatment performance.

2.0 SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

The key findings are:

- The WWTP has consistently performed well and produced excellent effluent quality with cBOD and TSS concentrations averaging between 5 and 6 mg/L during the eight year review period from 2009 through 2016.
- It is recommended that the WWTP continue the current operating strategies as no other strategies have been identified that would likely improve effluent quality. This includes:
  - Operating one (1) biotower, two (2) aeration tanks in parallel mode, and three (3) secondary clarifiers during dry weather.
  - Operating one (1) biotower, four (4) aeration tanks in parallel mode, and four (4) secondary clarifiers during wet weather.
  - Constant biotower feed pumping rate.
  - Flow paced RAS pumping.
- The operational evaluation is in Section 4 with a detailed summary in Appendix B. Key findings from the evaluation are:

- Degradation of effluent quality or poor flocculation may warrant bringing an additional aeration tank on-line so that three (3) are in operation during dry weather.
  - Poor sludge settleability (such as sludge volume index (SVI) being greater than 250 mL/g) may put the plant at risk of overloading the secondary clarifiers. If the WWTP experiences poor settleability for a week or greater, the Agency should consider increasing the biotower feed pumping rate or operating both biotowers.
  - If the secondary clarifiers are at risk of solids overload during wet weather events, the Agency should consider operating the aeration tanks in contact stabilization mode.

- Capital improvements totaling $13.2 million are recommended to improve reliability and performance of the secondary treatment system. Improvements include:
  - Replacing Biotower 1 media and the hydraulic rotary distributor. It is recommended that the hydraulic distributor be replaced with an electric-driven type to improve flexibility in how the biotowers are operated, flushed, and maintained.
  - Replacing secondary clarifier mechanisms. It is recommended that they be replaced with a suction tube-type configuration to optimize clarifier performance and provide better settled sludge removal.
  - Replacing RAS pumps. It is recommended that they be replaced with higher-capacity pumps to maintain effective clarifier performance, and allow operation at a higher sustained peak secondary flows. In addition, piping modifications are recommended to eliminate the clarifier sludge sumps.

- Rehabilitating and investing in the biotowers to extend their useful life appears to be consistent with near term, Level 1 Optimization alternatives identified in the BACWA Facility Evaluation for nutrient reduction. However, higher levels of nutrient reduction (i.e., Level 2 or Level 3 upgrades) may not require the biotowers. This will be evaluated further as part of TM No. 4, Nutrient Removal Evaluation.

3.0 BACKGROUND

3.1 Existing Secondary Treatment Facilities

The Agency's WWTP was designed in 1981 with an average dry weather flow (ADWF) capacity of 10.0 mgd and a corresponding sustained peak secondary treatment capacity of 30.0 mgd for the biotower/activated sludge system. Because influent flows can exceed the 30.0 mgd sustained peak capacity during wet weather events, primary effluent flow exceeding 30.0 mgd is diverted around the secondary treatment process and blended with secondary effluent upstream of final effluent disinfection. Twenty seven (27) blending events have been reported over the past three water years (October 1, 2013 – September 30, 2016), with an event duration ranging from approximately one hour to 2.4 days.

Upgrades have been made to the secondary process to improve efficiency and replace aging equipment. Upgrades include new aeration equipment, replacing the rotary distributor and top 2 layers of media for Biotower 2, and automating aeration tank inlet gates to simplify operational changes. The secondary treatment facilities at the WWTP include four (4) biotower feed pumps, two (2) biotowers, four (4) aeration tanks, four (4) secondary clarifiers, six (6) RAS pumps, four (4) WAS pumps, two (2) horizontal centrifugal blowers, and two (2) high-speed turbo blowers. Design data for these facilities are summarized in Table 8.1.

Secondary treatment is preceded by preliminary treatment (perforated plate fine screens, aerated grit tanks) and primary clarification. Ferric chloride and/or polymer are added to the primary clarifier influent during blending events to enhance primary TSS and cBOD removals.

Table 8.1 Secondary Treatment Design Data
2017 Facilities Master Plan
Central Marin Sanitation Agency

	Existing
Secondary Process Influent Flow Rate	
Average dry weather (ADWF), mgd	10.0
Sustained peak, mgd	30.0
Biotower Feed Pumps	
Number	4
Type	Horizontal centrifugal
Capacity, gpm ea	5,200
Drive	Variable speed
Biotowers	
Number	2
Area[(1)], sq ft	2,358
Rotary distributor drive	Hydraulic
Maximum hydraulic loading rate[(2)], gpm/sq ft	4.41
Structured plastic media:	
Type	Cross flow
Specific surface area, sq ft/cu ft	30
Depth, ft	22
Volume, 1,000 cu ft ea	51.9
Aeration Tanks	
Number	4

Table 8.1	Secondary Treatment Design Data 2017 Facilities Master Plan Central Marin Sanitation Agency
	Existing
Length, ft	54.00
Width, ft	51.63
Side water depth, ft	15.33
Volume, MG ea	0.320
Diffusers	
Type	Magnum Flexair 84P Tube Assembly (2.3 meters)
Number per Basin	90
Aeration Blowers	
Number	2
Type	Multi-Stage Centrifugal
Capacity, each, scfm	2,000
Number	2
Type	High Speed Turbo
Capacity, each, scfm	3,000
Secondary Clarifiers	
Number	4
Type	Suction tube
Diameter, ft	100
Area, sq ft	7,854
Side water depth, ft	10.4
Maximum surface overflow rate (SOR), gal/d-sq ft	955
RAS Pumps	
Number	6 (4 duty/2 standby)
Type	Horizontal centrifugal
Capacity, gpm	1,740
Drive	Variable speed
WAS Pumps	
Number	4
Type	Progressing cavity
Drive	Variable speed

Notes:
(1) Octagonal cross section, 54 ft between opposite sides.
(2) Both biotowers in service.

The Agency has flexibility to operate the activated sludge system in parallel, series, or contact stabilization mode. Figure 8.1 illustrates how these modes can be implemented at the Agency's WWTP.

When operating in the parallel or series mode, all of the biotower and/or primary effluent is mixed with the return activated sludge (RAS) in the inlet pipes upstream of the aeration tanks. While the parallel mode of operation is the simplest, it is more susceptible to short-circuiting than series operation. Both the series and parallel modes are susceptible to washout, or overloading the secondary clarifiers during wet weather events. Contact stabilization is an operational mode that temporarily reduces the mixed liquor suspended solids (MLSS) concentration to the secondary clarifiers, which reduces the solids loading and risk of washout during wet weather events. The main disadvantage of contact stabilization is that it may result in a slight reduction of effluent water quality. The WWTP has successfully operated in parallel mode exclusively for the last several years and has achieved very good effluent quality.

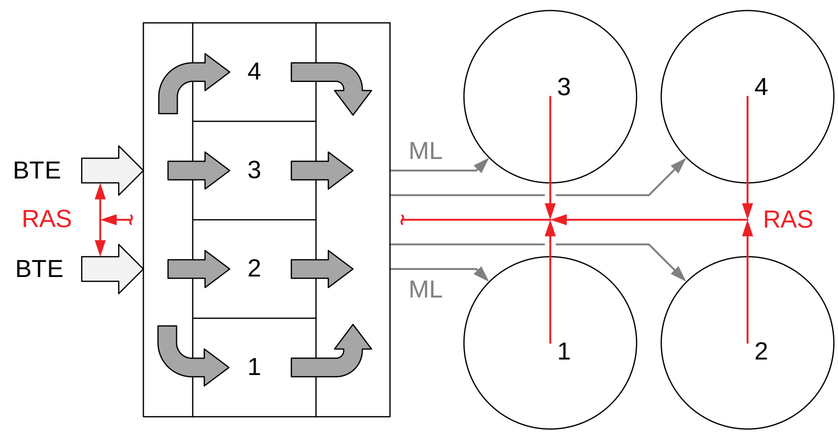
3.2 Operations and Performance Data Review

Plant data from January 2009 through August 2016 were compiled to evaluate secondary treatment operations and performance. Time series graphs were generated and are included in Appendix A for key operating parameters. Table 8.2 summarizes average operating conditions for the dry weather (May through October) and wet weather (November through April) periods during the review period. Performance of the secondary system has been excellent, with final effluent meeting permitted discharge limits for $cBOD_5$ and TSS during the entire review period, and averaging between 5 and 6 mg/L.

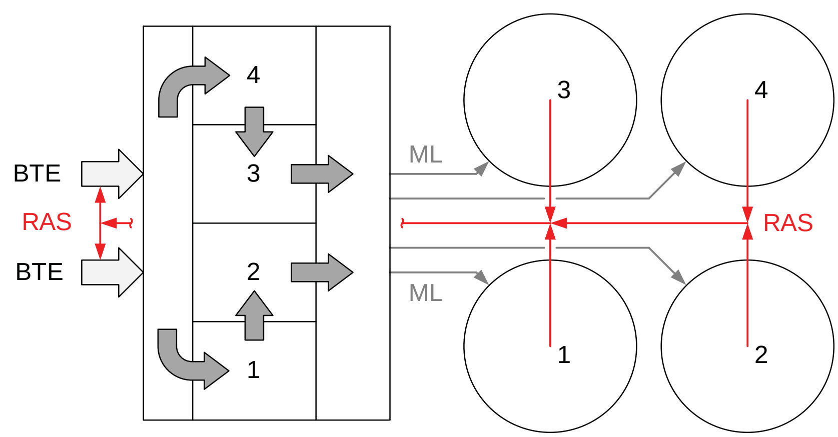
During the review period, the WWTP has typically run with just one biotower and one feed pump year-round. The organic and hydraulic loading on the biotower is within original design parameters and typical values for this type of process. However, the current strategy of operating with one biotower and one feed pump results in approximately 18 to 41 percent of the primary effluent flow and 27 to 49 percent of the primary effluent load being diverted directly to the aeration tanks.

The aeration tanks have been operated in the parallel mode only, and two and four tanks are typically used during the dry and wet weather seasons, respectively. While the average MLSS concentration only varies from 1,180 and 1,520 during the dry and wet weather seasons, respectively, the impact of using all the tanks requires a significant seasonal change in the solids residence time (SRT), which averaged 1.02 days in the dry weather season to 1.63 days in the wet weather season. The SRT is within the typical operating range for this type of process. Operating at a higher SRT during wet weather ensures treatment is adequate during colder, high flow periods. It also ensures there is sufficient inventory so that the operating mode could be changed to contact stabilization, to reduce clarifier solids loading rate if necessary, while maintaining a minimum MLSS concentration for bioflocculation and good settling.

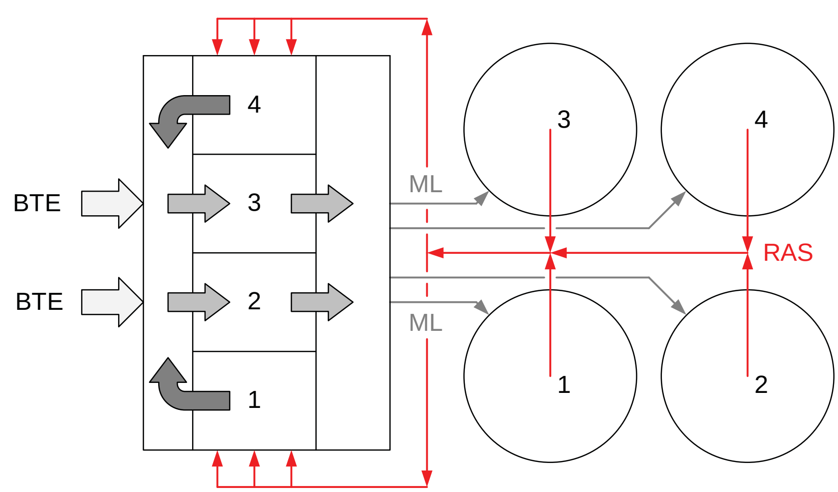
Parallel:



Series:



Contact Stabilization:



LEGEND
BTE = Biotower Effluent RAS = Return Activated Sludge ML = Mixed Liquor

ACTIVATED SLUDGE OPERATING MODES

FIGURE 8.1

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

Table 8.2 Current Operating Conditions 2017 Facilities Master Plan Central Marin Sanitation Agency		
	Average Dry Weather(1) 2009 to 2016	**Average Wet Weather(2) 2009 to 2016**
Influent		
Flow, mgd	8.86	14.06
TSS, mg/L	546	308
TSS load, klb/d	39.7	31.8
$cBOD_5$, mg/L	333	219
$cBOD_5$ load, klb/d	24.2	22.0
Equalized Primary Effluent		
Flow, mgd	8.86	13.4
TSS, mg/L	195	221
$cBOD_5$, mg/L	157	131
Biotowers		
Typical number in service	1	1
Flow, mgd	7.15	6.77
Hydraulic load, gpm/sf	1.98	1.96
Organic load, lb $cBOD_5$/1,000 cu ft	168	143
Fraction of PE Bypassed Around Biotowers		
Flow	18%	41%
$cBOD_5$ load	27%	49%
Biotower effluent $cBOD_5$, mg/L	102	88
Aeration Tanks		
Typical number in service	2	4
$cBOD_5$ load, klb/d	8.06	10.2
MLSS, mg/L	1,180	1,520
MLSS inventory, klb	6.58	14.7
MLVSS, mg/L	1,010	1,270
MLVSS inventory, klb	5.65	12.14
SRT, days (3)	1.02	1.63
Secondary Clarifiers		
Typical number in service (3)	3	4
Surface overflow rate, gal/d-sq ft	376	448
SVI, mL/g	152/184(4)	172/234(4)
Effluent		
TSS, mg/L	5.1	5.6
$cBOD_5$, mg/L	5.5	5.9

Table 8.2 Current Operating Conditions 2017 Facilities Master Plan Central Marin Sanitation Agency		
	Average Dry Weather(1) 2009 to 2016	**Average Wet Weather(2) 2009 to 2016**

Notes:
(1) May through October.
(2) November through April.
(3) 2015-2016 data only.
(4) Average/90th percentile.

Three secondary clarifiers are typically in service during dry weather and four during wet weather. The clarifiers have performed well and have sufficient capacity to accommodate the wet weather flows with historical sludge settleability. The sludge volume index (SVI) is a measure of mixed liquor settleability, which has an impact on secondary clarifier performance. Typically, a well-settling sludge has an SVI of approximately 150 mL/g or lower. The average SVI during dry weather has been 152 mL/g and 172 mL/g during wet weather. The 90th percentile value for these periods is 184 and 234 mL/g. While the high SVI periods (i.e., SVI greater than 150 mL/g) have not been an issue for the WWTP, eliminating them would improve process reliability, provide operational flexibility, and increase secondary clarifier capacity.

4.0 OPERATIONAL EVALUATION

This section evaluates several operating scenarios and the impacts it will have on plant performance, effluent quality, and power usage.

4.1 Number of Process Units in Service

The number of process units placed in service throughout the year controls hydraulic, organic, and solids loads on the secondary treatment system, which affects performance, effluent quality, and power usage. This section evaluates all of the available combinations of process units in service at the WWTP during average dry and wet weather conditions. The evaluation considered MLSS concentrations, operating SRT, aeration demands and diffuser loading, mixed liquor settleability (or SVI), allowable loading rates for the secondary clarifiers, as well as anticipated effluent quality. Figure 8.2 illustrates the recommendations for both dry and wet weather. Appendix B includes detailed summary tables of the evaluation results including process operating parameters for each combination evaluated.

Since the biotowers and aeration tanks work together to remove soluble cBOD and grow biomass that will settle well in the secondary clarifiers, the evaluation will consider their impacts together. A process simulator was used to evaluate the impact of bypassing the biotowers or operating 1 or 2 biotowers in conjunction with 0, 1, 2, 3, or 4 aeration tanks.

Dry Weather (May through October)

Increasing SRT
Increasing Power

Number of Aeration Tanks in Service	Number of Biotowers in Service		
	0	1	2
0	NO	NO	NO
1	NO	NO	NO
2	NO	RECOMMENDED	ACCEPTABLE
3	NO	ACCEPTABLE	ACCEPTABLE
4	NO	NO	NO

Decreasing SVI
Decreasing Power

Wet Weather (November through April)

Increasing SRT
Increasing Power

Number of Aeration Tanks in Service	Number of Biotowers in Service		
	0	1	2
0	NO	NO	NO
1	NO	NO	NO
2	NO	NO	NO
3	NO	ACCEPTABLE	ACCEPTABLE
4	NO	RECOMMENDED	ACCEPTABLE

Decreasing SVI
Decreasing Power

LEGEND / TABLE KEY	
NO	Not recommended, anticipate poor effluent quality or not meeting NPDES permit.
RECOMMENDED	Recommended as continued strategy. Has historically provided excellent effluent quality.
ACCEPTABLE	Acceptable operating mode and anticipate meeting NPDES permit. May result in slight reduction in effluent quality or increase (or decrease) in power usage.

OPERATIONAL EVALUATION SUMMARY

FIGURE 8.2

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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The evaluation considered the following criteria:

- Minimum MLSS concentration in the aeration basins is 1,000 mg/L so there is sufficient flocculation to generate well settling sludge. Maximum MLSS during wet and dry weather is 1,500 and 2,500 mg/L based on clarifier solids loading limitations.
- During dry weather, the plant should maintain an SRT ranging from 1.0 to 1.5 days and during wet weather, the target SRT is 1.0 to 2.0 days. Being below the target SRT could result in inadequate effluent quality. Being above the target SRT could cause settleability issues or result in partial nitrification.
- Based on manufacturer recommendations, the maximum air flow for each diffuser is 40 scfm.
- Minimizing primary effluent that is diverted directly to the aeration basins will maximize soluble BOD removal in the biotowers, which should reduce filamentous bacteria growth and the SVI.

4.1.1 Dry Weather

This section summarizes results for the dry weather period.

- Operation of 1 biotower, 2 aeration tanks (in parallel mode), and three (3) secondary clarifiers has produced excellent effluent quality (i.e. effluent cBOD and TSS between 5 and 6 mg/L) and it is recommended the plant continue this practice. There is no other operational mode with the existing facilities that would likely improve effluent quality.
- Triggers or potential reasons to modify this operational strategy include:
  - Degradation of effluent or poor flocculation. If this occurs, bringing another aeration tank on-line so that three (3) are in operation should improve water quality. However, doing so is expected to increase aeration demands and monthly power costs by $1,300.
  - SVIs exceeding 250 mL/g for a week or greater. If this occurs, the WWTP should consider bringing a second biotower on-line so that both are in operation. This would minimize primary effluent that is diverted directly to the aeration tanks and should reduce SVIs. Since the minimum feed rate for each biotower is 7 mgd, this operational change is expected to increase monthly power costs by $2,000 to $3,000. Another disadvantage of this approach is that the reduced SVIs may result in a slight increase in effluent cBOD and TSS. Even with a slight increase in these parameters, the WWTP should still be able to meet their NPDES discharge limits.
  - Secondary clarifiers are at risk of overload. This is unlikely to happen during dry weather unless SVIs are in exceedance of 250 mL/g. If this were to occur,

WWTP could bringing a fourth secondary clarifier on-line to reduce solids loading and risk of overload.

  – Secondary clarifier rehabilitation. If necessary, the WWTP should be able to operate with only two (2) secondary clarifiers in service as long as SVI's do not exceed 200 mL/g. This would be advantageous for construction sequencing if the Agency decides to move forward with secondary clarifier rehabilitation.

- Operational scenarios that are not recommended due to adverse impacts to effluent quality include:
  – Operation of 0 biotowers. Bypassing all of the primary effluent around the biotowers puts the WWTP at risk of having settleability issues, overloading the secondary clarifiers, and not meeting NPDES discharge limits. This risk could be mitigated with a capital project to implement selectors in the secondary process.
  – Operation of 0 aeration tanks. This scenario would not provide a sufficient level of secondary treatment to meet NPDES discharge limits.
  – Operation of 1 aeration tank. This scenarios would result in overloading the diffusers and put the WWTP at risk of not meeting NPDES discharge limits.
  – Operation of 4 aeration tanks. Operating with 4 aeration tanks in dry weather is not necessary. Furthermore, it is expected to increase monthly power costs by up to $2,100 and puts the plant at risk of partially nitrifying. If the WWTP were partially nitrifying, power demands would increase further and cause chlorination problems, increasing chemical costs.

4.1.2 Wet Weather

This section summarizes results for the wet weather period.

- Operation of 1 biotower, 4 aeration tanks (in parallel mode), and four (4) secondary clarifiers has produced excellent effluent quality (i.e. effluent cBOD and TSS between 5 and 6 mg/L) and it is recommended the plant continue this practice. There is no other operational mode with the existing facilities that would likely improve effluent quality.

- Triggers or potential reasons to modify this operational strategy include:
  – SVIs exceeding 250 mL/g for a week or greater. If this occurs, the WWTP should consider bringing a second biotower on-line so that both are in operation. This operational change will minimize primary effluent that is diverted directly to the aeration tanks and should reduce SVIs. This operational change could also reduce monthly power costs by up to $1,000. A disadvantage of this approach is that the reduced SVIs may result in a slight increase in effluent cBOD and TSS. Even with a slight increase in these parameters, the WWTP should still be able to meet their NPDES discharge limits.

  - Secondary clarifiers are at risk of overload. As long as SVIs and the MLSS concentration are less than 250 mL/g and 1,500 mg/L, respectively, the secondary clarifiers should be able to handle wet weather flows up to 30 mgd. However, if the clarifiers are at risk of overload because the settleability is worse (i.e. SVI > 250 mL/g) or the WWTP must treat more than 30 mgd, contact stabilization should be considered. While this mode of operation will mitigate the risk of clarifier overload and will meet NPDES discharge limits, effluent quality may degrade slightly. It should also be noted that if the WWTP plans to transition to contact stabilization, the MLSS concentration in parallel operation may need to be as high as 2,000 mg/L so that a minimum concentration of 1,000 mg/L is maintained in the contact zone for sufficient flocculation and settling.
  - Reduction of power demands. The WWTP could consider operating with 3 aeration tanks to reduce biological inventory. This mode would reduce aeration demands and monthly power costs by $1,000. While this mode should still be able to meet NPDES discharge limits, effluent quality may degrade slightly.

- Operational scenarios that are not recommended due to adverse impacts in effluent quality include:
  - Operation of 0 biotowers. Bypassing all of the primary effluent around the biotowers puts the WWTP at risk of having settleability issues, overloading the secondary clarifiers, and not meeting NPDES discharge limits. This risk could be mitigated with a capital project to implement selectors in the secondary process.
  - Operation of 0 aeration tanks. This scenario would not provide a sufficient level of secondary treatment to meet NPDES discharge limits.
  - Operation of 1 aeration tank. This scenarios would result in overloading the diffusers and put the WWTP at risk of not meeting NPDES discharge limits.
  - Operation of 2 aeration tanks. Operating with 2 aeration tanks in wet weather would not result in an acceptable minimum level of treatment and SRT of 1.0 days.

4.2 Pumping Strategies

There are two major pump stations associated with the secondary treatment facilities including the biotower feed and return activated sludge (RAS) pumping.

4.2.1 Biotower Feed Pumping

The WWTP currently pumps 7 mgd of primary effluent to 1 biotower year round. 7 mgd is the minimum flow needed for the hydraulic rotary distributor to work. When influent flows to the plant are less than 7 mgd, biotower effluent is recirculated back to the Biotower Pump Station. When influent flows are greater than 7 mgd, primary effluent is diverted around the biotowers directly to the aeration basin. Since this approach has resulted in excellent effluent quality, there is little reason to modify this approach. However, if the SVIs exceed 250 mL/g for a week or greater, the WWTP could consider allowing the biotower feed pumps to match the diurnal variation throughout the day to minimize primary effluent that is diverted directly to the aeration tanks. It is expected that this operational change would gradually reduce SVIs. The hydraulic capacity for each biotower rotary distributor is 15 mgd.

4.2.2 RAS Pumping

The WWTP currently paces the return activated sludge (RAS) flow rate as a percentage of the influent flow. This approach is a commonly used approach for activated sludge systems, and ensures that as flows (and solids loadings) to clarifiers increase, so does the clarifier's ability to remove settled sludge. Unless problems have been observed with accumulating sludge blankets, there is no reason to modify the RAS pumping approach.

5.0 CAPITAL IMPROVEMENT PROJECTS

The capital improvements described in this section are recommended to improve reliability and performance of the secondary treatment system. The secondary clarifier rehabilitation and RAS pump and piping improvements are the same as what was described in TM 7, Blending Reduction Alternatives Analysis.

5.1 Biotowers

The Agency removed the original rotary distributor and top two courses of media in Biotower 2 and replaced them in kind in 2010. The rotary distributor and plastic media in Biotower 1 have been in service since the CMSA WWTP was placed in service in the early 1980s. To increase overall reliability and performance, it is recommended that Biotower 1 also be rehabilitated and the rotary distributor and plastic media should be replaced. While the Agency could just replace the top two courses of media as was performed for Biotower 2, it is recommended that the Agency budget to replace all of the media given its age. At the beginning of design, testing should be performed to determine the condition of the lower media layers and whether replacement is needed or not. This project should also consider replacing the hydraulic rotary drive with an electric drive. Doing so will give the Agency more flexibility in how the biotower is operated, flushed, and maintained.

5.2 Secondary Clarifier Rehabilitation

The existing secondary clarifiers are shallow with a side water depth of 10 feet and the internal mechanisms are an “organ pipe”-type sludge suction removal configuration. When the internal mechanisms are at the end of their useful life, it is recommended that they be replaced with a suction tube-type configuration to optimize clarifier performance and provide better settled sludge removal. The new mechanisms would maintain the existing center-feed configuration.

Demolition of the existing mechanisms would include removal of the rake arms, surface skimmer, feedwell, return sludge control box, center column, drive unit, and bridge. The new mechanisms would include a center column, a single rotating sludge suction arm (and opposing counterweight), surface skimmer, drive unit, and bridge. A series of fixed orifices, with varying diameter, would be provided in the rotating sludge suction arm for settled sludge removal. Each mechanism would also include two additional components to optimize clarifier performance. First, an energy dissipating inlet (EDI) would reduce the clarifier inlet velocity out of the center column ports and balance flow distribution within the clarifier to minimize hydraulic short circuiting. Second, a circular flocculation baffle, with a diameter of approximately 33 feet and extending approximately 5 feet below the water surface, would provide additional mixed liquor flocculation to optimize sludge settleability.

5.3 RAS Pumps Suction Piping Modification

When the RAS pumps reach the end of their useful life, they should be replaced with higher-capacity pumps to maintain effective clarifier performance, and allow operation at a higher sustained peak secondary flows. The recommended sizing is 2,600 gpm, which would result in a firm capacity of 15 mgd. The existing RAS piping in the secondary clarifier pump room should also be modified so the inlet (suction side) is connected directly to the rotating suction arm. The existing waste activated sludge (WAS) piping would be modified so the inlet of the existing WAS pumps is connected directly to the modified RAS pump inlet piping. These modifications would improve control of return sludge pumping and activated sludge system solids residence time (SRT). In addition, eliminating the sludge sump associated with each clarifier reduces the risk of trapping filamentous organisms, foam, and scum, which could accumulate there and be a potential contributor to settleability issues.

5.4 Project Cost Summary

The estimated project costs for the Biotower 1 rotary distributor and media replacement and the secondary clarifier / RAS pump retrofits are $1.8 million and $11.4 million, respectively. The total project cost for the three capital improvement projects is $13.2 million. Detailed project costs are provided in Appendix C.

APPENDIX A – HISTORICAL OPERATIONS AND PERFORMANCE PLOTS AND AERATION TANK OPERATING CURVES

APPENDIX A – HISTORICAL OPERATIONS AND PERFORMANCE PLOTS AND AERATION TANK OPERATING CURVES

Plant data from January 2009 through August 2016 were compiled to evaluate secondary treatment operations and performance.

Final effluent from the CMSA WWTP has met permitted discharge limits during both dry weather and wet weather seasons throughout the nearly 8-year period analyzed. Figure A.1 and Figure A.2 show the final effluent TSS and cBOD concentrations throughout this period. The monthly average TSS and cBOD discharge limits are 30 and 25 mg/L, respectively, and the corresponding weekly average TSS and cBOD discharge limits are 45 and 40 mg/L. The figures show that the 28-day moving average concentrations are significantly lower than the permitted limits.

Figure A.3 through Figure A.8 summarize biotower operations and performance. Typically, one biotower and one biotower feed pump were in service during this period. Figure A.3 shows the equalized primary effluent flow rate, which represents the secondary treatment feed. The primary effluent flow rate to the secondary treatment facilities is limited to the sustained peak capacity of 30.0 mgd. The figure also shows the portion of the primary effluent pumped to the biotowers.

Figure A.4 and Figure A.5 show the biotower hydraulic loading rate and organic loading rate. The organic loading rate varies seasonally with the primary effluent cBOD concentration. Figure 8.6 shows the biotower cBOD removal. Figure A.7 and Figure A.8 show the fraction of the flow and the corresponding fraction of the primary effluent organic load diverted around the biotowers. The figures show that approximately 30 percent of the primary effluent organic load is diverted in the dry weather season and approximately 60 percent diverted in the wet weather season.

Figure A.9 through Figure A.14 show the activated sludge system performance. The activated sludge solids inventory varies by a factor of four between dry weather and wet weather, as shown in Figure A.12, based on the MLSS concentration and the number of aeration tanks in service.

The 90^{th} percentile SVI is typically the value used to evaluate critical secondary clarifier loading conditions. During the recent 12-month period shown in Figure A.14, the average SVI was 174 mL/g, but the 90^{th} percentile value was significantly higher – 244 mL/g.

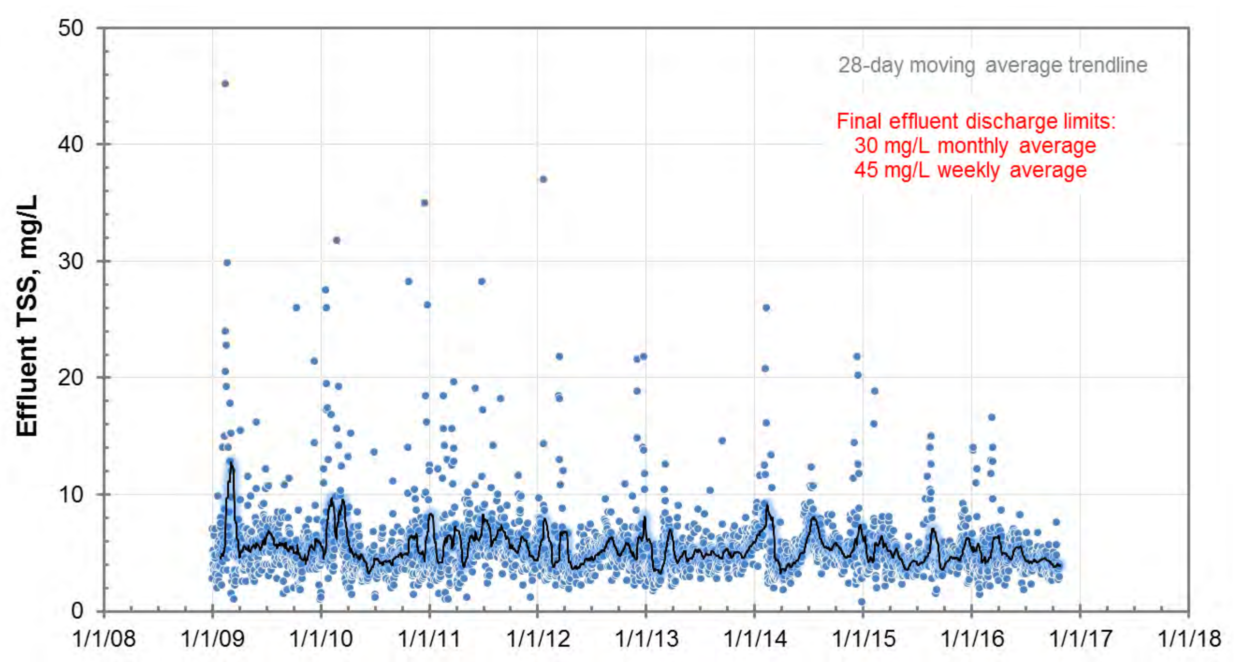

Figure A.1. Effluent TSS concentration

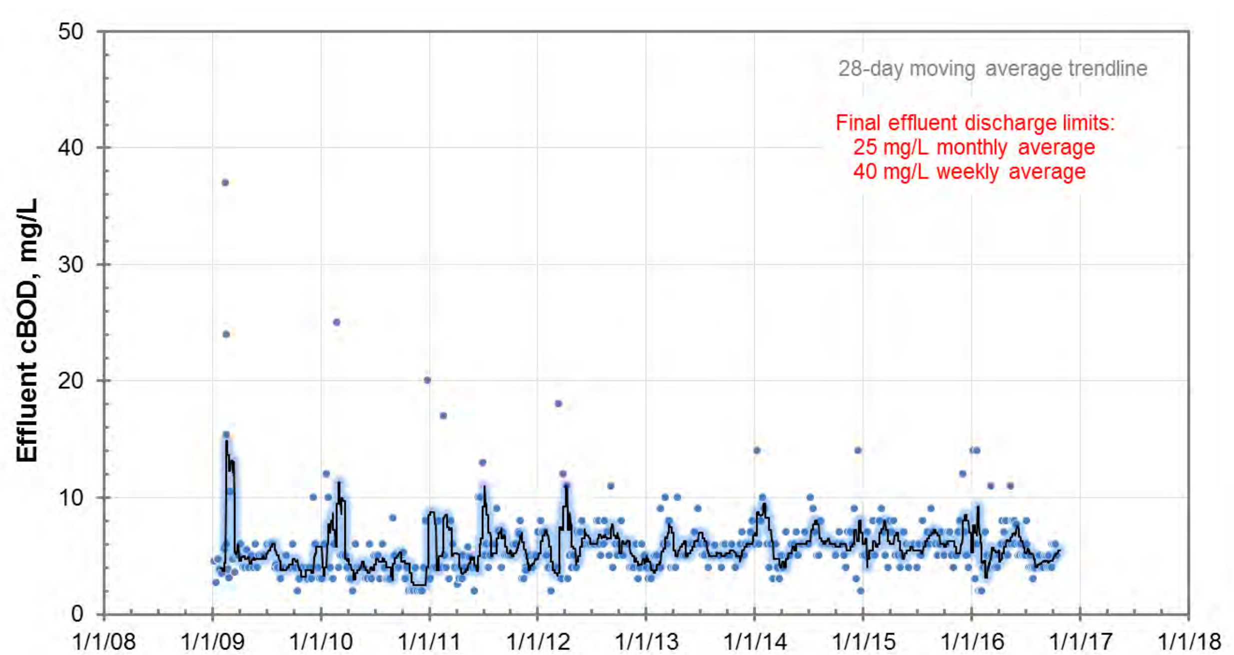

Figure A.2. Effluent cBOD concentration

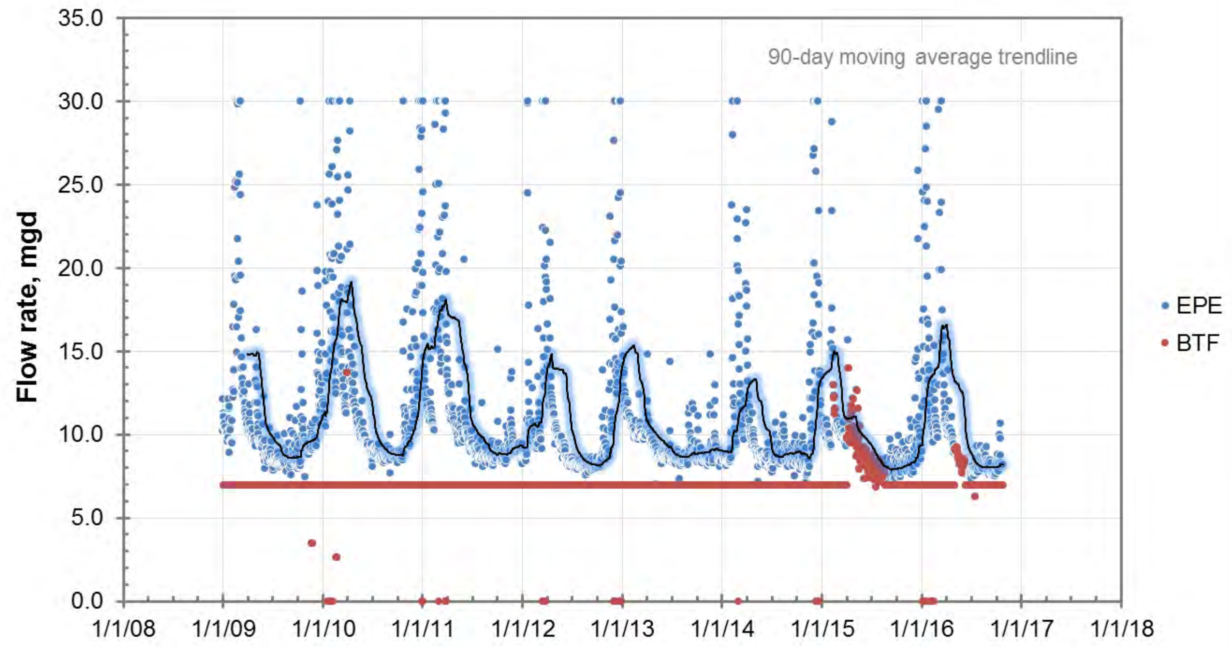

Figure A.3. Equalized primary effluent and biotower feed flow rate

The equalized primary effluent (EPE) flow rate is calculated assuming primary effluent blending when the influent flow rate is greater than 30 mgd. The biotower feed (BTF) flow rate is calculated as the number of biotower feed pumps times an assumed flow rate of 7.0 mgd each.

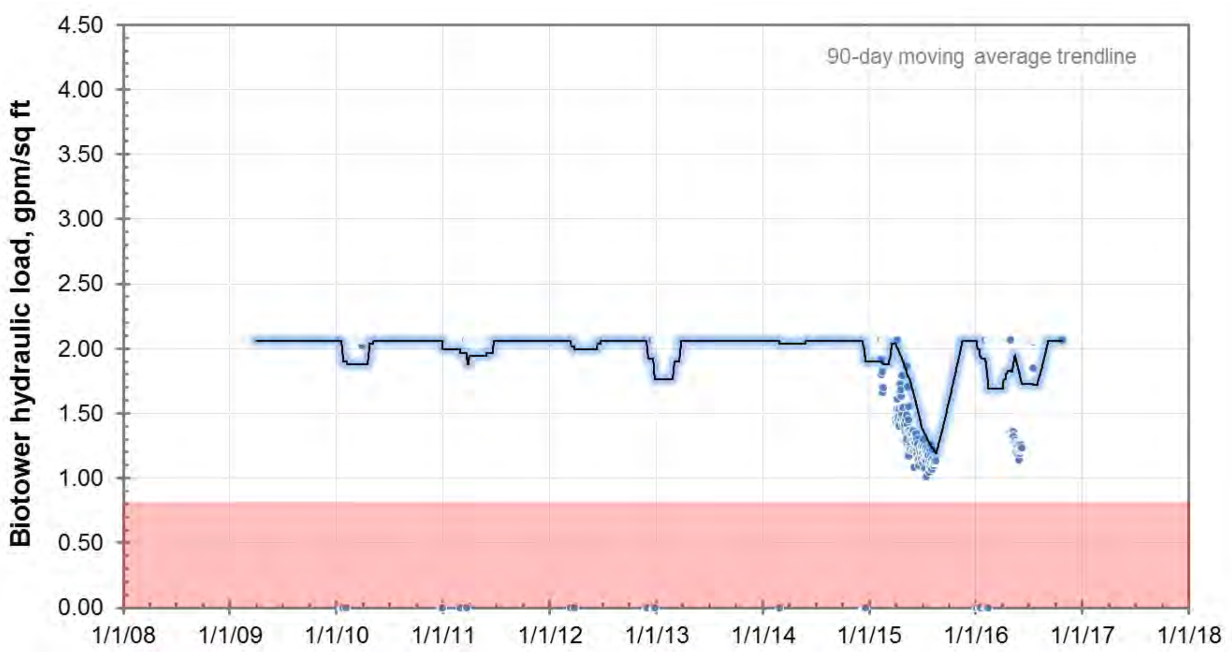

Figure A.4. Biotower hydraulic load

The red shaded area represents a hydraulic load less than the typical minimum value of 0.8 gpm/sq ft.

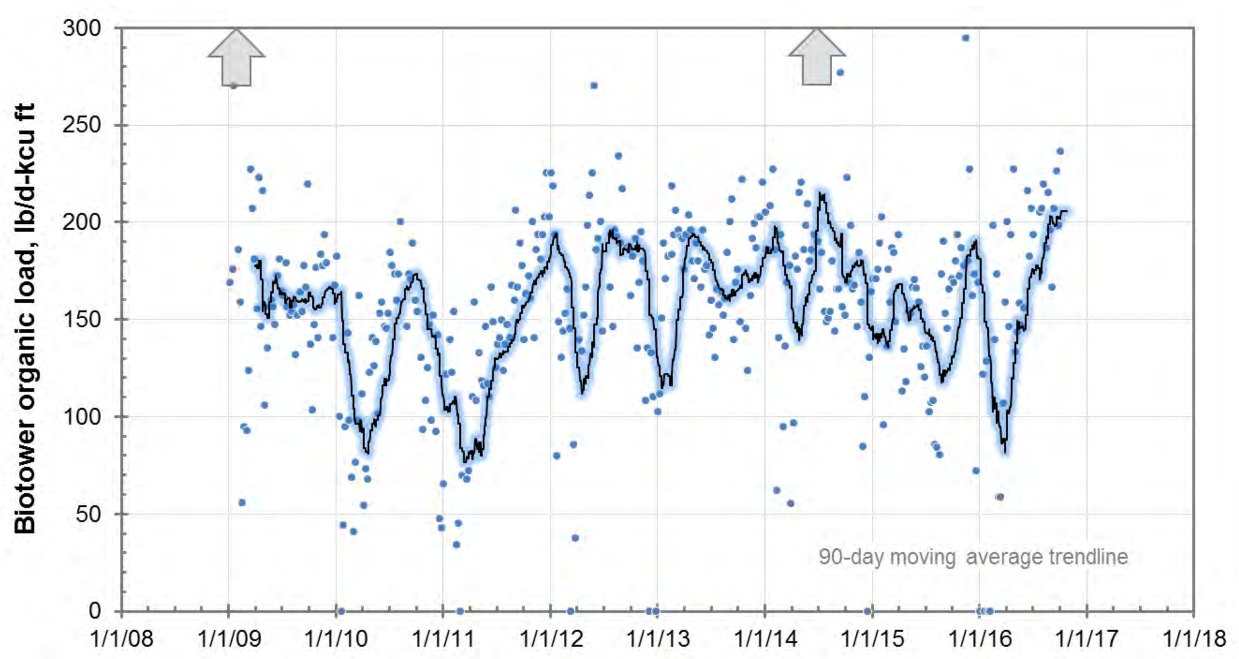

Figure A.5. Biotower organic load

Each shaded arrow indicate a data point greater than 300 lb/d-kcu ft.

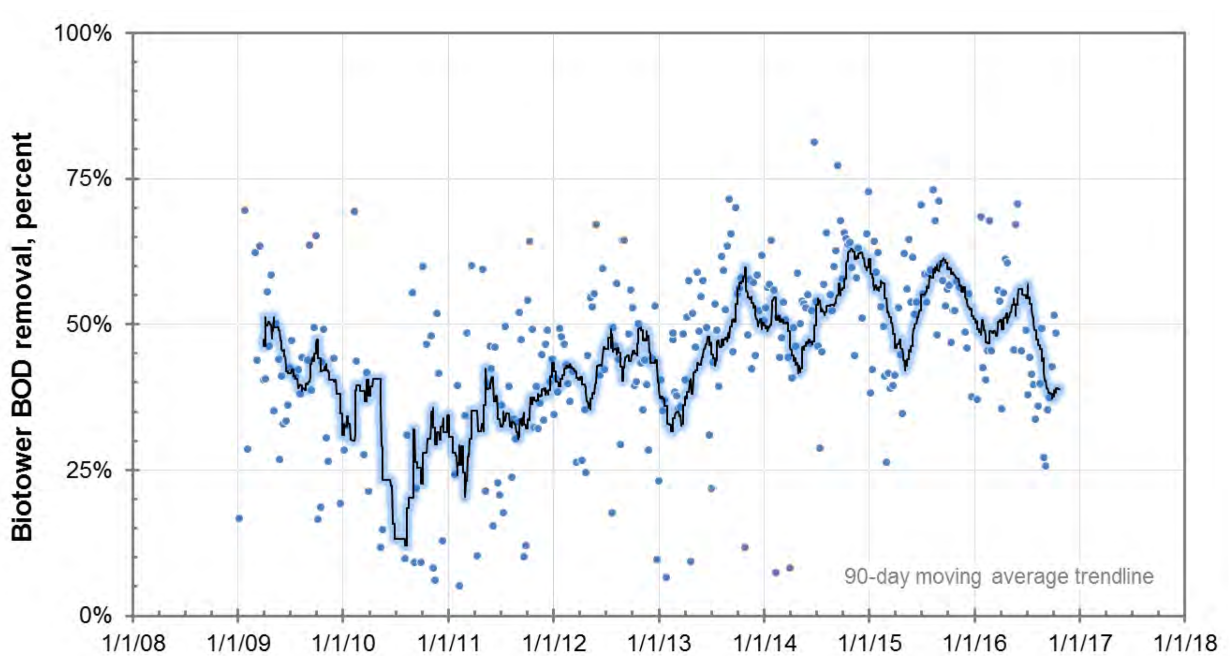

Figure A.6. Biotower cBOD removal

Note that calculated negative BOD removals are not plotted.

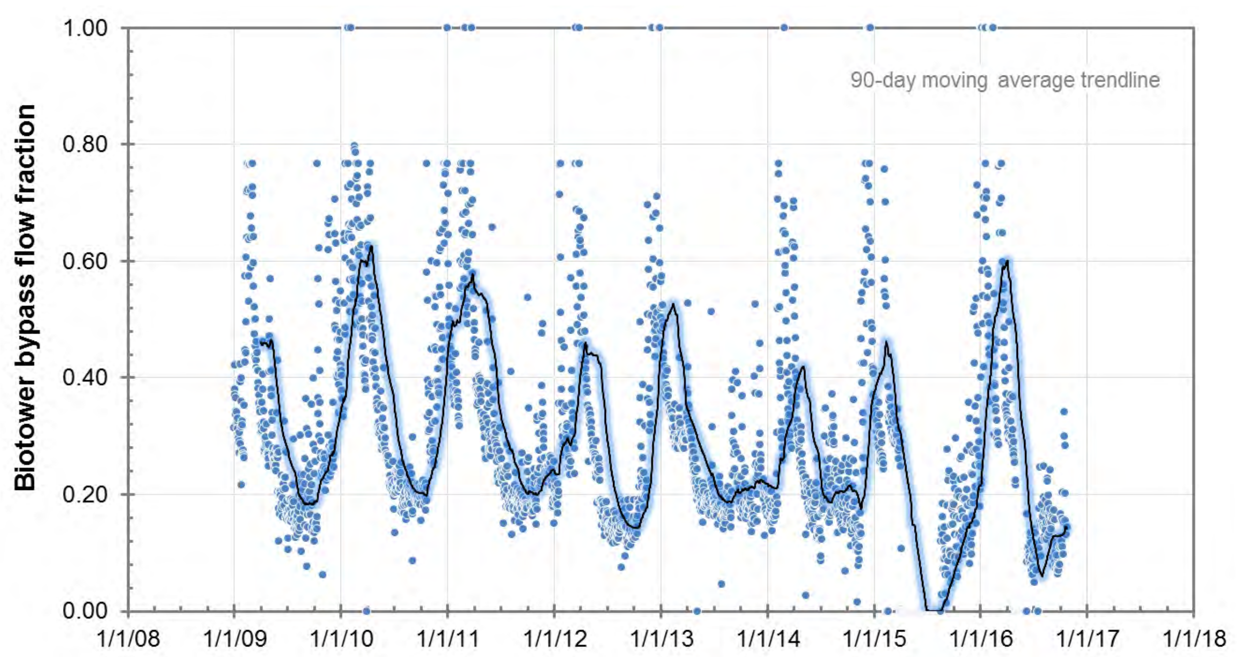

Figure A.7. Fraction of equalized primary effluent flow diverted around the biotower.

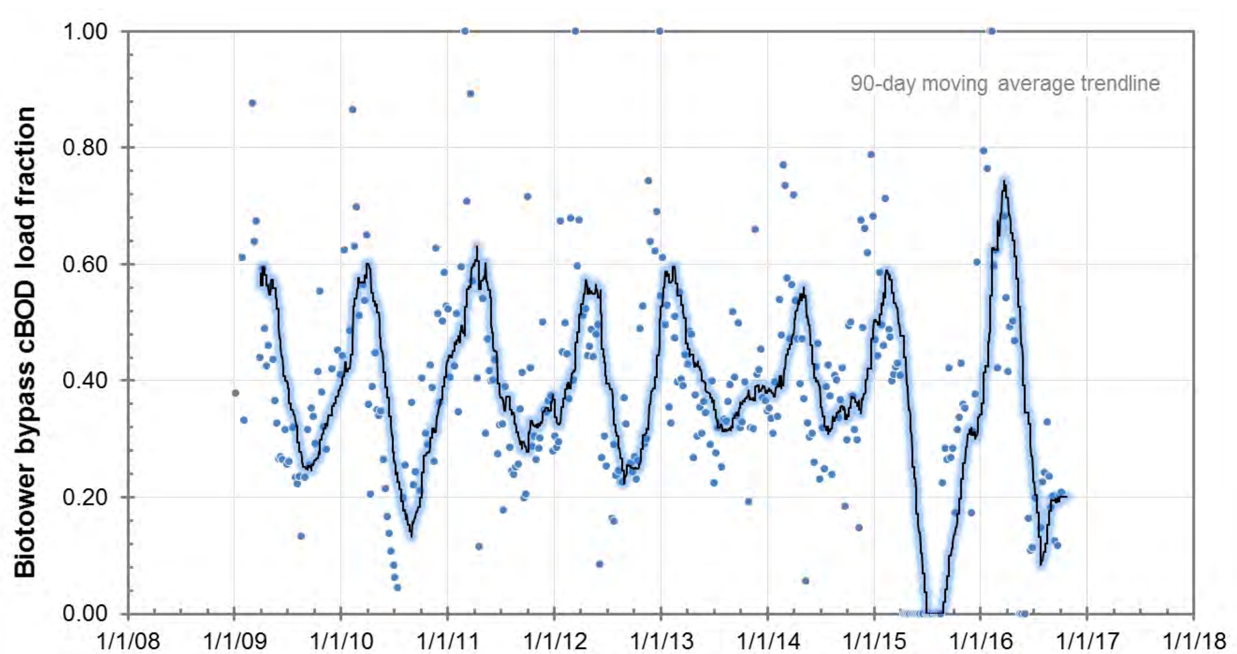

Figure A.8. Fraction of equalized primary effluent cBOD load diverted around the biotower.

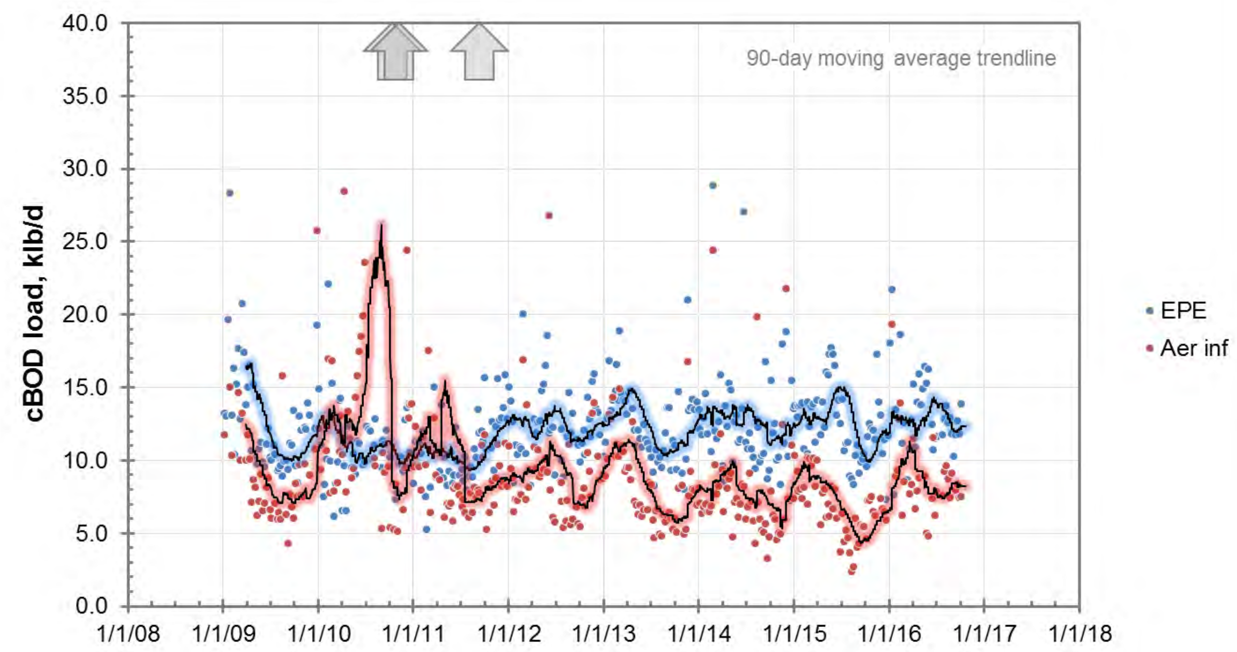

Figure A.9. Equalized primary effluent and aeration influent cBOD load
The aeration influent load is the sum of the biotower effluent load and the primary effluent load diverted around the biotower. Each shaded arrow indicates a data point greater than 40.0 klb/d.

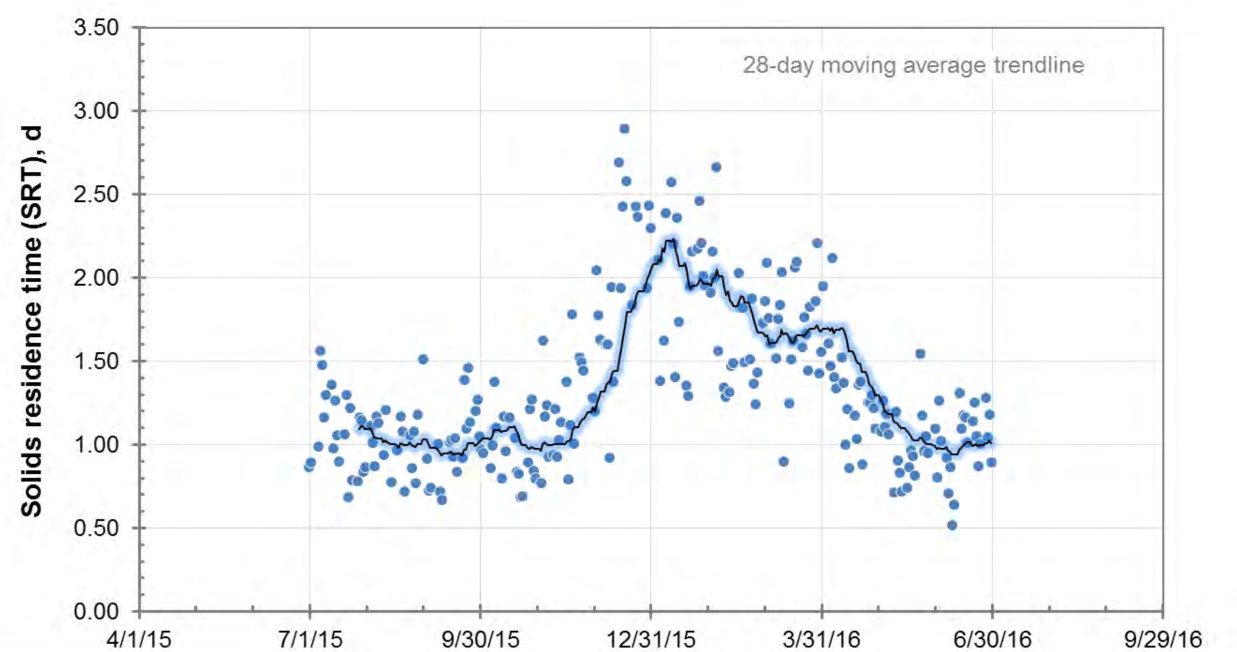

Figure A.10. Activated sludge solids residence time
Note that these data are for the 12-month period from July 1, 2015 through June 30, 2016 only.

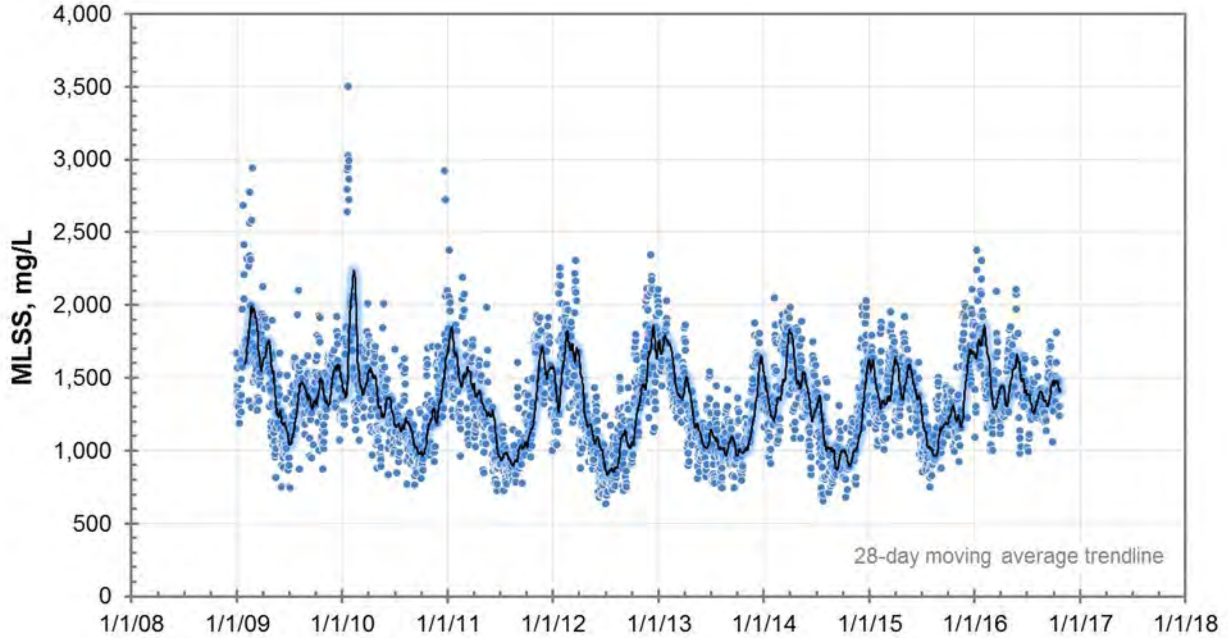

Figure A.11. Mixed liquor suspended solids.

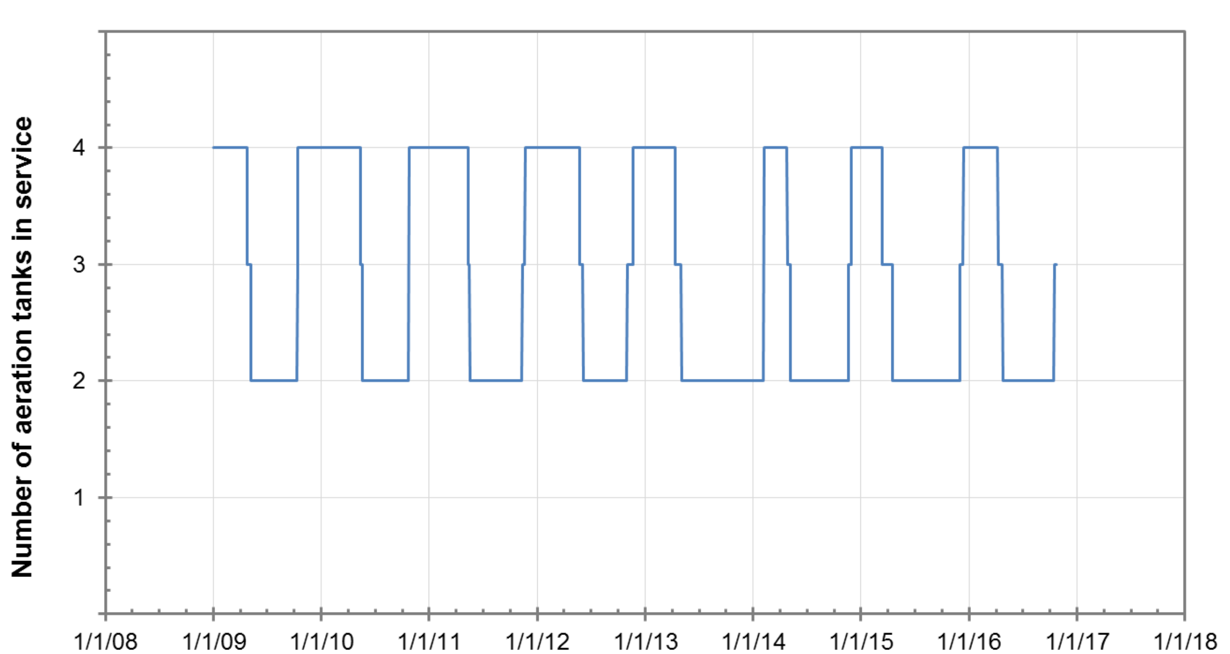

Figure A.12. Aeration tanks in service

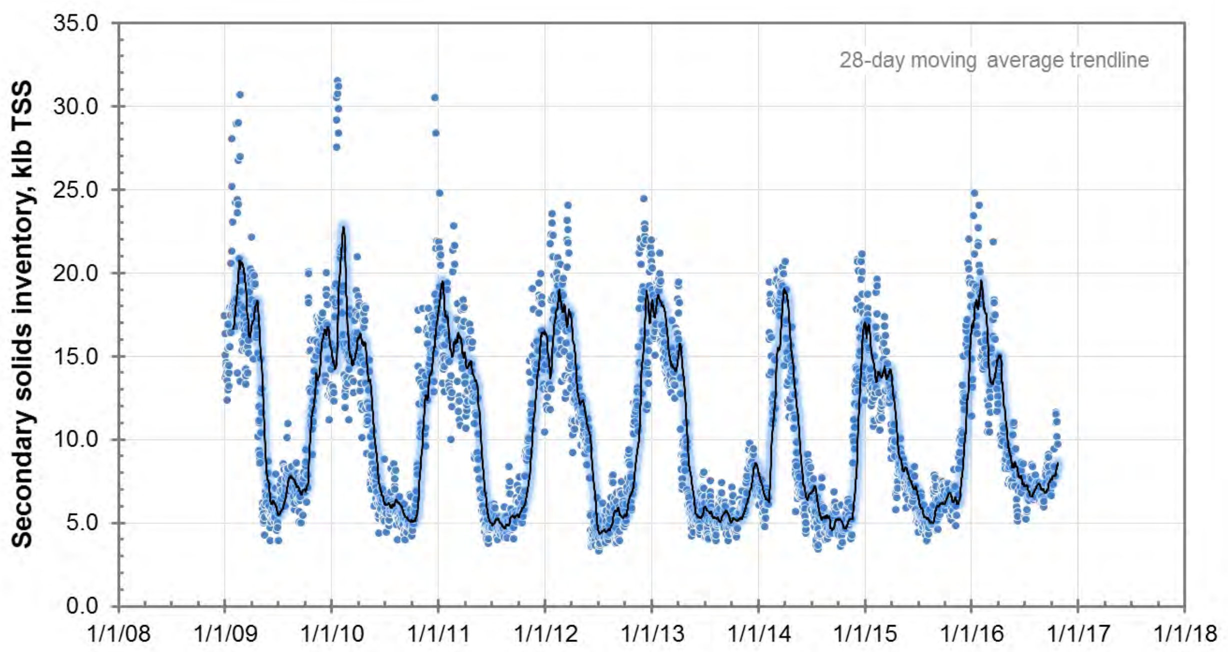

Figure A.13. Secondary total suspended solids inventory

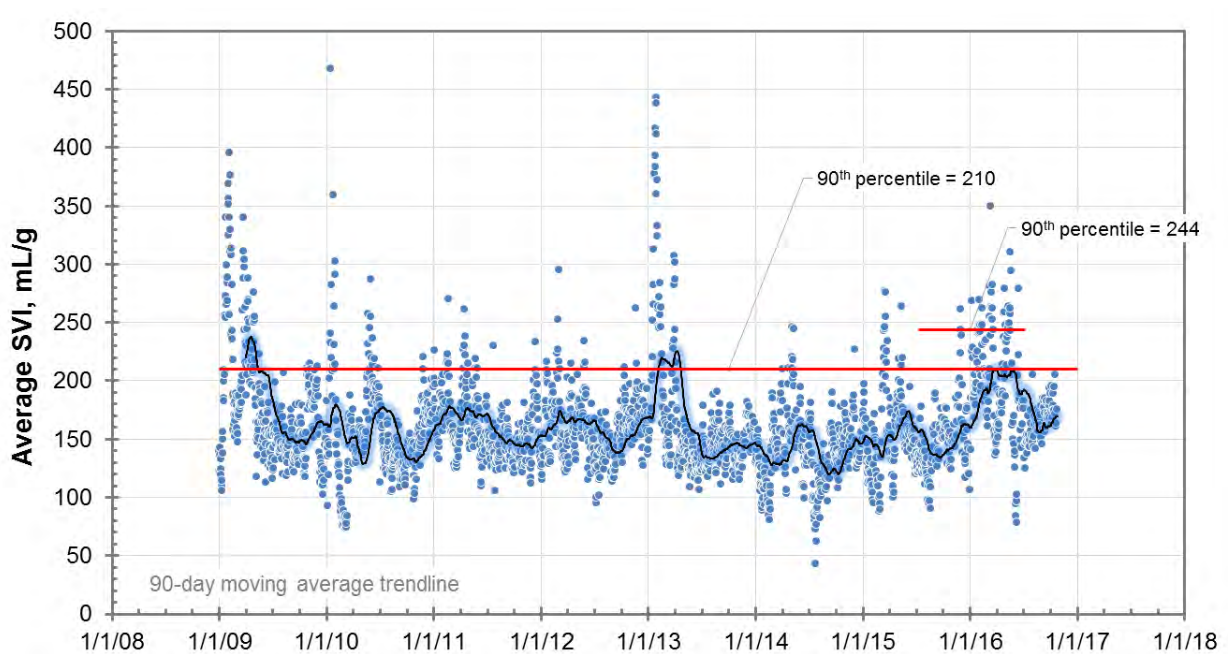

Figure A.14. Average sludge volume index.

The average SVI is the average of the value measured with mixed liquor from each aeration tank in service. The 90th percentile value is shown for both the full period plotted and for July 1, 2015 through June 30, 2016.

Figure A.15 and Figure A.16 show the proposed biotower hydraulic and organic loading conditions with both biotowers in service and all primary effluent flows up to 30.0 mgd pumped to the biotowers.

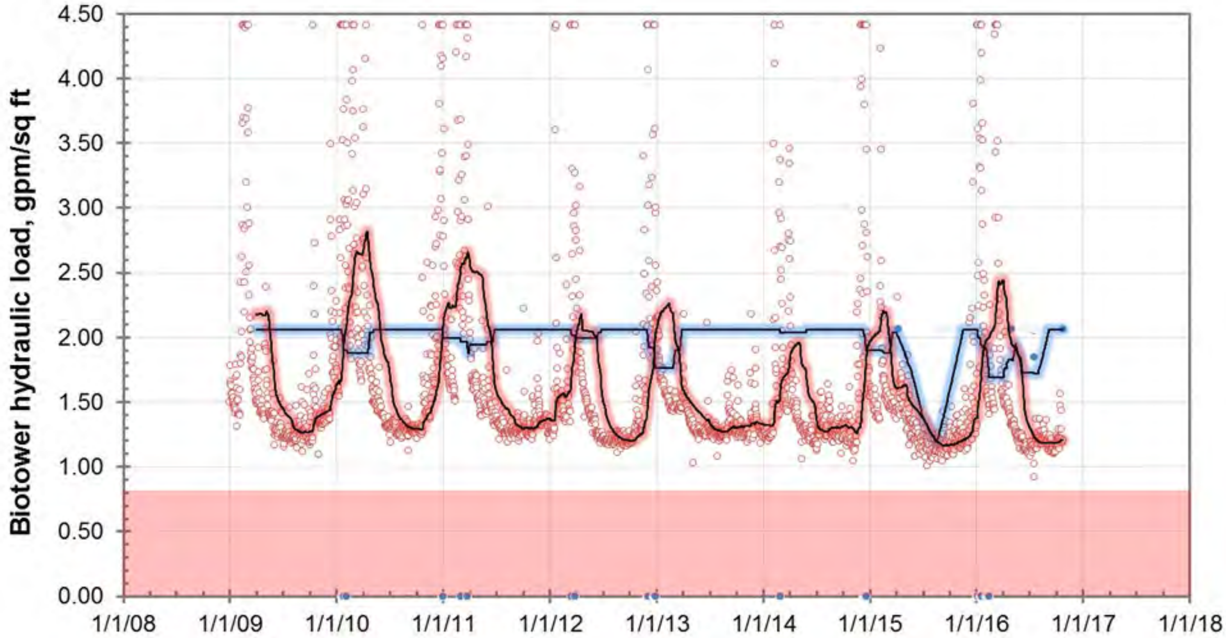

Figure A.15. Biotower hydraulic load, both biotowers in service.

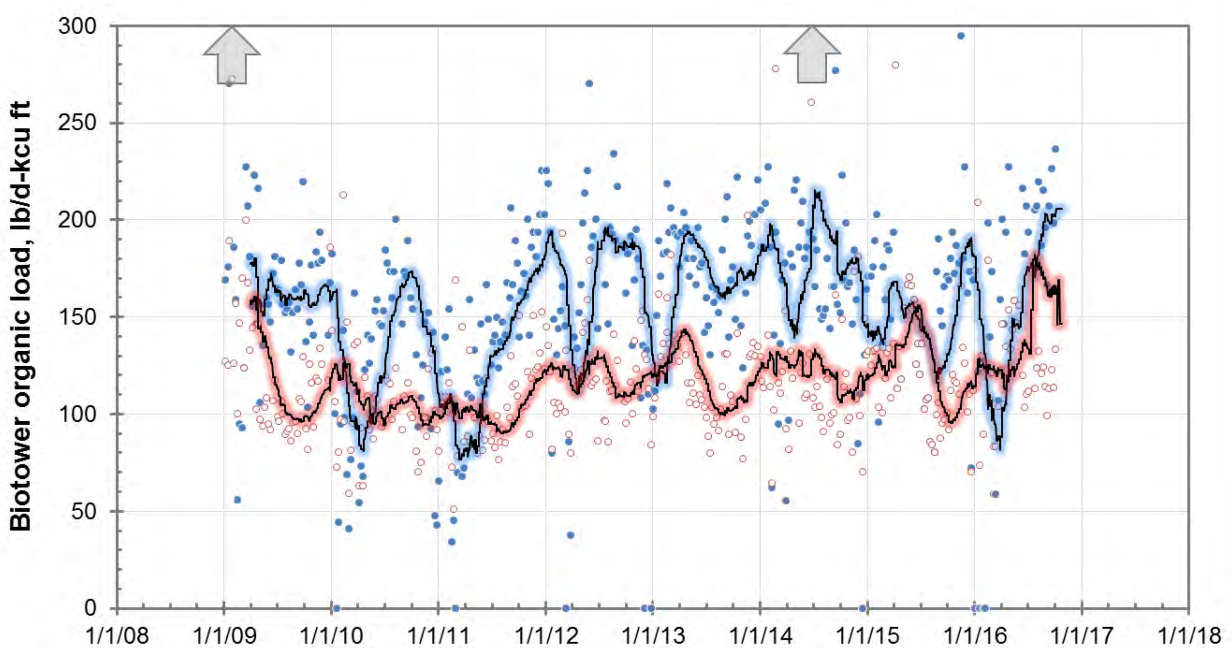

Figure A.16. Biotower organic load, both biotowers in service.
Each shaded arrow represents a data point greater than 300 lb/d-kcu ft

Secondary clarifier operation was evaluated using state point analysis to identify allowable maximum solids loading rate (SLR) for a range of sludge settleability, as shown in Figure A.17. The analysis shows that the maximum allowable SLR is 17.2 lb/d-sq ft at the current 90th percentile SVI of 244 mL/g. (The 90th percentile SVI is used as a conservative measure of sludge settleability.) If the 90th percentile SVI were reduced to 150 mL/g, the typical threshold between well-settling and bulking sludge, the maximum allowable SLR would be 32.5 lb/d-sq ft – approximately 90 percent greater.

The results of this evaluation can be summarized in an operating curve, that shows the flow rate at which contact stabilization is needed based on a given sludge settleability and RAS flow rate. Figure A.18 shows the operating curve for 244 mL/g SVI and 10.0 mgd RAS flow rate. The curve shows the aeration tank configuration should be switched from parallel to contact stabilization at a flow rate of approximately 21.4 mgd. The sustained peak secondary capacity would be approximately 31.5 mgd in the contact stabilization mode.

Figure A.19 shows the operating curve if the 90th percentile SVI was reduced to 150 mL/g and the RAS flow rate was increased to 15.0 mgd. Under these conditions, the aeration tank configuration should be switched from parallel to contact stabilization at a flow rate of approximately 38.6 mgd.

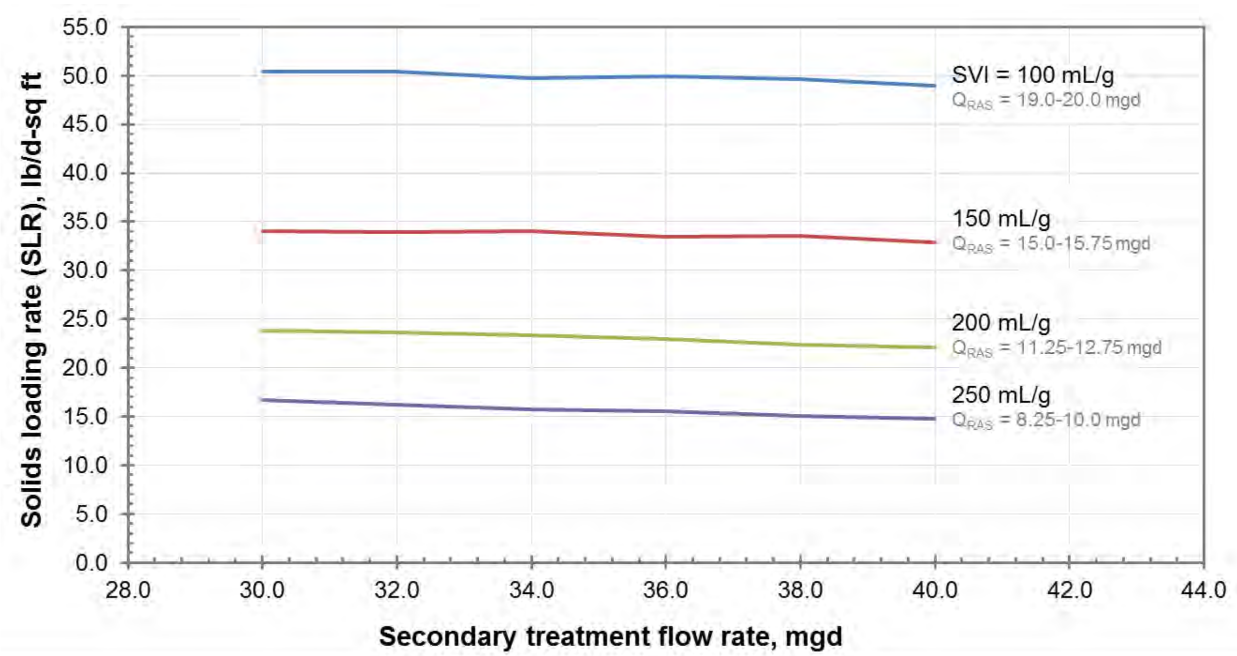

Figure A.17. Maximum clarifier solids loading rate

The curves show the maximum clarifier solids loading rate for a range of SVI values, calculated using state point analysis. The required RAS capacity tp realize these solids loading rates are indicated for each SVI value.

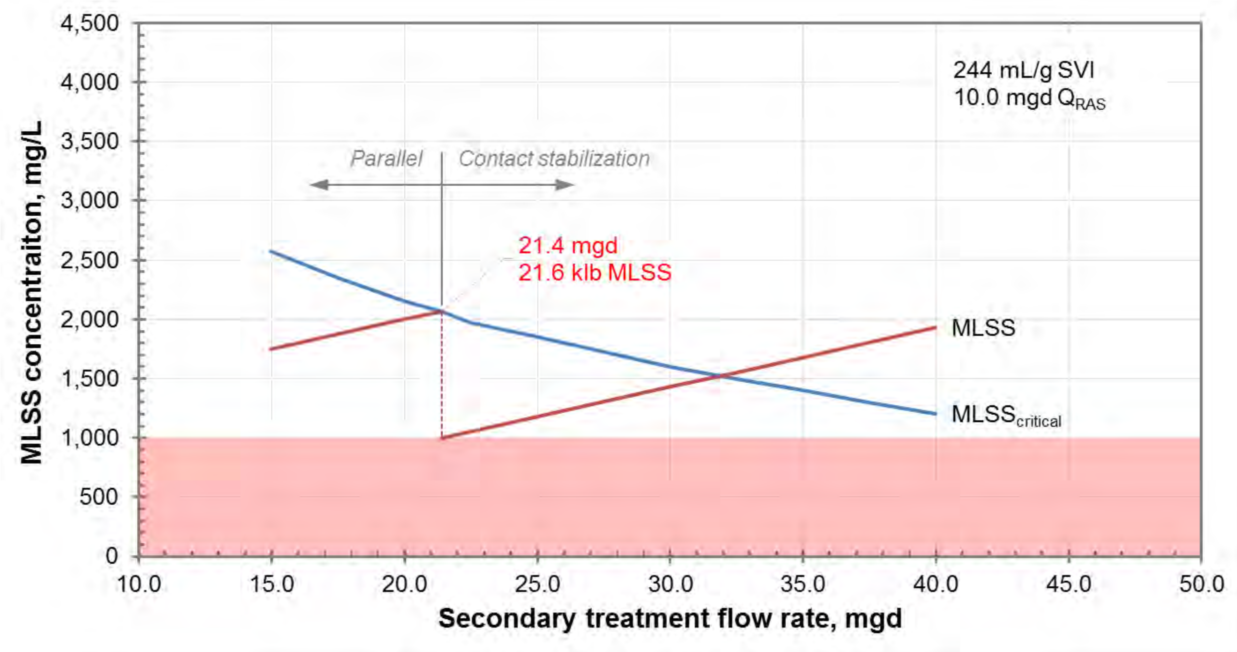

Figure A.18. Aeration tank operating curve, 10.0 mgd Q_{RAS}, 244 mL/g SVI

The operating curve shows the flow rate at which the aeration tank configuration must be switched from parallel to contact stabilization mode to avoid clarifier overload. The curve also shows the solids inventory necessary to maintain a clarifier inlet suspended solids concentration of at least 1,000 mg/L in the contact stabilization mode.

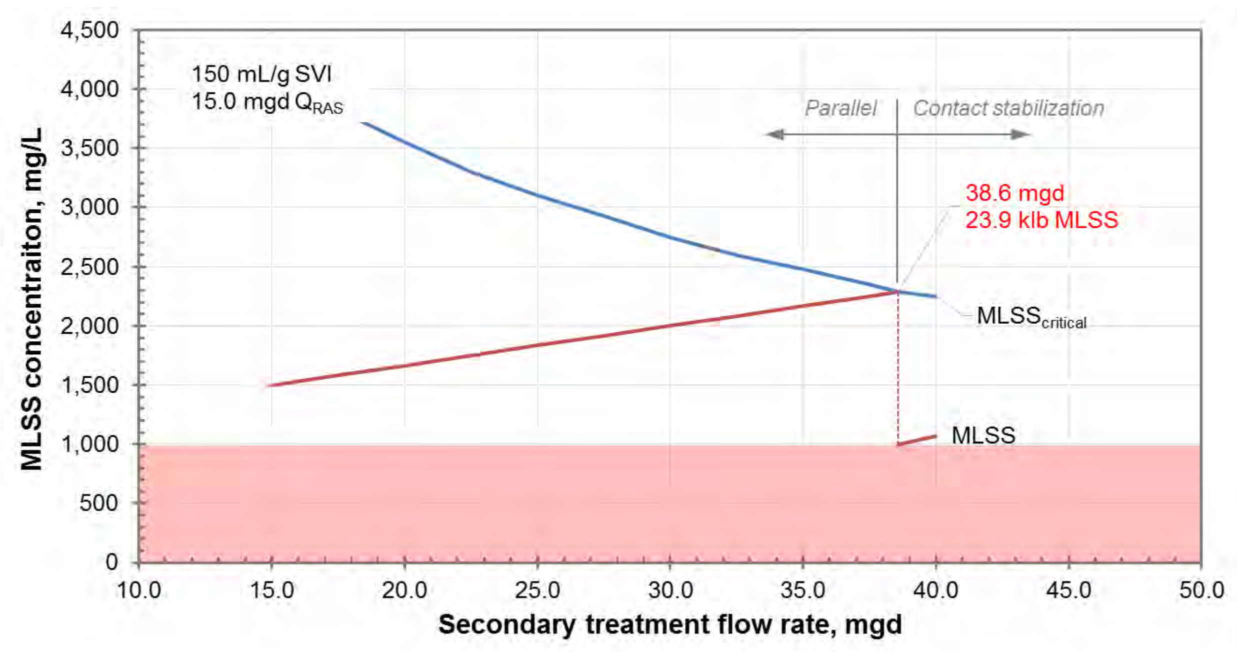

Figure 8.19 Aeration tank operating curve, 15.0 mgd Q_{RAS}, 150 mL/g SVI

The operating curve shows the flow rate at which the aeration tank configuration must be switched from parallel to contact stabilization mode to avoid clarifier overload. The curve also shows the solids inventory necessary to maintain a clarifier inlet suspended solids concentration of at least 1,000 mg/L in the contact stabilization mode.

APPENDIX B – OPERATIONAL EVALUATION SUMMARY TABLES

Dry Weather Operation (May through October)

	No. Biotowers	No. Aeration Tanks	MLSS, mg/L [1]	SRT, days	Process Air, scfm		Diffuser Loading, scfm/diff		Average Operating Power, hp			Expected Effluent Quality	Findings/Conclusion	Comment [5]
					Average	Peak [2]	Average	Peak	Biotower [3]	Aeration [4]	Total	cBOD and TSS, mg/L		
Acceptable Range	Varies	Varies	1,000 - 2,500	1.0 to 1.5	Varies	Varies	0 to 40	0 to 40	Varies	Varies	Varies	5 mg/L (current performance)		Current operation achieves excellent effluent quality.
	0	0	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	0	130 to 220	Not Recommended	Operating without biotowers or aeration tanks would not provide any secondary treatment and WWTP would not be able to meet NPDES discharge permit.
	0	1	2,600	1.0	4,290	8,600	47.7	95.6	0	240	240	30 to 90	Not Recommended	Operating without biotowers would put WWTP at risk of having settleability issues and not meeting NPDES permit. In addition, operating with only 1 aeration tank would result in overloading the existing diffusers.
	0	2	1,300	1.0	4,290	8,600	23.8	47.8	0	240	240	30 to 90	Not Recommended	Operating without biotowers would put WWTP at risk of having settleability issues and not meeting NPDES permit. In addition, operating with only 2 aeration tanks would result in overloading the existing diffusers.
	0	3	1,300	1.5	4,812	9,646	17.8	35.7	0	269	269	20 to 45	Not Recommended	Operating without biotowers would put WWTP at risk of having settleability issues and not meeting NPDES permit
	0	4	1,000	1.5	4,812	9,646	13.4	26.8	0	269	269	20 to 45	Not Recommended	Operating without biotowers would put WWTP at risk of having settleability issues and not meeting NPDES permit
	1	0	N/A	N/A	N/A	N/A	N/A	N/A	63	N/A	63	90 to 170	Not Recommended	Although this operational mode would reduce operating power demands significantly, it would not meet NPDES limits.
	1	1	2,400	1.0	2,942	6,261	32.7	69.6	63	165	227	20 to 45	Not Recommended	Would overload diffusers and would be at risk of not meeting NPDES permit.
	1	2	1,200	1.0	2,942	6,261	16.3	34.8	63	165	227	5 to 6 (current performance)	Recommended	Current practice achieves excellent effluent quality.
	1	3	1,200	1.5	3,300	7,023	12.2	26.0	63	185	247	5 to 20	Acceptable	This is an acceptable operating mode if effluent quality degrades or there is evidence of poor flocculation. This operational mode increases aeration demands by 10 percent, which increase monthly power costs by $1,300
	1	4	1,000	1.7	3,500	7,449	9.7	20.7	63	196	258	5 to 20	Not Recommended	Operating with 4 aeration tanks during dry weather is not necessary, increases aeration demand by 15 percent, which increase monthly power costs by $2,100. In addition, this mode of operation puts the plant at risk of partially nitrifying, which would further increase power demands and could cause chlorination problems and increase chemical costs.
	2	0	N/A	N/A	N/A	N/A	N/A	N/A	125	N/A	125	70 to 170	Not Recommended	Although this operational mode would reduce operating power demands significantly, it would not meet NPDES limits.
	2	1	2,200	1.0	2,380	4,800	26.4	53.3	125	133	258	20 to 45	Not Recommended	Would overload diffusers and would be at risk of not meeting NPDES permit.
	2	2	1,100	1.0	2,380	4,800	13.2	26.7	125	133	258	5 to 20	Acceptable	This is an acceptable operating mode if SVI exceeds 250 mL/g for one week or more, and if secondary clarifiers are at risk of solids overload. Operating the second biotower should reduce SVI and would increase power demands by approximately $2,000. While the reduced SVI reduces clarifier solids load, it may result in a slight increase in effluent CBOD and TSS.
	2	3	1,100	1.5	2,670	5,384	9.9	19.9	125	149	275	5 to 20	Acceptable	This is an acceptable operating mode if effluent quality degrades or there is evidence of poor flocculation AND if SVI exceeds 250 mL/g for a week or more and secondary clarifiers are at risk of solids overload. Operating the second biotower should reduce SVI and would increase power demands by approximately $3,000. While the reduced SVI reduces clarifier solids load, it may result in a slight increase in effluent CBOD and TSS.
	2	4	1,000	1.8	2,800	5,647	7.8	15.7	125	157	282	5 to 20	Not Recommended	Operating with 4 aeration tanks during dry weather is not necessary and puts the plant at risk of partially nitrifying, which could increase power demands and cause chlorination problems and increase chemical costs.

RECOMMENDED OPERATING STRATEGY

ACCEPTABLE OPERATING STRATEGY, BUT MAY RESULT IN REDUCED EFFLUENT QUALITY

Notes:

(1) Minimum based on maintaining adequate flocculation. Maximum based on historical settleability (244 mL/g) and peak dry weather flow of 12 mgd with 3 clarifiers in service.
(2) Based on historical peaking factors.
(3) Estimated based on 30 feet of pumping and 70% efficiency, and operation of 10 hp biotower fans.
(4) Based on 80% overall blower efficiency at 8 psig.
(5) Monthly power savings or increases based on $0.12/kwh.

Wet Weather Operation (November through April)

	No. Biotowers	No. Aeration Tanks	MLSS, mg/L (1)	SRT, days	Process Air, scfm		Diffuser Loading, scfm/diff		Average Operating Power, hp			Expected Effluent Quality	Findings/Conclusion	Comment (5)
					Average	Peak (2)	Average	Peak	Biotower (3)	Aeration (4)	Total			
Acceptable Range	Varies	Varies	1,000 to 1,500	1.0 to 2.0	Varies	Varies	0 to 40	0 to 40	Varies	Varies	Varies	5 mg/L (current performance)		Current operation achieves excellent effluent quality.
	0	0	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	0	130 to 220	Not Recommended	Operating without biotowers or aeration tanks would not provide any secondary treatment and WWTP would not be able to meet NPDES discharge permit.
	0	1	1,500	0.4	3,900	7,800	43.3	86.7	0	218	218	30 to 90	Not Recommended	Operating without biotowers would put WWTP at risk of having settleability issues and would not be able to maintain an acceptable minimum SRT. Would be at risk of not meeting NPDES permit. In addition, operating with only 1 aeration tank would overload the existing diffusers.
	0	2	1,500	0.7	4,300	8,600	23.9	47.8	0	240	240	30 to 90	Not Recommended	Operating without biotowers would put WWTP at risk of having settleability issues and would not be able to maintain an acceptable minimum SRT. Would be at risk of not meeting NPDES permit. In addition, operating with only 2 aeration tanks would result in overloading the existing diffusers.
	0	3	1,500	1.1	4,600	9,200	17.0	34.1	0	257	257	20 to 45	Not Recommended	Operating without biotowers would put WWTP at risk of having settleability issues and not meeting NPDES permit
	0	4	1,500	1.5	4,990	10,000	13.9	27.8	0	279	279	20 to 45	Not Recommended	Operating without biotowers would put WWTP at risk of having settleability issues and not meeting NPDES permit
	1	0	N/A	N/A	N/A	N/A	N/A	N/A	85	N/A	85	90 to 170	Not Recommended	Although this operational mode would reduce operating power demands significantly, it would not meet NPDES limits.
	1	1	1,500	0.4	3,000	5,802	33.3	64.5	85	168	253	30 to 90	Not Recommended	Would overload diffusers and would not be able to maintain an acceptable minimum SRT and level of treatment. Would not meet NPDES permit.
	1	2	1,500	0.8	3,200	6,205	17.8	34.5	85	179	264	20 to 45	Not Recommended	Would not be able to maintain an acceptable minimum SRT and level of treatment may be compromised. Would be at risk of not meeting NPDES permit.
	1	3	1,500	1.2	3,400	6,635	12.6	24.6	85	190	275	5 to 20	Acceptable	This is an acceptable operating mode, however, it will likely not result in the same effluent quality as operating with 4 aeration tanks. By operating with only 3 aeration tanks and reducing the biological inventory, aeration demands would be reduced by 5 percent, which would reduce monthly power costs by $1,000.
	1	4	1,500	1.6	3,636	7,096	10.1	19.7	85	203	289	5 to 6 (current performance)	Recommended	Recommended, current practice achieves excellent effluent quality.
	2	0	N/A	N/A	N/A	N/A	N/A	N/A	125	N/A	125	70 to 170	Not Recommended	Although this operational mode would reduce operating power demands significantly, it would not meet NPDES limits.
	2	1	1,500	0.5	2,200	4,400	24.4	48.9	125	123	248	30 to 90	Not Recommended	Would overload diffusers and would not be able to maintain an acceptable minimum SRT and level of treatment. Would be at risk of not meeting NPDES permit.
	2	2	1,500	0.9	2,300	4,600	12.8	25.6	125	129	254	20 to 45	Not Recommended	Would not be able to maintain an acceptable minimum SRT and level of treatment may be compromised. Would be at risk of not meeting NPDES permit.
	2	3	1,500	1.4	2,600	5,200	9.6	19.3	125	145	271	5 to 20	Acceptable	This is an acceptable operating mode if effluent quality degrades or there is evidence of poor flocculation AND if SVI exceeds 250 mL/g for a week or more and secondary clarifiers are at risk of solids overload. Operating the second biotower should reduce SVI but may result in a slight increase in effluent CBOD and TSS. This operational mode would reduce power demands by 5 to 10 percent, reducing monthly power costs by $1,000.
	2	4	1,500	1.8	2,950	5,900	8.2	16.4	125	165	290	5 to 20	Acceptable	This is an acceptable operating mode if effluent quality degrades or there is evidence of poor flocculation AND if SVI exceeds 250 mL/g for a week or more and secondary clarifiers are at risk of solids overload. Operating the second biotower should reduce SVI but may result in a slight increase in effluent CBOD and TSS.

RECOMMENDED OPERATING STRATEGY

ACCEPTABLE OPERATING STRATEGY, BUT MAY RESULT IN REDUCED EFFLUENT QUALITY

Notes:

(1) Minimum based on maintaining adequate flocculation. Maximum based on historical settleability (244 mL/g) and peak wet weather flow of 30 mgd.
(2) Based on historical peaking factors.
(3) Estimated based on 30 feet of pumping and 70% efficiency, and operation of 10 hp biotower fans.
(4) Based on 80% overall blower efficiency at 8 psig.
(5) Monthly power savings or increases based on $0.12/kwh.

APPENDIX C – PROJECT COST ESTIMATES

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CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TASK :	8 - SECONDARY TREATMENT	**LOCATION FACTOR :**	1.15
JOB # :	10405A.00	**SF ENR OCTOBER 2016 :**	11578
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	1/13/2017
UPGRADE:	Biotower 1 Distributor and Media Replacement	**PREPARED BY :**	DBH
		REVIEWED BY :	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Biotower Distributor Mechanism Replacement**					
	Distributor Mechanism	1	EA	$119,000	$119,000	
	Installation & Demolition of Existing Mechanism	1	LS	$36,000	$36,000	
	Total					$155,000
2	**Biotower Media Replacement**					
	Biotower Media - Top 2 Layers	11000	CF	$8	$88,000	
	Media Installation - Top 2 Layers	1	LS	$9,000	$9,000	
	Existing Media Disposal - Top 2 Layers	407	CY	$42	$18,000	
	Biotower Media - Lower 9 Layers	49500	CF	$8	$396,000	
	Media Installation - Lower 9 Layers	1	LS	$40,000	$40,000	
	Existing Media Disposal - Lower 9 Layers	1833	CY	$42	$77,000	
	Total					$628,000
	SUBTOTAL					**$783,000**
3	**Allowances**					
	Process Mechanical Allowance	0	%		$0	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	0	%		$0	
	Coating/Painting Allowance	0	%		$0	
	Total					$0
	SUBTOTAL					**$783,000**
	Estimating Contingency	30	%			$235,000
	SUBTOTAL					**$1,018,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$47,000
	SUBTOTAL					**$1,065,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$266,000
	CONSTRUCTION COST SUBTOTAL					**$1,331,000**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35	%			$466,000
	PROJECT COST					**$1,797,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

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TASK :	8 - SECONDARY TREATMENT	**LOCATION FACTOR :**	1.15
JOB # :	10405A.00	**SF ENR OCTOBER 2016 :**	11578
LOCATION :	San Rafael, CA	**ESTIMATE PREPARATION DATE :**	11/30/2016
		PREPARED BY :	DBH
		REVIEWED BY :	AG

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	TOTAL
1	**Secondary Clarifier**					
	Tow-Bro Clarifier Mechanisms, 100 ft. dia., 304SS	4	EA	$500,000	$2,000,000	
	Demolition	1	LS	$125,000	$125,000	
	Sheet Piling	4	EA	$150,000	$600,000	
	Center Column Foundation	4	EA	$125,000	$500,000	
	Total					$3,225,000
2	**RAS Pumping and Piping Modifications**					
	RAS Pumps	6	EA	$37,500	$225,000	
	RAS Piping Modifications	1	LS	$100,000	$100,000	
	Total					$325,000
	SUBTOTAL					**$3,550,000**
3	**Allowances**					
	Process Mechanical Allowance	10	%		$355,000	
	Yard Piping & Site Civil Allowance	0	%		$0	
	EIC Allowance	20	%		$710,000	
	Coating/Painting Allowance	10	%		$355,000	
	Total					$1,420,000
	SUBTOTAL					**$4,970,000**
	Estimating Contingency	30	%			$1,491,000
	SUBTOTAL					**$6,461,000**
	Sales Tax on 50% of Subtotal Above	9.25	%			$299,000
	SUBTOTAL					**$6,760,000**
	General Conditions, Contractor Overhead, & Profit	25	%			$1,690,000
	CONSTRUCTION COST SUBTOTAL					**$8,450,000**
	Engineering, Legal, Admin, Permitting, & Const. Mgmt.*	35	%			$2,958,000
	PROJECT COST					**$11,408,000**

* Project cost estimates for TMs prepared before August 2017 used a 35% engineering cost factor instead of a 20% engineering cost factor for TMs prepared after August 2017.

MDB CONSULTING ENGINEERS, LLC

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM NO. 9
SOLAR POWER GENERATION

FINAL
October 2018

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM
NO. 9
SOLAR POWER GENERATION

TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF FIGURES

DISCLOSURE STATEMENT

Funding for this document has been provided in full or in part through an agreement with the State Water Resources Control Board. California's Clean Water State Revolving Fund is capitalized through a variety of funding sources, including grants from the United States Environmental Protection Agency and state bond proceeds. The contents of this document do not necessarily reflect the views and policies of the foregoing, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

SOLAR POWER GENERATION

1.0 INTRODUCTION

This technical memorandum (TM) summarizes the technical and financial feasibility for providing solar power generation at the Central Marin Sanitation Agency's (Agency) Wastewater Treatment Plant (WWTP).

This TM also summarizes the implications and the opportunities for additional on-site generation including impacts on the Interconnection Agreement and electricity export.

2.0 SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

The key findings are:

- The WWTP site has unobstructed and unshaded areas that can accommodate up to 500 kilowatt (kW) of solar photovoltaic (PV) generation including roof arrays of the Control and Maintenance Buildings, ground-mount arrays to the south and west of the effluent pond, and canopy arrays in the parking lot.
- The Agency has existing on-site electricity generation which limits the economic value of solar generation. Due to this and the Agency's ineligibility for tax credits and accelerated depreciation, Agency owned solar PV is uneconomical.
- A third-party ownership arrangement of solar generation may be economically feasible with potential for the cost of solar electricity to be less than the value of excess electricity sold to the grid. Accordingly, the Agency may wish to consider issuing a Request for Proposals (RFP) to determine if private firms can offer an attractive solar project. This should be done soon as the available tax credits decline each year, based upon when construction begins.
- Adding solar PV is not anticipated to impact the Interconnection Agreement as solar electricity would not be exporting to the grid.

3.0 BACKGROUND

In 2001, the Agency received a proposal from BP Solar for a 1 megawatt (MW) solar PV system. In 2002, The Agency completed a Solar Power Feasibility Study that included analysis of the BP Solar proposal and further refined the findings to develop a solar PV assessment for the WWTP, which recommended nearly 250 kW of solar.

Since completion of the 2002 Study, the Agency has expanded operations at the WWTP reducing the area available for solar. However, the efficiency of solar has more than doubled in that same period and the cost has declined by approximately five-fold. Even though direct subsidies have expired, the dramatic reduction in costs along with tax credits and accelerated depreciation (for private, third-party owners of solar assets) have allowed solar to compete on a cost per kilowatt-hour (kWh) basis with conventional generating technology.

In 2016, the Agency applied for an Interconnection Agreement (IA) with Pacific Gas and Electric (PG&E) to allow the Agency to export power from their existing on-site cogeneration system. The IA application was filed in anticipation of the Agency producing excess electricity (net of on-site use) from enhanced biogas production. The new IA is anticipated to be in place in early 2018.

4.0 SITE CHARACTERISTICS

This section describes the site characteristics noted during the on-site assessment as well as subsequent review of building drawings. The assessment focused on the following site characteristics for determining the feasibility of solar.

4.1 Solar Insolation

Solar insolation is the measure of solar radiation (measured in energy per unit area) received on a given surface in a given time. The Agency's WWTP is situated in an area with relatively high solar insolation making it conducive to generating solar energy. According to the SolarAnywhere® from Clean Power for San Rafael, CA, the average daily insolation on a horizontal surface is 4.93 kWh/m2/day. The solar insolation across the continental US ranges from 3.4 to 5.4 kWh/m2/day. In the San Francisco Bay Area, comparable solar insolation values include Oakland: 4.63 kWh/m2/day; San Francisco: 4.75 kWh/m2/day; Concord 4.85 kWh/m2/day; and San Jose 4.95 kWh/m2/day. Table 9.1 shows the monthly average daily insolation at the WWTP.

4.2 Site Shading

The WWTP site has minimal shading obstructions in the area available for solar PV arrays. The parking lot areas are free from shading obstructions other than the trees that will have to be removed to accommodate parking canopy structures. The roof of the administration and maintenance building and are shade free as is the vegetated area south and west of the effluent pond.

Table 9.1 Solar Insolation at the WWTP 2017 Facilities Master Plan Central Marin Sanitation Agency	
Location	**San Rafael, CA**
Latitude (deg N)	37.95
Longitude (deg W)	-122.55
Month	**Horizontal Solar Radiation (kWh/m^2/day)**
January	2.13
February	2.78
March	4.86
April	5.92
May	7.11
June	7.38
July	7.74
August	6.97
September	5.83
October	3.92
November	2.63
December	1.93
Average Annual	**4.93**

4.3 Electrical System Capacity

PG&E provides electrical service to the WWTP site through a PG&E-owned transformer with power arriving at 12 kV and subsequently stepped down to 480 kV. The interconnection point (main switchgear bus) is located in the switchgear building and has a rated capacity of 3000 A. At present, the main switchgear bus has sufficient capacity to accommodate approximately 500 kW of solar. In addition, it may be possible to interconnect the solar array(s) into the nearest motor control center (MCC). The MCC location most likely to be used for interconnection includes MCCs 2.1 and 3.1 which are located in the Control Building and Maintenance Building, respectively, and MCCs 8.1 and 8.2, which are located near the Secondary Clarifiers. Interconnecting at the electrical subpanel in MCC 2.1 yields approximately 50 kW of capacity, MCC 3.1 has 110 kW of capacity, and MCCs 8.1 and 8.2 have 220 kW of capacity each. Each MCC may be able to accommodate additional solar capacity if interconnection occurs at the feeder tap. The solar generation being analyzed in this TM will be used for on-site use only and will not be fed into the grid in any manner including net metering. Incorporating solar electricity into the existing electrical infrastructure does not appear to require modifications to the Interconnection Agreement that is being finalized in early 2018. Further discussions with PG&E regarding interconnection are recommended prior to moving forward with any on-site solar implementation.

4.4 Roof Structure and Composition

The Control Building and the Maintenance Building have standing seam metal roofs. During the site visit on September 27, 2017 the Agency stated that the roof was nearing 30 years old and at this age should be replaced prior to solar PV installation as removal and installation of the system to accommodate roof replacement would be cost prohibitive. If considering a roof mounted solar array, the Agency should complete it following roof replacement and consult the roofing installation contractor and/or holder of the roof warranty prior to installation of any PV system to ensure the integrity of the roof and any existing warranties on the roof would not be voided. Solar PV systems installed on standing seam metal roofs are typically attached to the seam and require no roof penetrations.

Most roof structures have adequate capacities to carry the additional weight of a PV system. A licensed structural engineer should field-verify the existing framing and calculations to ensure there is sufficient structural capacity to carry the additional loads imparted by a PV system.

5.0 SOLAR PV PERFORMANCE

5.1 Solar Array Layout

Based on the site walk and review of aerial imagery and prior studies, the team identified the main areas that could host solar PV. The key criteria for areas hosting a solar PV array include areas with no future planned use and no impact on current or future operations; orientation to the south to southwest; sufficient space to achieve economies of scale (>5,000 sq ft); and unobstructed (no shading constraints). Areas that met these criteria include: the parking lot, the roof top of the Control Building and Maintenance Building, and the strip of land west and south of the effluent pond. Other areas that were considered but deemed infeasible include the effluent pond (support structure would be too costly), the corporation yard (plant operational constraints), and the new maintenance shed in the southeast corner (roof top too small for cost effective array). The areas identified for solar PV arrays are shown in the Figure 9.1 with close up of the areas shown in Figures 9.2 and 9.3.

The parking area would host solar canopies similar to ones shown in Figure 9.4 and the Control and Maintenance roof would be fitted with an array similar to that shown in Figure 9.5.

The area adjacent to the effluent pond would accommodate a ground mount array similar to that shown in Figure 9.6.

The locations deemed suitable for solar PV are spread over four parking lot canopies, two building rooftops, and a ground mounted array. The approximate array sizes are described in Table 9.2.

SOLAR PV LOCATIONS

FIGURE 9.1

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2017 FACILITIES MASTER PLAN

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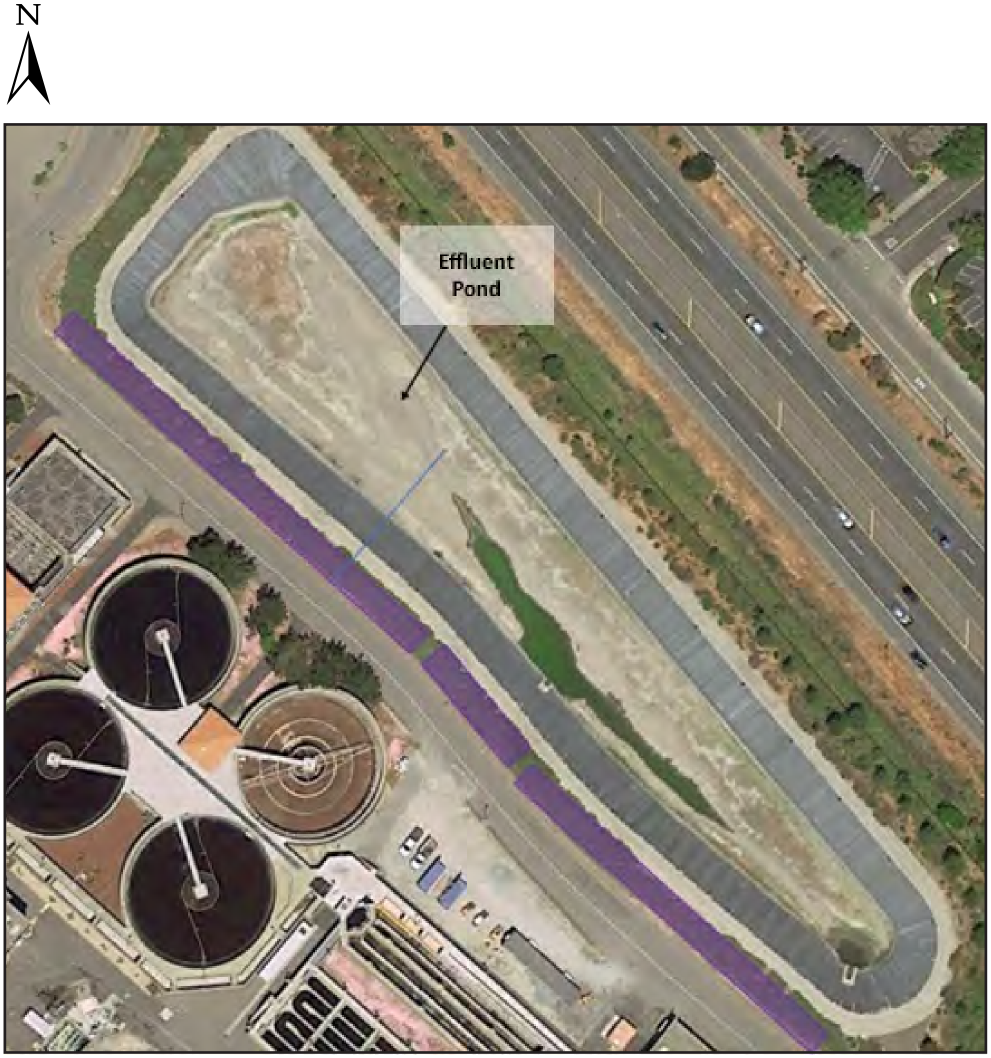
MAINTENANCE AND CONTROL BUILDINGS AND PARKING LOT SOLAR AREAS

FIGURE 9.2

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN



LEGEND
Solar Areas

EFFLUENT POND SOLAR AREAS

FIGURE 9.3

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Photo Courtesy of Sun Sentinel

TYPICAL SOLAR CANOPY IN PARKING LOT

FIGURE 9.4

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Photo Courtesy of Mid South Construction

TYPICAL ROOFTOP SOLAR ON STANDING SEAM METAL ROOF LOT

FIGURE 9.5

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

cmsa1017rf6-10405.ai

Photo Courtesy of Solar Panel Talk

TYPICAL GROUND MOUNT SOLAR

FIGURE 9.6

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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Table 9.2 Solar Array Description and Estimated Capacity 2017 Facilities Master Plan Central Marin Sanitation Agency			
Array	**Description**	**Area (sq ft)**	**Est PV Capacity (kW-DC)**
Array 1	Parking Canopies (4 total)	15,600	220
Array 2	Roof Top (Control and Maintenance Buildings)	8,600	100
Array 3	Ground Mount by Effluent Pond	13,000	180
Total		**37,100**	**500**

Based on the available parking lot and roof and ground area, after shading and obstructions are taken into account, the total available solar capacity is estimated to be 500 kW. The Agency has a limit of exporting no more than 25 percent of annual on-site demand, which equates to approximately 1,350,000 kWh/year or the equivalent of 900 kW of solar PV capacity. The maximum solar PV system being considered is well within this export limitation. The final designed capacity will vary depending on the exact panel layout and specific solar module selected.

5.2 PV System Scenarios

The optimal PV system size will depend on the priorities of the Agency. Priorities could include maximizing export of renewable electricity from the WWTP and increasing the visibility of on-site renewable energy. For this TM, the following PV system scenarios were evaluated:

5.2.1 Scenario 1: Roof Top Array (100 kW)

This scenario represents the simplest configuration for generating solar electricity for the Agency as roof-top systems require the least mounting and racking hardware. The primary drawback for this array is that the roofs of the Control and Maintenance Buildings are nearing the end of their useful lives and it is likely that within the lifetime of the solar PV system that the roofs would have to be replaced. This scenario assumes the panels are removed in Year 10 in order to replace the roof and reinstalled following replacement at an estimated cost of $50,000. The closest interconnection point is MCC 3.1 which has sufficient capacity for this system size.

5.2.2 Scenario 2: Ground Mount Array (180 kW)

This scenario consists of a ground mount system (adjacent to the effluent pond) that provides a large solar array on an unutilized area without any apparent constraints. The area adjacent to the effluent pond suits this system well because it is well oriented to the southwest and the ground has an existing gradient that will minimize racking structure. In addition, this array is located closest to the interconnection point which is in the Switchgear Building. Interconnection can also take place at MCC 8.1 and/or 8.2. Both MCCs have sufficient capacity to accommodate this system.

5.2.3 Scenario 3: Canopy Array (220 kW)

This scenario consists of the canopy mounted array located in the parking lot northeast of the Control and Maintenance Buildings. This system would provide desired shading in the parking lot and prominently display renewable energy generation on-site. However, this system has the added cost of new canopy structures which makes it the least cost-effective layout. In addition, further investigation is required to determine whether the nearest MCCs (2.1 and 3.1) have sufficient capacity to accommodate this system size.

5.2.4 Scenario 4: Maximum System Size (500 kW)

This scenario provides the maximum system size, and combines all the above arrays (roof top, ground mount, and parking canopy arrays.

5.3 Incentives and Grants

Federal tax incentives for solar PV are available if the solar PV system is owned and operated by a private, third party. These incentives include the 30 percent Investment Tax Credit (ITC) the Modified Accelerated Cost Recovery System (MACRS), which provides for a five-year depreciation schedule of renewable energy assets. Section 48 of the Internal Revenue Code provides for a 30 percent Investment Tax Credit of the "basis" of eligible property that a company places in service through 2019. Basis is generally the cost of the property and, in certain circumstances, may also include a capitalized portion of other costs related to buying or developing the property (e.g., permitting, engineering, and interest during construction). For example, if gross eligible project costs or "basis" were $1,000,000, the solar ITC would be 30 percent of the cost basis of $1,000,000, or $300,000.

The MACRS is a permanent tax benefit that was established in 1986. It is a method of depreciation in which a business' investments in certain tangible property are recovered, for tax purposes, over a specified time period through annual deductions. Qualifying renewable energy equipment is eligible for an attractive cost recovery period of five years, far shorter than its 25- to 30-year useful life in the case of solar. This acceleration of cost recovery has a financial benefit to entities with taxable income.

There are presently no available state, local, or utility incentives available for solar. In addition, since this analysis assumes Agency ownership of solar, ITC and MACRS depreciation are not incorporated into the financial analysis.

5.4 System Performance

The analysis utilizes PVWatts to model the solar PV system generation and a proprietary spreadsheet model developed by MDB Engineers to perform financial modeling. PVWatts is a solar PV specific model developed by the National Renewable Energy Laboratory (NREL) that estimates electricity production from a specified solar layout. The inputs to PVWatts include location, solar PV components, and system layout. The inputs to the spreadsheet model include system production, analysis period, system cost, discount rate, and available incentives/credits. The analysis assumes that the Agency would own and operate the solar system and the electricity generated would be used to offset the consumption of co-generation sourced electricity allowing it to be sold to MCE through a feed-in-tariff. In addition, system cost estimates do not include the cost of interconnecting the solar generation system with the Agency's electrical system or PG&E's grid. The following assumptions were incorporated into the spreadsheet model:

Financial Assumptions:

- Analysis Period: 20 years.
- System Cost: $1.70/W-DC (roof top); $1.90/W-DC (ground mount); $3.00/W-DC (canopy).
- Operation and Maintenance Cost: $20/kW-year.
- Roof top system removal and reinstallation (in Year 10): $50,000.
- Discount Rate: 5 percent.
- MCE Feed-in-tariff (FIT): $0.105/kWh.
- FIT escalation rate: 0 percent/year.
- Business Investment Tax Credit (ITC): N/A.
- MACRS Depreciation: N/A.
- State/Local Incentives: None.

Performance Assumptions:

- System Performance Degradation: 0.5 percent per year.

Table 9.3 summarizes the modeling results for the Solar PV System scenarios using the assumptions listed above. This table includes the following information:

- Estimated cost: Capital cost of installation (does not include operation and maintenance (O&M)).
- System Capacity (kW): Nameplate capacity of system.
- Year 1 output (kWh): Estimated output of the system in first year of operation.
- Average annual cash flow: Average cash flow over the 20-year analysis period.
- 20-year net present value (NPV): Discounted value of the sum of annual cash flow over the 20-year analysis period.

- Benefit-cost ratio: Ratio of the undiscounted sum of benefits (FIT value) divided by undiscounted sum of costs (capital and O&M) over 20 year analysis period.

Table 9.3 Solar Scenario Performance – Agency Ownership
2017 Facilities Master Plan
Central Marin Sanitation Agency

Scenario/System Description	Estimated Cost	System Capacity (kW)	Year 1 Output (kWh)	Average Annual Cash Flow	20-year Net Present Value (NPV)	Benefit-Cost Ratio
Scenario 1: Rooftop Only	$175,000	100	150,000	$(3,700)	$(63,400)	0.73
Scenario 2: Ground Mount System	$345,000	180	277,000	$(5,000)	$(82,700)	0.79
Scenario 3: Canopy Mount System	$655,000	220	327,000	$(23,700)	$(429,600)	0.44
Scenario 4: Maximum System Size	$1,175,000	500	754,000	$(29,200)	$(513,300)	0.63

The analysis indicates that Scenario 1, the rooftop only (100 kW) solar PV system, has the second highest benefit-cost ratio despite having the lowest capital cost ($/kW). This configuration has the lowest initial capital cost since it does not require the additional structures for ground mount and canopy systems. However, the analysis includes the cost of removing and reinstalling the system in Year 10 as a result of a projected need for roof replacement of the Control and Maintenance Buildings due to the age of the existing roofs.

Scenario 2, the ground mount system (180 kW), provides the highest benefit-cost ratio. This system also has minimal implementation constraints (i.e., there is no contingent activity required to allow installation).

Scenario 3, the canopy system (220 kW), provides the lowest benefit cost ratio as the added cost of the canopy structure leads to the highest first cost ($/kW).

Scenario 4, the maximum system size (500 kW), has the second lowest benefit-cost ratio as the additional cost of the canopy structures dilutes the value of the roof-top and ground mount systems.

All four scenarios analyzed have a benefit-cost ratio of less than one and a negative net present value (NPV), which indicates that Agency owned solar is presently not economic for implementation. Details of the economic analysis for Scenarios 1 to 4 are included in Appendix A.

However, if the Agency were to consider third-party ownership of the solar system, it is possible (but not certain) that the cost of solar electricity under a power purchase agreement (PPA) from a third-party could be less than the value of exporting excess co-generation electricity to the grid through the MCE FIT ($0.105/kWh). PPAs for system sizes less than 500 kW require higher rates to offset the transaction costs which are typically fixed regardless of system size. Since cost of capital and deal structure may vary among developers serving commercial space ranging from 100 kW to 1 MW, it is difficult to model with any degree of accuracy a projected PPA price. The best case scenario involves implementing the most cost-effective portions of the project (ground mount and roof top system) with a developer specializing in PPAs for smaller system sizes. Table 9.4 shows the best case scenario with a third party PPA priced at $0.095/kWh (0% escalator) compared to the same system in an Agency owned scenario.

Table 9.4 Solar Scenario Performance – Third Party Ownership
2017 Facilities Master Plan
Central Marin Sanitation Agency

Scenario/System Description	Estimated Cost	System Capacity (kW)	Year 1 Output (kWh)	Average Annual Cash Flow	20-year Net Present Value (NPV)	Benefit-Cost Ratio
Scenario 1: Rooftop and Ground Mount Third Party PPA	$0.095/kWh	280	427,000	$3,100	$59,700)	1.07
Scenario 2: Rooftop and Ground Mount – Agency owned	$520,000	280	427,000	$(8,800)	$(146,100)	0.76

The best case third-party owned system produces a positive cash flow and 20-year NPV as well as a benefit-cost ratio greater than 1. This compares favorably to the Agency owned scenario with negative cash flow and 20-year NPV and benefit cost ratio less than 1. This best case assumes the developer is able to efficiently allocate the tax benefits and maintain low transaction costs in order to deliver a PPA rate below the MCE FIT rate. Details of the economic analysis for Scenarios 1 and 2 are included in Appendix B.

Another potential option is for the Agency to lease land or collect royalties from a developer looking to generate renewable electricity and sell directly to the grid under a separate interconnection agreement. This option would only be feasible with a private, third-party developer able to monetize the investment tax credit and MACRS accelerated depreciation. This arrangement would not impact the Agency’s interconnection agreement that is being finalized as it would be a separate agreement between the developer and the utility. Lease payments are typically around $1,000/acre-year.

Accordingly, the Agency may wish to consider issuing a Request for Proposals (RFP) to determine if private firms can offer an attractive solar project. This should be done soon because the available tax credits decline each year based on when construction begins, as follows: through 2019 - 30%; through 2020 - 26%; through 2021 - 22%; and through 2022 - 10%. Construction must be completed by 2023 to qualify for the tax credits greater than 10%.

APPENDIX A - SOLAR SCENARIO WITH AGENCY OWNERSHIP ECONOMIC ANALYSIS

Economic Analysis: CMSA Roof Top Mount (Scenario 1)	100 kw									
Discount Rate	5.00%									
Turn-key PV Plant Cost	$174,624									
Solar reinstall following roof replacement	$ 50,000									
	1	2	3	4	5	6	7	8	9	10
Annual Energy Production	150,000	149,250	148,504	147,761	147,022	146,287	145,556	144,828	144,104	143,383
Energy offset	150,000	149,250	148,504	147,761	147,022	146,287	145,556	144,828	144,104	143,383
	0	0	0	0	0	0	0	0	0	0
MCE FIT rate	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105
	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Benefits	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
MCE FIT value	$15,750	$15,671	$15,593	$15,515	$15,437	$15,360	$15,283	$15,207	$15,131	$15,055
Net metering savings	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Benefits	$15,750	$15,671	$15,593	$15,515	$15,437	$15,360	$15,283	$15,207	$15,131	$15,055
Costs										
Finance Payment	$14,012	$14,012	$14,012	$14,012	$14,012	$14,012	$14,012	$14,012	$14,012	$14,012
Operations and Maintenance	$1,500	$1,530	$1,561	$1,592	$1,624	$1,656	$1,689	$1,723	$1,757	$51,793
Insurance	$873	$891	$908	$927	$945	$964	$983	$1,003	$1,023	$1,043
Recapitalization (Inverter Replacement Years 15 and 30)										
Annual Costs	$16,385	$16,433	$16,481	$16,531	$16,581	$16,632	$16,685	$16,738	$16,793	$66,848
Annual Cash Flows	-$635	-$762	-$888	-$1,016	-$1,144	-$1,272	-$1,401	-$1,531	-$1,662	-$51,793
Cumulative Cash Flows	-$635	-$1,397	-$2,285	-$3,301	-$4,445	-$5,717	-$7,118	-$8,650	-$10,312	-$62,105

20-Year Analysis Results	
Real Value of Lifecycle Cash Flow ($2017)	$ (112,429)
NPV of lifecycle cash flow	$ (63,417)
Average Annual Cash Flow ($2017)	$ (3,748)
Years to Cash Flow Positive	
NPV of Costs	$ 263,296
NPV of kWh	2,184,345
Levelized Cost of Energy	$ 0.1205
Return on Investment	-
Benefit-Cost Ratio	0.73

11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**TOTAL 20 YEARS**
142,667	141,953	141,243	140,537	139,835	139,135	138,440	137,747	137,059	136,373	2,861,686
142,667	141,953	141,243	140,537	139,835	139,135	138,440	137,747	137,059	136,373	
0	0	0	0	0	0	0	0	0	0	
$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	
$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	
2027	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	
$14,980	$14,905	$14,831	$14,756	$14,683	$14,609	$14,536	$14,463	$14,391	$14,319	$300,477
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$14,980	$14,905	$14,831	$14,756	$14,683	$14,609	$14,536	$14,463	$14,391	$14,319	$300,477
$14,012	$14,012	$14,012	$14,012	$14,012	$14,012	$14,012	$14,012	$14,012	$14,012	$280,246
$1,828	$1,865	$1,902	$1,940	$1,979	$2,019	$2,059	$2,100	$2,142	$2,185	$86,446
$1,064	$1,086	$1,107	$1,129	$1,152	$1,175	$1,199	$1,223	$1,247	$1,272	$21,215
				$25,000						$25,000
$16,905	$16,963	$17,022	$17,082	$42,144	$17,206	$17,270	$17,335	$17,402	$17,469	$412,906
-$1,925	-$2,058	-$2,191	-$2,326	-$27,461	-$2,597	-$2,734	-$2,872	-$3,011	-$3,150	-$112,429
-$64,030	-$66,088	-$68,279	-$70,605	-$98,066	-$100,663	-$103,397	-$106,268	-$109,279	-$112,429	-$151,042

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Economic Analysis: CMSA Ground Mount (Scenario 2) 180 kW

Discount Rate 5.00%

Turn-key PV Plant Cost $344,736

	1	2	3	4	5	6	7	8	9	10
Annual Energy Production	277,000	275,615	274,237	272,866	271,501	270,144	268,793	267,449	266,112	264,781
Energy offset	277,000	275,615	274,237	272,866	271,501	270,144	268,793	267,449	266,112	264,781
	0	0	0	0	0	0	0	0	0	0
MCE FIT rate	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105
	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Benefits	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
MCE FIT value	$29,085	$28,940	$28,795	$28,651	$28,508	$28,365	$28,223	$28,082	$27,942	$27,802
Net metering savings	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Benefits	$29,085	$28,940	$28,795	$28,651	$28,508	$28,365	$28,223	$28,082	$27,942	$27,802
Costs										
Finance Payment	$27,663	$27,663	$27,663	$27,663	$27,663	$27,663	$27,663	$27,663	$27,663	$27,663
Operations and Maintenance	$2,700	$2,754	$2,809	$2,865	$2,923	$2,981	$3,041	$3,101	$3,163	$3,227
Insurance	$1,724	$1,758	$1,793	$1,829	$1,866	$1,903	$1,941	$1,980	$2,020	$2,060
Recapitalization (Inverter Replacement Years 15 and 30)										
Annual Costs	$32,086	$32,175	$32,265	$32,357	$32,451	$32,547	$32,644	$32,744	$32,846	$32,949
Annual Cash Flows	-$3,001	-$3,235	-$3,470	-$3,706	-$3,943	-$4,181	-$4,421	-$4,662	-$4,904	-$5,147
Cumulative Cash Flows	-$3,001	-$6,236	-$9,706	-$13,412	-$17,356	-$21,537	-$25,958	-$30,620	-$35,524	-$40,671

30-Year Analysis Results		
Real Value of Lifecycle Cash Flow ($2017)	$	(150,853)
NPV of lifecycle cash flow	$	(82,733)
Average Annual Cash Flow ($2017)	$	(5,028)
Years to Cash Flow Positive		
NPV of Costs	$	452,038
NPV of kWh		4,033,757
Levelized Cost of Energy	$	0.1121
Return on Investment		-
Benefit-Cost Ratio		0.79

11	12	13	14	15	16	17	18	19	20	TOTAL 20 YEARS
263,458	262,140	260,830	259,525	258,228	256,937	255,652	254,374	253,102	251,836	5,284,579
263,458	262,140	260,830	259,525	258,228	256,937	255,652	254,374	253,102	251,836	
0	0	0	0	0	0	0	0	0	0	
$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	
$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	
2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	
$27,663	$27,525	$27,387	$27,250	$27,114	$26,978	$26,843	$26,709	$26,576	$26,443	$554,881
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$27,663	$27,525	$27,387	$27,250	$27,114	$26,978	$26,843	$26,709	$26,576	$26,443	$554,881
$27,663	$27,663	$27,663	$27,663	$27,663	$27,663	$27,663	$27,663	$27,663	$27,663	$553,250
$3,291	$3,357	$3,424	$3,493	$3,563	$3,634	$3,707	$3,781	$3,856	$3,933	$65,603
$2,101	$2,143	$2,186	$2,230	$2,274	$2,320	$2,366	$2,414	$2,462	$2,511	$41,881
				$45,000						$45,000
$33,055	$33,163	$33,273	$33,385	$78,499	$33,616	$33,735	$33,857	$33,981	$34,107	$705,734
-$5,392	-$5,638	-$5,886	-$6,135	-$51,386	-$6,638	-$6,892	-$7,147	-$7,405	-$7,664	-$150,853
-$46,063	-$51,701	-$57,586	-$63,721	-$115,107	-$121,745	-$128,637	-$135,784	-$143,189	-$150,853	-$150,853

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Economic Analysis: CMSA Canopy Mount (Scenario 3) 220 kW

Discount Rate 5.00%

Turn-key PV Plant Cost $655,200

	1	2	3	4	5	6	7	8	9	10
Annual Energy Production	277,000	275,615	274,237	272,866	271,501	270,144	268,793	267,449	266,112	264,781
Energy offset	277,000	275,615	274,237	272,866	271,501	270,144	268,793	267,449	266,112	264,781
	0	0	0	0	0	0	0	0	0	0
MCE FIT rate	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105
	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Benefits	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
MCE FIT value	$29,085	$28,940	$28,795	$28,651	$28,508	$28,365	$28,223	$28,082	$27,942	$27,802
Net metering savings	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Benefits	$29,085	$28,940	$28,795	$28,651	$28,508	$28,365	$28,223	$28,082	$27,942	$27,802
Costs										
Finance Payment	$52,575	$52,575	$52,575	$52,575	$52,575	$52,575	$52,575	$52,575	$52,575	$52,575
Operations and Maintenance	$3,300	$3,366	$3,433	$3,502	$3,572	$3,643	$3,716	$3,791	$3,866	$3,944
Insurance	$3,276	$3,342	$3,408	$3,477	$3,546	$3,617	$3,689	$3,763	$3,838	$3,915
Recapitalization (Inverter Replacement Years 15 and 30)										
Annual Costs	$59,151	$59,282	$59,417	$59,553	$59,693	$59,835	$59,981	$60,129	$60,280	$60,434
Annual Cash Flows	-$30,066	-$30,343	-$30,622	-$30,903	-$31,185	-$31,470	-$31,757	-$32,047	-$32,338	-$32,632
Cumulative Cash Flows	-$30,066	-$60,409	-$91,031	-$121,933	-$153,118	-$184,589	-$216,346	-$248,393	-$280,731	-$313,362

30-Year Analysis Results

Real Value of Lifecycle Cash Flow ($2017)	$	(711,398)
NPV of lifecycle cash flow	$	(429,572)
Average Annual Cash Flow ($2017)	$	(23,713)
Years to Cash Flow Positive		
NPV of Costs	$	808,987
NPV of kWh		4,033,757
Levelized Cost of Energy	$	0.2006
Return on Investment		-
Benefit-Cost Ratio		0.44

11	12	13	14	15	16	17	18	19	20	TOTAL 20 YEARS
263,458	262,140	260,830	259,525	258,228	256,937	255,652	254,374	253,102	251,836	5,284,579
263,458	262,140	260,830	259,525	258,228	256,937	255,652	254,374	253,102	251,836	
0	0	0	0	0	0	0	0	0	0	
$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	
$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	
2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	
$27,663	$27,525	$27,387	$27,250	$27,114	$26,978	$26,843	$26,709	$26,576	$26,443	$554,881
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$27,663	$27,525	$27,387	$27,250	$27,114	$26,978	$26,843	$26,709	$26,576	$26,443	$554,881
$52,575	$52,575	$52,575	$52,575	$52,575	$52,575	$52,575	$52,575	$52,575	$52,575	$1,051,499
$4,023	$4,103	$4,185	$4,269	$4,354	$4,441	$4,530	$4,621	$4,713	$4,807	$80,181
$3,993	$4,073	$4,155	$4,238	$4,323	$4,409	$4,497	$4,587	$4,679	$4,773	$79,598
				$55,000						$55,000
$60,591	$60,751	$60,915	$61,082	$116,252	$61,425	$61,602	$61,783	$61,967	$62,155	$1,266,278
-$32,928	-$33,227	-$33,528	-$33,832	-$89,138	-$34,447	-$34,759	-$35,074	-$35,391	-$35,712	-$711,398
-$346,290	-$379,517	-$413,045	-$446,876	-$536,014	-$570,461	-$605,220	-$640,294	-$675,685	-$711,398	-$711,398

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Economic Analysis: CMSA Max size (Scenario 4) 500 kW

Discount Rate 5.00%

Turn-key PV Plant Cost $1,175,000

	1	2	3	4	5	6	7	8	9	10
Annual Energy Production	754,000	750,230	746,479	742,746	739,033	735,338	731,661	728,003	724,363	720,741
Energy offset	754,000	750,230	746,479	742,746	739,033	735,338	731,661	728,003	724,363	720,741
	0	0	0	0	0	0	0	0	0	0
MCE FIT rate	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105
	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Benefits	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
MCE FIT value	$79,170	$78,774	$78,380	$77,988	$77,598	$77,210	$76,824	$76,440	$76,058	$75,678
Net metering savings	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Benefits	$79,170	$78,774	$78,380	$77,988	$77,598	$77,210	$76,824	$76,440	$76,058	$75,678
Costs										
Finance Payment	$94,285	$94,285	$94,285	$94,285	$94,285	$94,285	$94,285	$94,285	$94,285	$94,285
Operations and Maintenance	$7,500	$7,650	$7,803	$7,959	$8,118	$8,281	$8,446	$8,615	$8,787	$58,963
Insurance	$5,875	$5,993	$6,112	$6,235	$6,359	$6,486	$6,616	$6,749	$6,883	$7,021
Recapitalization (Inverter Replacement Years 15 and 30)										
Annual Costs	$107,660	$107,928	$108,200	$108,479	$108,763	$109,052	$109,347	$109,649	$109,956	$160,269
Annual Cash Flows	-$28,490	-$29,153	-$29,820	-$30,490	-$31,164	-$31,842	-$32,523	-$33,208	-$33,898	-$84,592
Cumulative Cash Flows	-$28,490	-$57,643	-$87,464	-$117,954	-$149,118	-$180,960	-$213,483	-$246,691	-$280,589	-$365,181

30-Year Analysis Results

Real Value of Lifecycle Cash Flow ($2017)	$ (875,280)
NPV of lifecycle cash flow	$ (513,283)
Average Annual Cash Flow ($2017)	$ (29,176)
Years to Cash Flow Positive	
NPV of Costs	$ 1,524,804
NPV of kWh	10,979,974
Levelized Cost of Energy	$ 0.1389
Return on Investment	-
Benefit-Cost Ratio	0.63

11	12	13	14	15	16	17	18	19	20	TOTAL 30 YEARS
717,137	713,551	709,984	706,434	702,902	699,387	695,890	692,411	688,949	685,504	14,384,740
717,137	713,551	709,984	706,434	702,902	699,387	695,890	692,411	688,949	685,504	
0	0	0	0	0	0	0	0	0	0	
$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	
$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	
2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	
$75,299	$74,923	$74,548	$74,176	$73,805	$73,436	$73,068	$72,703	$72,340	$71,978	$1,510,398
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$75,299	$74,923	$74,548	$74,176	$73,805	$73,436	$73,068	$72,703	$72,340	$71,978	$1,510,398
$94,285	$94,285	$94,285	$94,285	$94,285	$94,285	$94,285	$94,285	$94,285	$94,285	$1,885,701
$9,142	$9,325	$9,512	$9,702	$9,896	$10,094	$10,296	$10,502	$10,712	$10,926	$232,230
$7,162	$7,305	$7,451	$7,600	$7,752	$7,907	$8,065	$8,226	$8,391	$8,559	$142,747
				$125,000						$125,000
$110,589	$110,915	$111,248	$111,587	$236,933	$112,286	$112,646	$113,013	$113,388	$113,770	$2,385,678
-$35,290	-$35,992	-$36,699	-$37,411	-$163,128	-$38,850	-$39,578	-$40,310	-$41,048	-$41,792	-$875,280
-$400,470	-$436,463	-$473,162	-$510,574	-$673,702	-$712,552	-$752,130	-$792,440	-$833,488	-$875,280	-$875,280

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APPENDIX B - SOLAR SCENARIO WITH THIRD PARTY OWNERSHIP ECONOMIC ANALYSIS

Economic Analysis: Third Party PPA - CMSA Ground Mount and Roof Top 280 kW

Discount Rate 5.00%

Turn-key PV Plant Cost N/A

	1	2	3	4	5	6	7	8	9	10
Annual Energy Production	754,000	750,230	746,479	742,746	739,033	735,338	731,661	728,003	724,363	720,741
Energy offset	754,000	750,230	746,479	742,746	739,033	735,338	731,661	728,003	724,363	720,741
	0	0	0	0	0	0	0	0	0	0
MCE FIT rate	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105
PPA Rate	$0.095	$0.095	$0.095	$0.095	$0.095	$0.095	$0.095	$0.095	$0.095	$0.095
Benefits	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
MCE FIT value	$79,170	$78,774	$78,380	$77,988	$77,598	$77,210	$76,824	$76,440	$76,058	$75,678
Net metering savings	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Benefits	$79,170	$78,774	$78,380	$77,988	$77,598	$77,210	$76,824	$76,440	$76,058	$75,678
Costs										
PPA cost	$71,630	$71,272	$70,915	$70,561	$70,208	$69,857	$69,508	$69,160	$68,814	$68,470
Operations and Maintenance (system removal)		$0	$0	$0	$0	$0	$0	$0	$0	$50,000
Insurance		$0	$0	$0	$0	$0	$0	$0	$0	$0
Recapitalization (Inverter Replacement Years 15 and 30)										
Annual Costs	$71,630	$71,272	$70,915	$70,561	$70,208	$69,857	$69,508	$69,160	$68,814	$118,470
Annual Cash Flows	$7,540	$7,502	$7,465	$7,427	$7,390	$7,353	$7,317	$7,280	$7,244	-$42,793
Cumulative Cash Flows	$7,540	$15,042	$22,507	$29,935	$37,325	$44,678	$51,995	$59,275	$66,519	$23,726

30-Year Analysis Results	
Real Value of Lifecycle Cash Flow ($2017)	$ 93,847
NPV of lifecycle cash flow	$ 59,656
Average Annual Cash Flow ($2017)	$ 3,128
Years to Cash Flow Positive	
NPV of Costs	$ 1,073,793
NPV of kWh	10,979,974
Levelized Cost of Energy	$ 0.0978
Return on Investment	11.80%
Benefit-Cost Ratio	1.07

11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**TOTAL 20 YEARS**
717,137	713,551	709,984	706,434	702,902	699,387	695,890	692,411	688,949	685,504	14,384,740
717,137	713,551	709,984	706,434	702,902	699,387	695,890	692,411	688,949	685,504	
0	0	0	0	0	0	0	0	0	0	
$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	
$0.095	$0.095	$0.095	$0.095	$0.095	$0.095	$0.095	$0.095	$0.095	$0.095	
2027	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	
$75,299	$74,923	$74,548	$74,176	$73,805	$73,436	$73,068	$72,703	$72,340	$71,978	$1,510,398
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$75,299	$74,923	$74,548	$74,176	$73,805	$73,436	$73,068	$72,703	$72,340	$71,978	$1,510,398
$68,128	$67,787	$67,448	$67,111	$66,776	$66,442	$66,110	$65,779	$65,450	$65,123	$1,366,550
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$50,000
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
										$0
$68,128	$67,787	$67,448	$67,111	$66,776	$66,442	$66,110	$65,779	$65,450	$65,123	$1,416,550
$7,171	$7,136	$7,100	$7,064	$7,029	$6,994	$6,959	$6,924	$6,889	$6,855	$93,847
$30,897	$38,033	$45,133	$52,197	$59,226	$66,220	$73,179	$80,103	$86,992	$93,847	$93,847

`

Economic Analysis: Agency owned - CMSA Ground Mount and Roof Top	280	kW								
Discount Rate	5.00%									
Turn-key PV Plant Cost	$519,360									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Annual Energy Production	427,000	424,865	422,741	420,627	418,524	416,431	414,349	412,277	410,216	408,165
Energy offset	427,000	424,865	422,741	420,627	418,524	416,431	414,349	412,277	410,216	408,165
	0	0	0	0	0	0	0	0	0	0
MCE FIT rate	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105
	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Benefits	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
MCE FIT value	$44,835	$44,611	$44,388	$44,166	$43,945	$43,725	$43,507	$43,289	$43,073	$42,857
Net metering savings	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Benefits	$44,835	$44,611	$44,388	$44,166	$43,945	$43,725	$43,507	$43,289	$43,073	$42,857
Costs										
Finance Payment	$41,675	$41,675	$41,675	$41,675	$41,675	$41,675	$41,675	$41,675	$41,675	$41,675
Operations and Maintenance	$4,200	$4,284	$4,370	$4,457	$4,546	$4,637	$4,730	$4,824	$4,921	$55,019
Insurance	$2,597	$2,649	$2,702	$2,756	$2,811	$2,867	$2,924	$2,983	$3,043	$3,103
Recapitalization (Inverter Replacement Years 15 and 30)										
Annual Costs	$48,472	$48,608	$48,746	$48,888	$49,032	$49,179	$49,329	$49,482	$49,638	$99,798
Annual Cash Flows	-$3,637	-$3,997	-$4,358	-$4,722	-$5,087	-$5,454	-$5,822	-$6,193	-$6,566	-$56,940
Cumulative Cash Flows	-$3,637	-$7,633	-$11,992	-$16,713	-$21,800	-$27,254	-$33,077	-$39,270	-$45,835	-$102,776

30-Year Analysis Results		
Real Value of Lifecycle Cash Flow ($2017)	$	(263,282)
NPV of lifecycle cash flow	$	(146,149)
Average Annual Cash Flow ($2017)	$	(8,776)
Years to Cash Flow Positive		
NPV of Costs	$	715,334
NPV of kWh		6,218,102
Levelized Cost of Energy	$	0.1150
Return on Investment		-
Benefit-Cost Ratio		0.76

11	12	13	14	15	16	17	18	19	20	TOTAL 20 YEARS
406,124	404,093	402,073	400,063	398,062	396,072	394,092	392,121	390,161	388,210	8,146,265
406,124	404,093	402,073	400,063	398,062	396,072	394,092	392,121	390,161	388,210	
0	0	0	0	0	0	0	0	0	0	
$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	$0.105	
$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	
2027	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	
$42,643	$42,430	$42,218	$42,007	$41,797	$41,588	$41,380	$41,173	$40,967	$40,762	$855,358
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$42,643	$42,430	$42,218	$42,007	$41,797	$41,588	$41,380	$41,173	$40,967	$40,762	$855,358
$41,675	$41,675	$41,675	$41,675	$41,675	$41,675	$41,675	$41,675	$41,675	$41,675	$833,496
$5,120	$5,222	$5,327	$5,433	$5,542	$5,653	$5,766	$5,881	$5,999	$6,119	$152,049
$3,165	$3,229	$3,293	$3,359	$3,426	$3,495	$3,565	$3,636	$3,709	$3,783	$63,095
				$70,000						$70,000
$49,960	$50,126	$50,295	$50,467	$120,643	$50,822	$51,005	$51,192	$51,382	$51,576	$1,118,640
-$7,317	-$7,696	-$8,077	-$8,461	-$78,846	-$9,235	-$9,626	-$10,019	-$10,415	-$10,814	-$263,282
-$110,093	-$117,788	-$125,866	-$134,326	-$213,173	-$222,408	-$232,033	-$242,052	-$252,468	-$263,282	-$263,282

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM NO. 10
SEA LEVEL RISE

FINAL
October 2018

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CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

TECHNICAL MEMORANDUM
NO. 10
SEA LEVEL RISE

TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF FIGURES

SEA LEVEL RISE

1.0 INTRODUCTION

This technical memorandum (TM) summarizes the review of the Marin Bay Waterfront Adaptation and Vulnerability Evaluation (BayWAVE) project (a vulnerability assessment focused on the eastern Marin shoreline from the Golden Gate Bridge to the county line north of Novato), the proposed scenarios to determine which, if any, will have adverse impacts on Central Marin Sanitation Agency's (Agency) Wastewater Treatment Plant (WWTP) and assets on the Agency's property, and the anticipated timeframe to expect impacts.

This TM also summarizes the hydraulic assessments of the gravity and pumped outfall discharge capacities with respect to the projected rise in sea level. A sensitivity analysis was also conducted on the gravity and pumped outfall capacities with respect to some of the diffuser ports on the outfall potentially getting buried in mud and unable to discharge flow.

2.0 SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

The key findings are:

- The 2030 near-term BayWAVE project scenario, which accounts for sea level rise plus the 100-year flood event, is projected to impact a portion of Andersen Drive that provides access to the Agency's WWTP. Potential flooding to the eastern portion of the WWTP along Interstate 580 is also projected to occur during the 2050 mid-term and 2100 long-term BayWAVE project scenarios. Since the projected flooding under all three BayWAVE project scenarios is to a city roadway, the Agency should meet with the City of San Rafael to discuss what mitigation measures the City will be evaluating to address the potential flooding risk to this and other city roadways.

- A sensitivity analysis was performed on the gravity outfall capacity at current design low and high tide levels with and without the 2030 near-term scenario sea level rise and 100-year flood event:
  - When not accounting for any sea level rise and 100-year flood events, the estimated gravity outfall capacity at the Agency's current design low tide elevation datum of 97.0 feet (Mean Low Low Water (MLLW) tide elevation of -0.3 feet) is approximately 133 million gallons per day (mgd) with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated gravity outfall capacity would reduce to about 132 mgd and 129 mgd, respectively.

- When accounting for the 2030 near-term scenario sea level rise and 100-year flood event of 46 inches above the Agency's current design low tide elevation datum of 97.0 feet (MLLW tide elevation of -0.3 feet), the estimated gravity outfall capacity is approximately 119 mgd with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated gravity outfall capacity would reduce to approximately 117 mgd and 113 mgd, respectively.
- When not accounting for any sea level rise and 100-year flood events, the estimated gravity outfall capacity at the Agency's current design high tide elevation datum of 105.84 feet (MLLW tide elevation of 8.5 feet) with no buried diffusers is approximately 95 mgd. If 30 to 60 diffusers were buried in mud, the estimated gravity outfall capacity would reduce to about 93 mgd and 89 mgd, respectively.
- When accounting for the 2030 near-term scenario sea level rise and 100-year flood event of 46 inches above the Agency's current design high tide elevation datum of 105.84 feet (MLLW tide elevation of 8.5 feet), the estimated gravity outfall capacity is approximately 69 mgd with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated gravity outfall capacity would reduce to approximately 67 mgd and 64 mgd, respectively.

- A sensitivity analysis was performed on the pumped outfall capacity at design high tide with and without the 2030 near-term and 2050 mid-term scenario sea level rise and 100-year flood events:
  - When not accounting for any sea level rise and 100-year flood events, the estimated firm pumped outfall capacity at the Agency's current design high tide elevation datum of 105.84 feet (MLLW tide elevation of 8.5 feet) is approximately 158 mgd with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated firm pumped outfall capacity would reduce to approximately 157 mgd and 156 mgd, respectively.
  - When accounting for the 2030 near-term scenario sea level rise and 100-year flood event of 46 inches above the Agency's current design high tide elevation datum of 105.84 feet (MLLW elevation of 8.5 feet), the estimated firm pumped outfall capacity is approximately 152 mgd with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated firm pumped outfall capacity would reduce to approximately 151 mgd and 149 mgd, respectively.
  - When accounting for the 2050 mid-term scenario sea level rise and 100-year flood event of 76 inches above the Agency's current design high tide elevation datum of 105.84 feet (MLLW elevation of 8.5 feet), the estimated firm pumped outfall capacity is approximately 147 mgd with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated firm pumped outfall capacity would reduce to approximately 146 mgd and 144 mgd, respectively.

3.0 BACKGROUND

The Agency's WWTP was designed in 1981 with an average dry weather flow (ADWF) capacity of 10 mgd and a peak wet weather flow (PWWF) capacity of 90 mgd. The WWTP is located on Andersen Drive within the City of San Rafael near the foot of the western span of the San Rafael Bridge. Secondary treated effluent from the WWTP currently discharges to the San Francisco Bay via an outfall that consists of a land segment of approximately 2,540 feet and a bay segment of approximately 8,380 feet. Figure 10.1 shows the location of the Agency's WWTP and the approximate outfall alignment.

The original discharge capacity of the submerged gravity outfall was designed for approximately 92 mgd during wet weather flows. In 2010, construction was completed on the Wet Weather Improvements Project, which increased the wet weather capacity of the treatment plant to 125 mgd. As part of this project, a new effluent pump station was provided with a firm discharge capacity of more than 155 mgd during wet weather flows to handle flows above the discharge capacity of the gravity outfall.

4.0 SEA LEVEL RISE EVALUATION

4.1 Projection Basis

The BayWAVE project is a vulnerability assessment focused on the eastern Marin shoreline from the Golden Gate Bridge to the county line north of Novato (including the area encompassing the Agency). The goal of the BayWAVE project is to increase awareness and help the shoreline residents plan and prepare for potential future sea level rise impacts due to climate change.

The BayWAVE project selected the U.S. Geological Survey's (USGS) Coastal Storm Modeling System (CoSMoS) to model sea level rise scenarios countywide (i.e., across Marin County). The CoSMoS combines wave models with projected sea level rise to identify areas at risk of flooding. Because of the uncertainty in future greenhouse gas emissions, BayWAVE is the first step in an iterative process that will need to be updated as additional science becomes available and adaptation efforts are implemented.

The BayWAVE project uses CoSMoS to evaluate six different sea level rise scenarios (relative to mean sea levels in 2000). As shown in Table 10.1, these include:

1. Near-term: 2030 sea level rise projection <u>without</u> consideration of the 100-year flood event.
2. Near-term: 2030 sea level rise projection <u>with</u> consideration of the 100-year flood event.
3. Mid-term: 2050 sea level rise projection <u>without</u> consideration of the 100-year flood event.

4. Mid-term: 2050 sea level rise projection with consideration of the 100-year flood event.
5. Long-term: 2100 sea level rise projection without consideration of the 100-year flood event.
6. Long-term: 2100 sea level rise projection with consideration of the 100-year flood event.

Table 10.1 BayWAVE Scenarios Based on USGS CoSMoS
2017 Facilities Master Plan
Central Marin Sanitation Agency

Scenario	Sea Level Rise[1] (Inches)	100-Year Flood Event (Inches)	Sea Level Rise + 100-Year Flood Event (Inches)
1. Near-term: 2030	9.6	36	46
2. Mid-term: 2050	19.2	56	76
3. Long-term: 2100	60	96	156

Note:
(1) The BayWAVE model uses the projected median sea level rise. Projected ranges for the near, mid, and long-term scenarios, which do not include the increased loss of the Antarctic Ice Sheet, which may underestimate sea level rise (Kopp et al., 2014).

4.2 Flooding Impact

The 2017 Facilities Master Plan needs to determine which of the proposed CoSMoS scenarios, if any, will have an adverse impact on the WWTP and in what timeframe.

Figures 10.2 through 10.5 were created using the "Our Coast, Our Future" flood maps based on the CoSMoS output and applied to Marin County's coastline. The tool is publicly available online. The figures are aerials zoomed in on the Agency's WWTP for easy viewing. Figure 10.2 shows an aerial image of the Agency's current facilities and flood-prone areas for reference. Figure 10.3 shows an aerial of the projected flooding from sea level rise only by 2030 (top aerial, the blue shading represents the flooded area and the shade of blue represents the depth of flooding according to the legend) on top of a 100-year flood event (bottom aerial). Figures 10.4 and 10.5 show the same aerials for the mid-term (2050) and long-term (2100) scenarios, respectively.

LOCATION OF THE AGENCY'S WWTP AND OUTFALL

FIGURE 10.1

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

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Based on the aerial maps in the figures when both sea level rise and the 100-year flood event are considered, potential flooding in the 2030 near-term scenario is anticipated to impact only access to the WWTP via Andersen Drive and not the WWTP or its assets. In the 2050 mid-term scenario and the 2100 long-term scenario, potential flooding is also anticipated to impact the eastern portion of the WWTP along Interstate 580. For all scenarios where the projected flooding is to affect Andersen Drive, the Agency should meet with the City of San Rafael to discuss what mitigation measures the city will be evaluating to address the potential flooding risk to this and other city roadways.

5.0 OUTFALL CAPACITY EVALUATION

5.1 Submerged Outfall Inspection

In June 2017, the Agency contracted with Underwater Resources to perform an inspection and repair of an approximately 1,050 foot section of submerged outfall that contains 176 “duckbill” diffusers that are spaced approximately every 6 feet. The inspection found that about 40 diffusers were buried below the Bay floor. A copy of the 2017 Outfall Diffuser and Mudline Record Drawing prepared by the Agency is shown in Appendix A. Although Underwater Resources was able to remove the mud that covered some of the buried diffusers, it is anticipated that these and other diffusers will get covered with mud over time and continue to potentially reduce or eliminate flow out of the buried diffuser ports. Accordingly, a sensitivity analysis was performed to evaluate the gravity and pumped outfall capacities for various tide levels assuming 30 to 60 diffusers are buried in mud and become inoperable.

5.2 Gravity Outfall Capacity

At the Agency’s request, a sensitivity analysis was performed on the capacity of the gravity outfall at current design high and low tide levels with and without the 2030 near-term scenario sea level rise and 100-year flood event.

The gravity outfall capacity was calculated based on the maximum flow that can be conveyed via gravity through the outfall without flooding the RAS box, which occurs when the water surface elevation in the secondary clarifiers reached 114.92 feet. Figure 10.6 presents the impact of the number of buried diffusers have on the capacity of the gravity outfall without flooding the RAS box at the current design low tide elevation of 97.0 feet with and without the 2030 near-term scenario sea level rise and 100-year flood event and the current design high tide elevation of 105.84 feet with and without the 2030 near-term scenario sea level rise and 100-year flood event. For reference purposes, the tide elevations of 97.0 feet and 105.84 feet discussed above have been adjusted to the Agency’s datum, which is equal to the MLLW tide elevation plus 97.34.

AERIAL SHOWING AGENCY'S FACILITY TODAY AND NEARBY FLOOD PRONE AREAS

FIGURE 10.2

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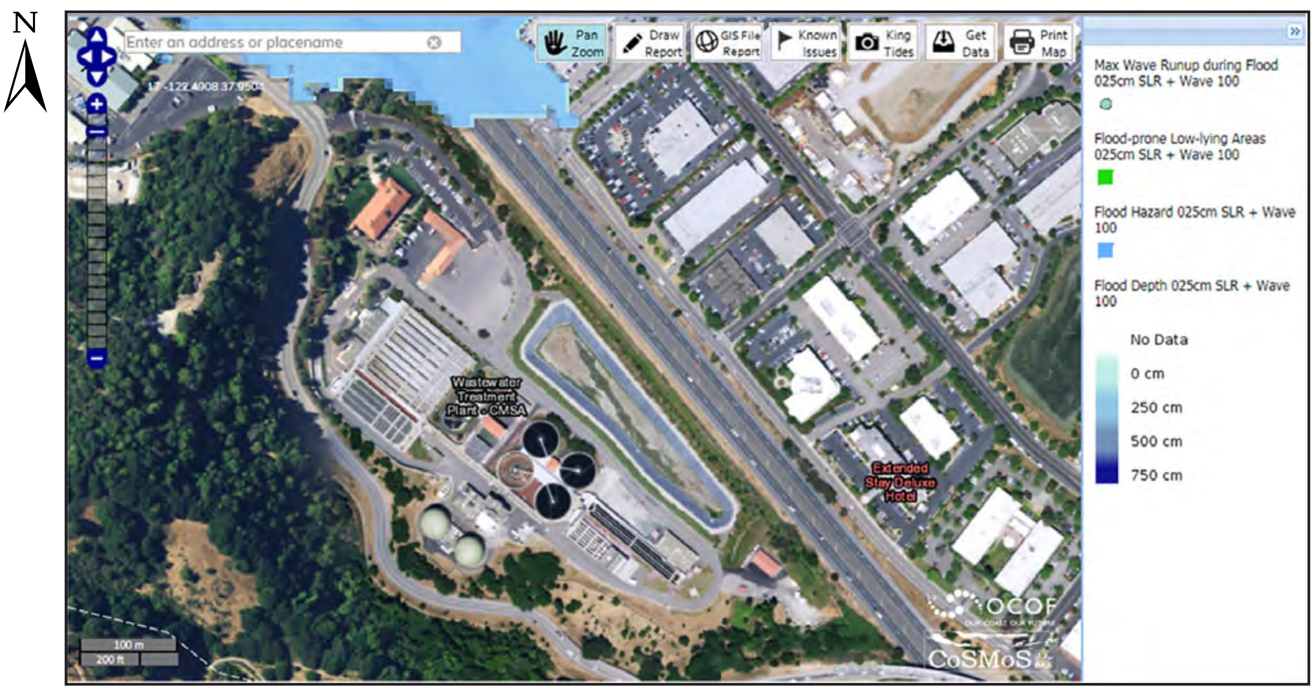
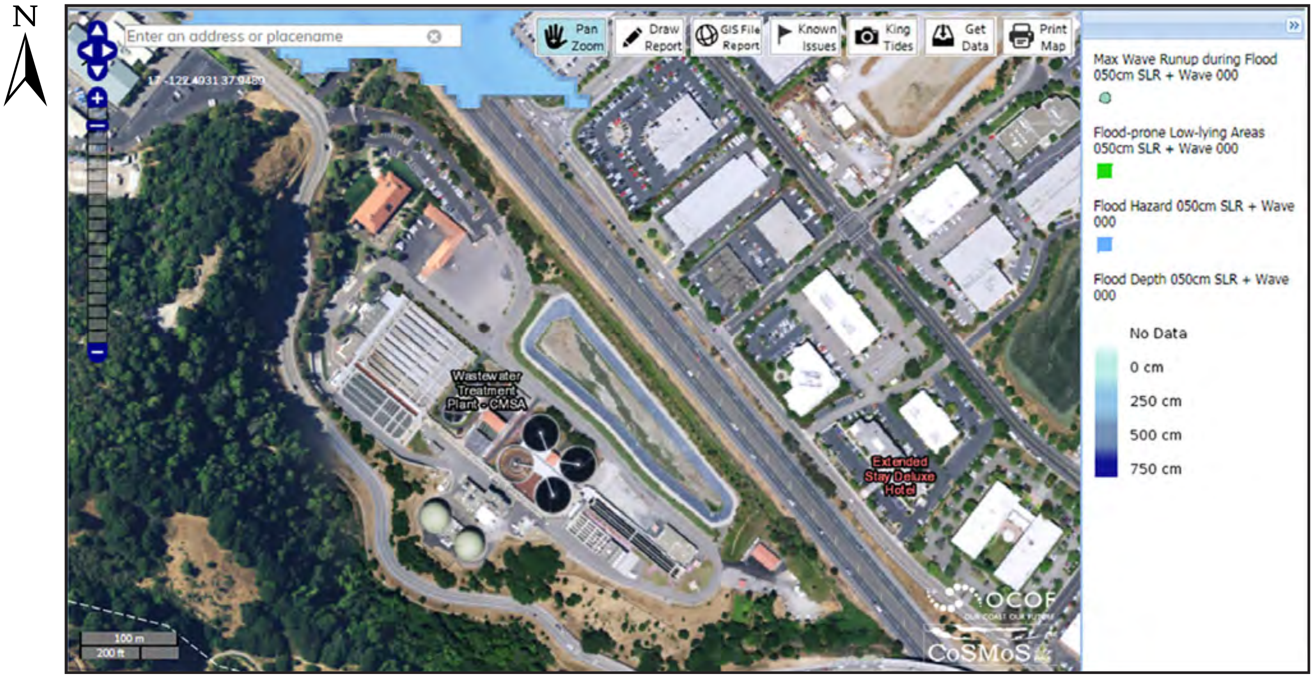
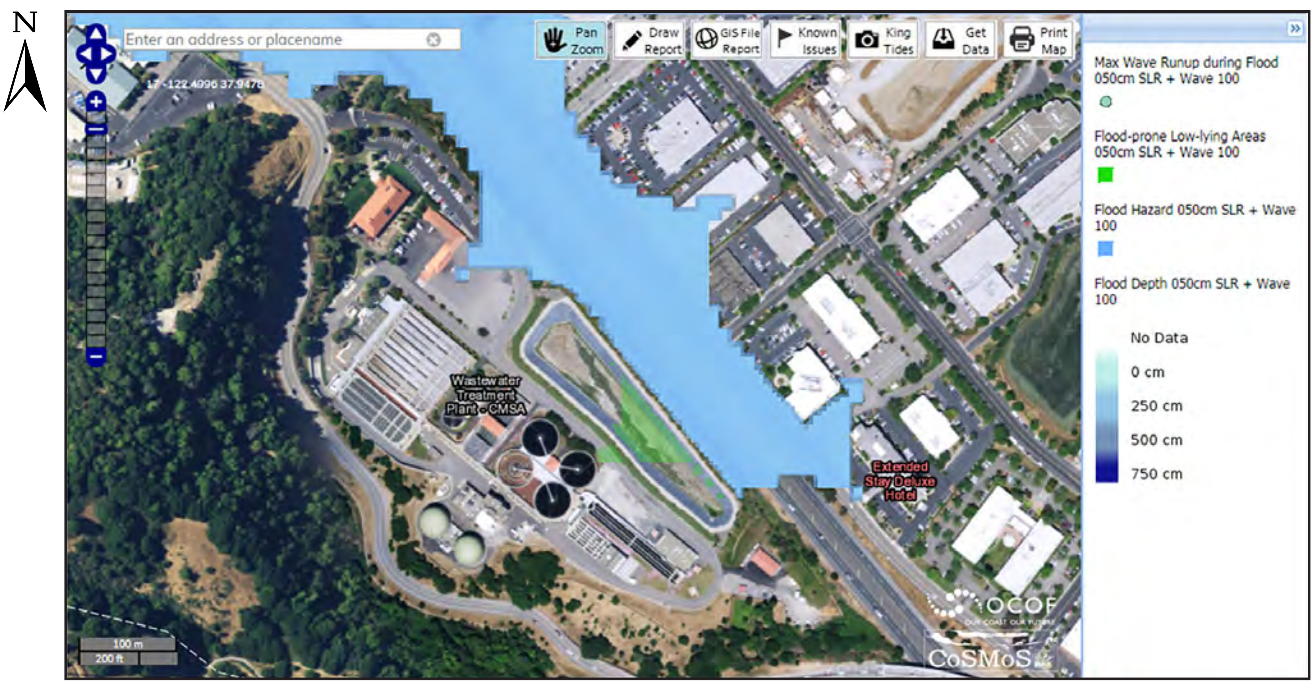


NEAR-TERM POTENTIAL FLOODING CONSIDERING SEA LEVEL RISE ONLY (TOP) AND SEA LEVEL RISE DURING A 100-YEAR FLOOD EVENT (BOTTOM) BY 2030

FIGURE 10.3



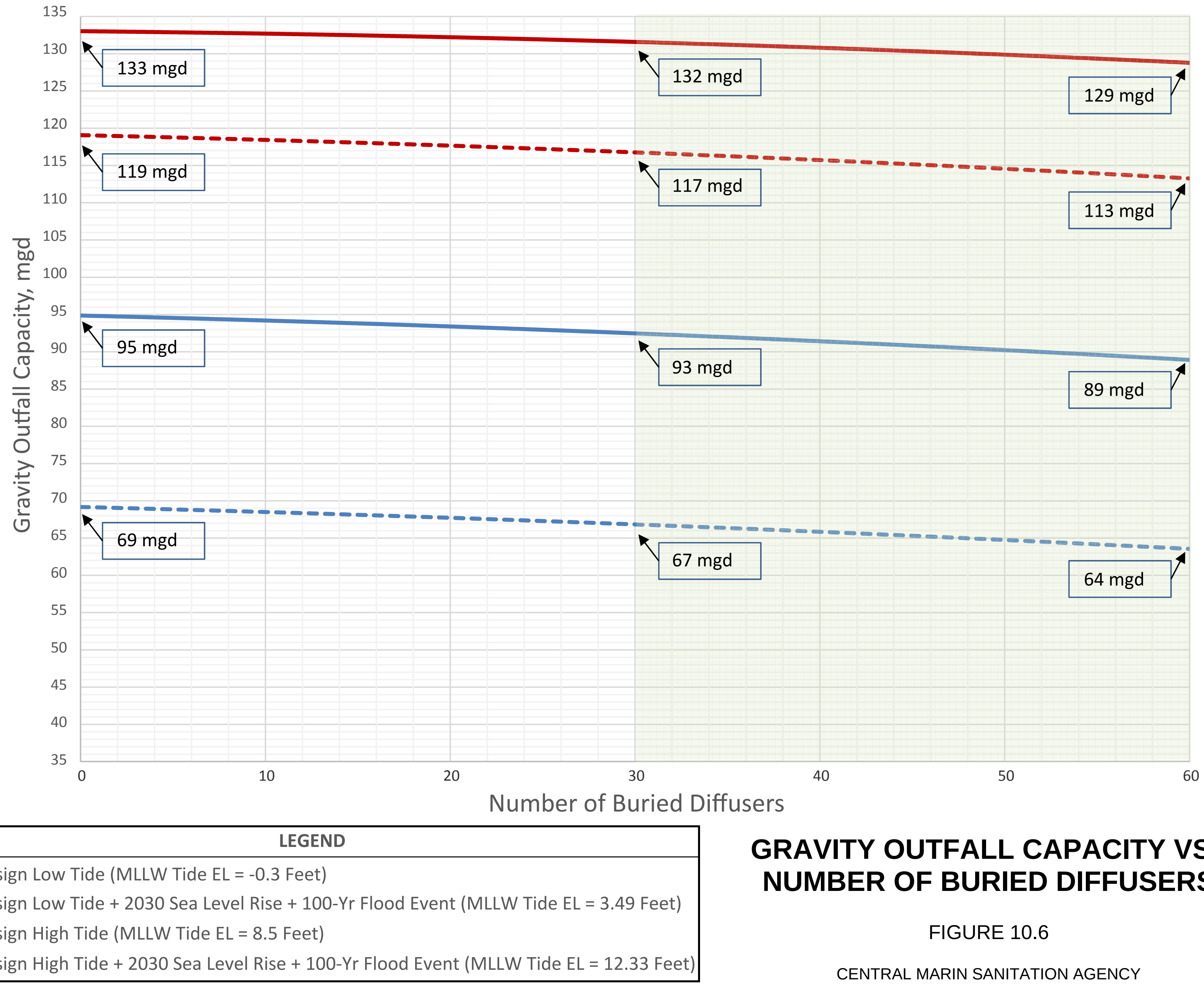


MID-TERM POTENTIAL FLOODING CONSIDERING SEA LEVEL RISE ONLY (TOP) AND SEA LEVEL RISE DURING A 100-YEAR FLOOD EVENT (BOTTOM) BY 2050

FIGURE 10.4

LONG-TERM POTENTIAL FLOODING CONSIDERING SEA LEVEL RISE ONLY (TOP) AND SEA LEVEL RISE DURING A 100-YEAR FLOOD EVENT (BOTTOM) BY 2100

FIGURE 10.5



GRAVITY OUTFALL CAPACITY VS. NUMBER OF BURIED DIFFUSERS

FIGURE 10.6

CENTRAL MARIN SANITATION AGENCY
2017 FACILITIES MASTER PLAN

As presented in Figure 10.6, the estimated gravity outfall capacity at current low tide with no buried diffusers is approximately 133 mgd. If 30 to 60 diffusers were buried in mud, the estimated gravity outfall capacity would reduce to about 132 mgd and 129 mgd, respectively.

When accounting for the 2030 near-term scenario sea level rise and 100-year flood event of 46 inches above the low tide elevation of 97.0 feet, the estimated gravity outfall capacity is approximately 119 mgd with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated gravity outfall capacity would reduce to approximately 117 mgd and 113 mgd, respectively.

Similarly, the estimated gravity outfall capacity at current high tide with no buried diffusers is approximately 95 mgd. If 30 to 60 diffusers were buried in mud, the estimated gravity outfall capacity would reduce to about 93 mgd and 89 mgd, respectively.

When accounting for the 2030 near-term scenario sea level rise and 100-year flood event of 46 inches above the high tide elevation of 105.84 feet, the estimated gravity outfall capacity is approximately 69 mgd with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated gravity outfall capacity would reduce to approximately 67 mgd and 64 mgd, respectively.

Table 10.2 summarizes the results of the gravity outfall capacity analysis.

5.3 Pumped Outfall Capacity

At the Agency's request, a sensitivity analysis was performed on the pumped outfall capacity at design high tide with and without the 2030 near-term and 2050 mid-term scenario sea level rise and 100-year flood events.

The effluent pump station at the WWTP includes a total of five effluent pumps. To estimate the firm hydraulic capacity of the pumped outfall using four effluent pumps, a system-head curve analysis was performed based on an effluent pump station wet well setpoint elevation of 110.00 feet and the submitted pump curve from the pump manufacturer (Prime Pump). Figure 10.7 presents the impact of the number of buried diffusers on the capacity of the pumped outfall at the current design high tide with and without the 2030 near-term and 2050 mid-term scenario sea level rise and 100-year flood events.

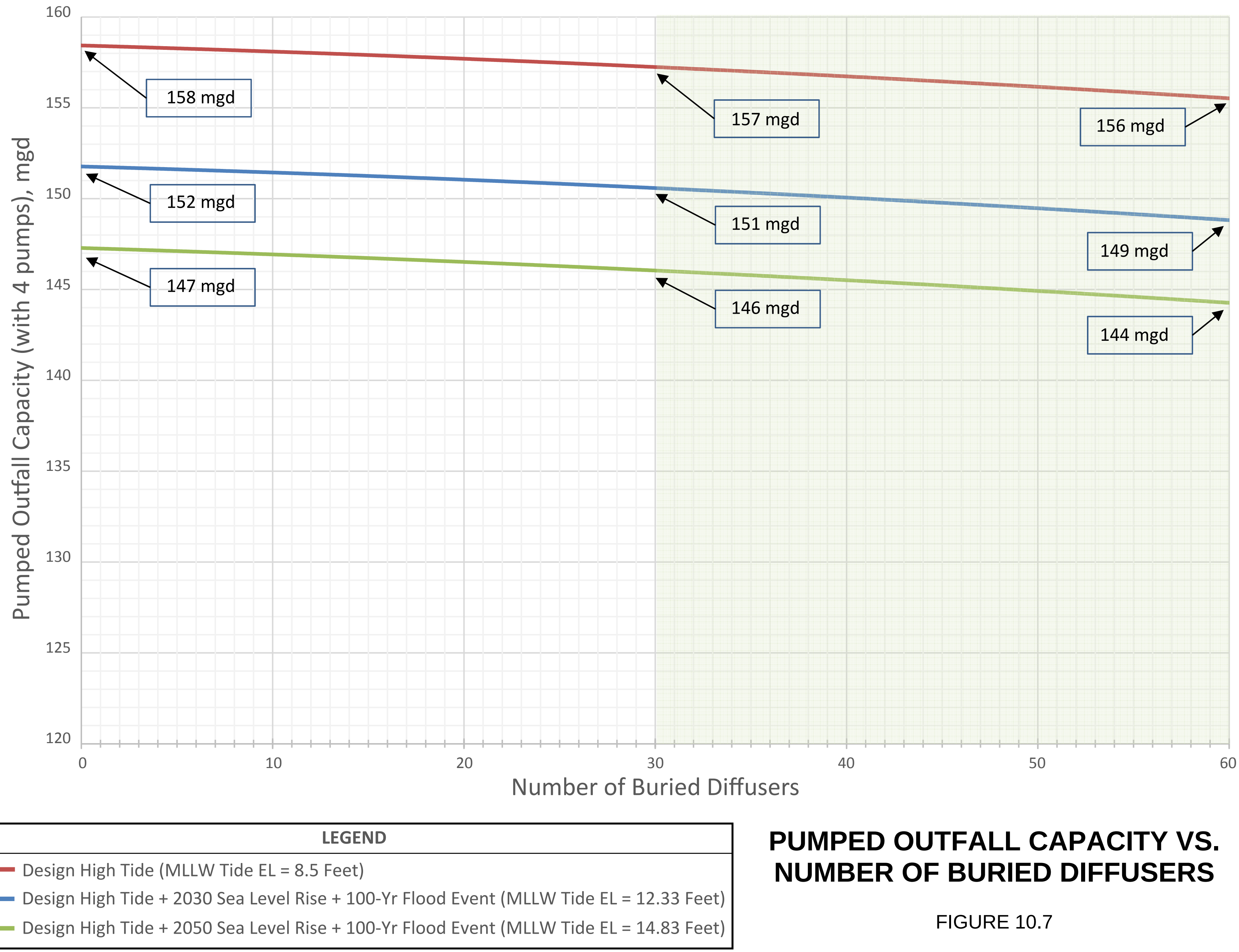
Table 10.2 Gravity Outfall Capacity Analysis
2017 Facilities Master Plan
Central Marin Sanitation Agency

Number of Buried Diffusers	Gravity Outfall Capacity, mgd			
	Design High Tide(1)	Design High Tide + 2030 Sea Level Rise + 100-Yr Flood(2)	Design Low Tide(3)	Design Low Tide + 2030 Sea Level Rise + 100-Yr Flood(4)
0	95.0	69.3	133.0	119.0
10	94.3	68.5	132.8	118.5
20	93.3	67.8	132.3	117.5
30	92.5	66.8	131.5	116.8
40	91.3	65.8	130.8	115.8
50	90.3	64.8	130.0	114.5
60	88.8	63.5	128.8	113.3

Notes:
(1) Based on Agency's design high tide datum of 105.84 feet. This is equal to a MLLW tide elevation of 8.5 feet.
(2) Based on Agency's design high tide datum of 105.84 feet + 2030 near-term scenario sea level rise and 100-year flood event of an additional 46 inches, which equals 109.67 feet. This is equal to a MLLW tide elevation of 12.33 feet.
(3) Based on Agency's design low tide datum of 97.0 feet. This is equal to a MLLW tide elevation of -0.3 feet.
(4) Based on Agency's design low tide level datum of 97.0 feet + 2030 near-term scenario sea level rise and 100-year flood event of an additional 46 inches, which equals 100.83 feet. This is equal to a MLLW tide elevation of 3.49 feet.

As presented in Figure 10.7, the estimated firm pumped outfall capacity at the current design high tide elevation of 105.84 feet is approximately 158 mgd with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated firm pumped outfall capacity would reduce to approximately 157 mgd and 156 mgd, respectively.

When accounting for the 2030 near-term scenario sea level rise and 100-year flood event of 46 inches above the current design high tide elevation of 105.84 feet, the estimated firm pumped outfall capacity is approximately 152 mgd with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated firm pumped outfall capacity would reduce to approximately 151 mgd and 149 mgd, respectively.



PUMPED OUTFALL CAPACITY VS. NUMBER OF BURIED DIFFUSERS

FIGURE 10.7

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When accounting for the 2050 mid-term scenario sea level rise and 100-year flood event of 76 inches above the current design high tide elevation of 105.84 feet, the estimated firm pumped outfall capacity is approximately 147 mgd with no buried diffusers. If 30 to 60 diffusers were buried in mud, the estimated firm pumped outfall capacity would reduce to approximately 146 mgd and 144 mgd, respectively.

Table 10.3 summarizes the results of the pumped outfall capacity analysis.

Table 10.3 Pumped Outfall Capacity Analysis
2017 Facilities Master Plan
Central Marin Sanitation Agency

Number of Buried Diffusers	Pumped Outfall Capacity with Four Effluent Pumps, mgd		
	Design High Tide(1)	Design High Tide + 2030 Sea Level Rise + 100-Yr Flood(2)	Design High Tide + 2050 Sea Level Rise + 100-Yr Flood(3)
0	158.4	151.9	147.2
10	158.0	151.6	146.9
20	157.7	151.2	146.5
30	157.3	150.5	146.2
40	156.6	150.1	145.4
50	156.2	149.4	145.1
60	155.5	148.7	144.4

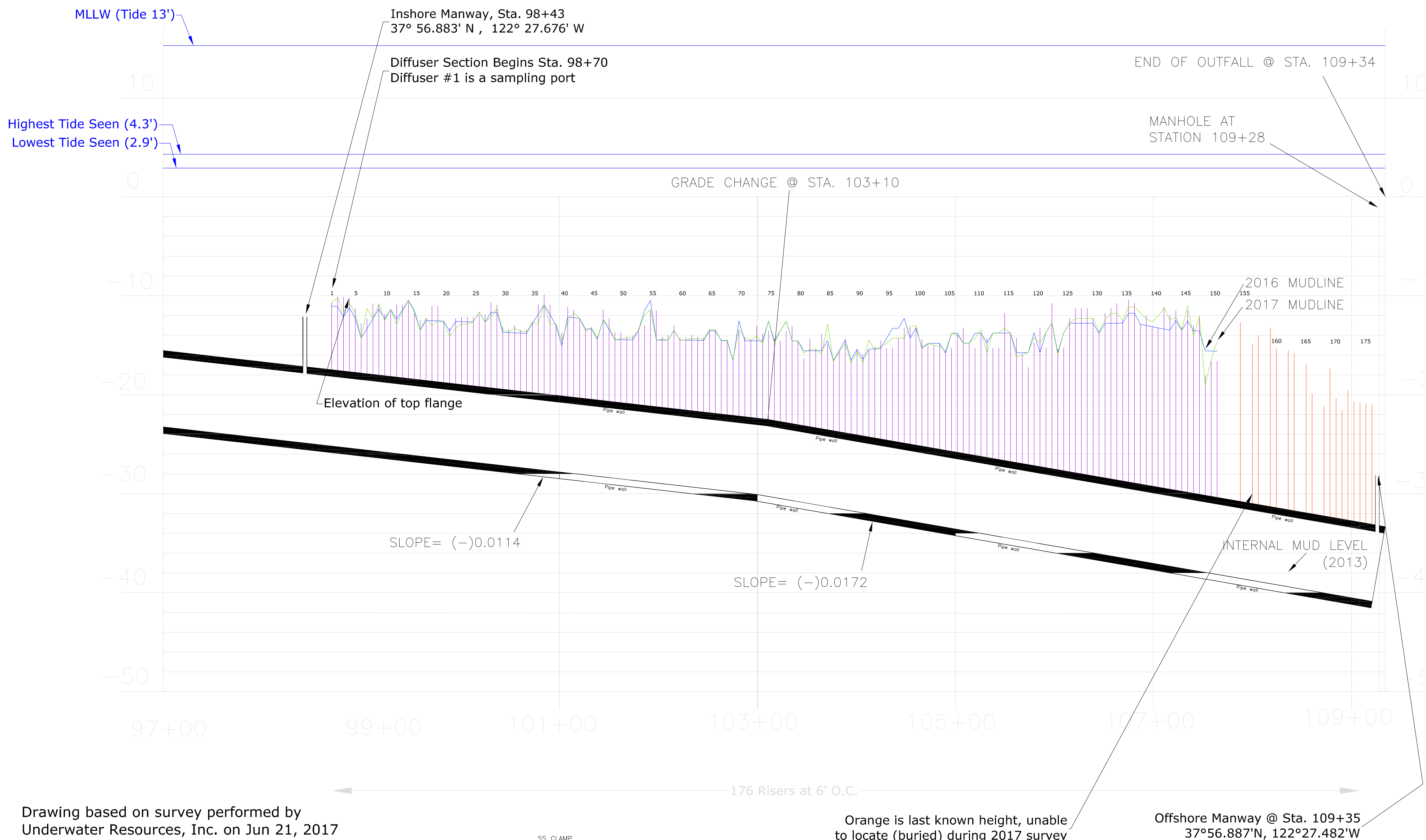
Notes:

(1) Based on Agency's design high tide datum of 105.84 feet. This is equal to a MLLW tide elevation of 8.5 feet.

(2) Based on Agency's design high tide datum of 105.84 feet + 2030 near-term scenario sea level rise and 100-year flood event of an additional 46 inches, which equals 109.67 feet. This is equal to a MLLW tide elevation of 12.33 feet.

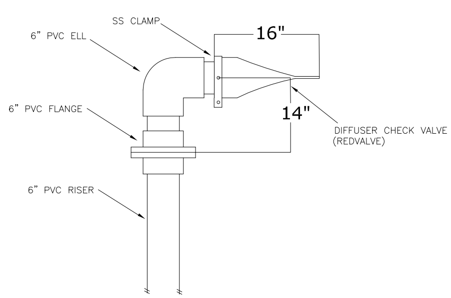
(3) Based on Agency's design high tide level datum of 105.84 + 2050 mid-term scenario sea level rise and 100-year flood event of an additional 76 inches, which equals 112.17 feet. This is equal to a MLLW tide elevation of 14.83 feet.

APPENDIX A – 2017 OUTFALL DIFFUSER AND MUDLINE RECORD DRAWING



Drawing based on survey performed by
Underwater Resources, Inc. on Jun 21, 2017

Tide Level to Points		
	Lowest Tide	Highest Tide
Inshore Manway	10.1 ft	20 ft
Offshore Manway	26.1 ft	36 ft
Diffuser 3	6.3 ft	16.1 ft
Diffuser 135	8.0 ft	17.8 ft
Diffuser 145	7.5 ft	17.3 ft



Riser with diffuser check valve No scale

Central Marin Sanitation Agency Marine Outfall Diffuser Section Diffuser Riser and Mudline Record Drawing			
Drawn By: AH	Date: 09-25-17	CONTRACT NO.	
Checked By:	Date:	APPENDIX	
CMSA		Scale	Sheet Number
		Not to scale	1 of 1