City of San José

San José/Santa Clara Water Pollution Control Plant Master Plan

TASK NO. 5
PROJECT MEMORANDUM NO. 2
BIOSOLIDS TREATMENT ALTERNATIVES

FINAL DRAFT
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CITY OF SAN JOSÉ

SAN JOSÉ/SANTA CLARA WATER POLLUTION CONTROL PLANT MASTER PLAN

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GLOSSARY OF ACRONYMS AND TERMS

AB	Assembly Bill
AC	Acre
ACH	Air Changes per Hour
AD	Air Drying
ADAF	Average Day Annual Flow (Average daily flow or loading for an annual period)
ADC	Alternative Daily Cover
ADMMF	Average Day Maximum Month Flow (Peak month for each year)
ADMML	Average Day Maximum Month Load
ADWF	Average Dry Weather Flow (Average of daily influent flow occurring between May - October)
ADWIF	Average Dry Weather Influent Flow (Average of five consecutive weekday flows occurring between June - October)
ADWL	Average Dry Weather Load
AES	Advanced Energy Storage
ANSI	American National Standards Institute
ARWTF	Advanced Recycled Water Treatment Facility
BAAQMD	Bay Area Air Quality Management District
BAB2E	Bay Area Biosolids to Energy
BACWA	Bay Area Clean Water Association
BAF	Biological Aerated Filter
BC	Brown and Caldwell
BCDC	Bay Conservation and Development Commission
BNR	Biological Nutrient Removal
BNR1	Formerly Secondary Facilities
BNR2	Formerly Nitrification Facilities
BOD	Biochemical Oxygen Demand
BTUs	British Thermal Units

CAG	Community Advisory Group
CAL OSHA	California Occupational Safety and Health Administration
CAMBI	Vendor name for a pre-processing technology
CARB	California Air Resources Board
CCB	Chlorine Contact Basin
CEC	California Energy Commission
CEPT	Chemically Enhanced Primary Treatment
CEQA	California Environmental Quality Act
CFM	Cubic feet per minute
CH_4	Methane
CH_3SH	Methyl mercaptan
CIP	Capital Improvement Program
City	City of San José
CL	Covered Lagoons
CO	Catalytic Oxidation
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalence
CSI	California Solar Incentive
DAFT	Dissolved Air Flotation Thickener
DO	Dissolved Oxygen
DG	Digester Gas
DPH	Department of Public Health
D/T	Dilutions to threshold
EBOS	Emergency Basin Overflow Structure
EDCs	Endocrine Disrupting Compounds
EEC	Environmental Engineering and Contracting, Inc.
e.g.	For example
EIR	Environmental Impact Report
ELAC	Engineering, Legal, and Administrative Costs

EPA	United States Environmental Protection Agency
EQ	Equalization
ESD	Environmental Services Department
etc	etcetera
Fe_2O_3	Ferric Oxide
Fe_2S_3	Ferric Sulfide
FIPS	Filter Influent Pump Station
FOG	Fats, Oils, and Grease
fps	foot per second
FRP	Fiberglass Reinforced Plastic
FWS	Food Waste Separation
GC/SCD	Gas Chromatograph/Sulfur Chemiluminescence Detector
GHG	Greenhouse Gas Emissions
gpd/ft^2	Gallons per Day per Square Foot
GWP	Global Warming Potential
H_2S	Hydrogen Sulfide
H_2SO_4	Sulfuric Acid
HOCl	Hypochlorous Acid
HP	Harvest Power
HRT	Hydraulic Residence Time
HVAC	Heating Ventilation and Air Conditioning
HW	Headworks
IMLR	Internal Mixed Liquor Return
IWA	International Water Association
ISCST3	Industrial Source Complex Short-Term 3
ITC	Investment Tax Credit
JEPA	Joint Exercise of Power Authority
L	Liter
LFG	Landfill Gas

LHV	Lower Heating Value
MAD	Mesophilic Anaerobic Digestion
MBR	Membrane Bioreactor
MD	Mechanical Dewatering
MG	Million Gallons
mgd	Million Gallons per Day
mg/L	Milligrams per Liter
MLE	Modified Ludzack - Ettinger
MLSS	Mixed Liquor Suspended Solids
MM	Million
MOP	Manual of Practice
MSW	Municipal Solid Waste
MW	Mega Watt
NAS	Nitrification with Anaerobic Selector
NBB	Nitrification Blower Building
NFPA	National Fire Protection Association
NG	Natural Gas
NH_3	Ammonia
N_2O	Nitrous Oxide
NPDES	National Pollutant Discharge Elimination System
OCMP	Odor Control Master Plan
O&M	Operations and Maintenance
ORP	Oxidation-Reduction Potential
OUR	Oxygen Uptake Rate
PE	Primary Effluent
PEPS	Primary Effluent Pump Station
PG&E	Pacific Gas and Electric
PHWWF	Peak Hour Wet Weather Flow (Peak hour flow resulting from a rainfall event)
PM	Project Memorandum

PMP	Plant Master Plan
PPA	Power Purchase Agreement
ppbv	Parts per billion by volume
PPCD	Pounds per capita per day
ppmv	Parts per million by volume
PPP	Public-Private Partnerships
PS	Primary Sludge
PV	Photovoltaic
QA/QC	Quality Assurance/Quality Control
RAS	Return Activated Sludge
RO	Reverse Osmosis
RPS	Renewable Portfolio Standard
ROAP	Regional Odor Assessment Program
RSPS	Raw Sewage Pump Station
SBB	Secondary Blower Building
SBR	Sequencing Batch Reactor
SBWR	South Bay Water Recycling
SC	Santa Clara
SCAQMD	South Coast Air Quality Management District
SCR	Selective Catalytic Reduction
SGIP	Self-Generation Incentive Program
SJ	San Jose
sf	Square Feet
SOM	Skidmore, Owings, and Merrill
SOTE	Standard Oxygen Transfer Efficiency
SRT	Solids Residence Time
SS	Suspended Solids
SSPS	Settled Sewage Pump Station
SVI	Sludge Volume Index

TAD	Thermophilic Anaerobic Digestion
TAG	Technical Advisory Group
TBL	Triple Bottom Line
TM	Technical memorandum
TN	Total Nitrogen (organic & inorganic forms which are ammonia, nitrates, nitrite)
TSS	Total Suspended Solids
TWAS	Thickened Waste Activated Sludge
UV	Ultraviolet
VFDs	Variable Frequency Drives
VOC	Volatile Organic Compound
VSL	Volatile Solids Loading
WAS	Waste Activated Sludge
WEF	Water Environment Federation
WPCP	Water Pollution Control Plant
WWTP	Wastewater Treatment Plant

BIOSOLIDS TREATMENT ALTERNATIVES

1.0 INTRODUCTION/SUMMARY

This section introduces the biosolids treatment alternatives evaluation and provides a summary of the recommended implementation plan.

1.1 Introduction

This project memorandum (PM) summarizes the biosolids treatment alternatives investigated for the San José (City)/Santa Clara Water Pollution Control Plant (WPCP) Master Plan (Master Plan). This PM was developed in parallel with PM 5.1, Liquid Treatment Alternatives. As in PM 5.1, this PM compares the full and reliable capacities of the treatment processes developed in PM 3.5 with the projected flows and loads developed in PM 3.8 to determine future capacity needs.

This PM presents the range of technologies identified and considered. The initial wide range of alternatives was narrowed through a screening (fatal flaw analysis) and selection process down to the alternatives presented in this PM. The narrowed list of alternatives was assessed from a conceptual perspective for their engineering feasibility, cost, land-use requirements, and Triple Bottom Line (TBL) analysis. This assessment will allow City staff to compare alternatives, review recommendations, and select an alternative for further detailed analysis.

The current biosolids program with mesophilic anaerobic digestion, sludge lagoons, air drying beds, and disposition at the Newby Island Landfill is very cost-effective for the WPCP. However, this is currently the only disposition route the WPCP has under contract. The Master Plan recommendation is to expand the biosolids management program to provide more flexibility with multiple and diversified disposition options. The 2025 projected closing of the Newby Island Landfill, changes in future biosolids regulations, and long-term land use changes for the WPCP site are potential triggers that require evaluation of alternatives to the current biosolids management program. This PM presents a biosolids program and implementation plan (Biosolids Management Plan) that incorporates many of the cost-effective elements of the existing facilities with a phased plan that has the potential to develop multiple and diversified disposition options.

1.2 Summary

The elements of the recommended Biosolids Management Plan include:

- A Biosolids Management Program that provides flexibility in implementation, operation, use/disposal, and incorporation of future technologies.

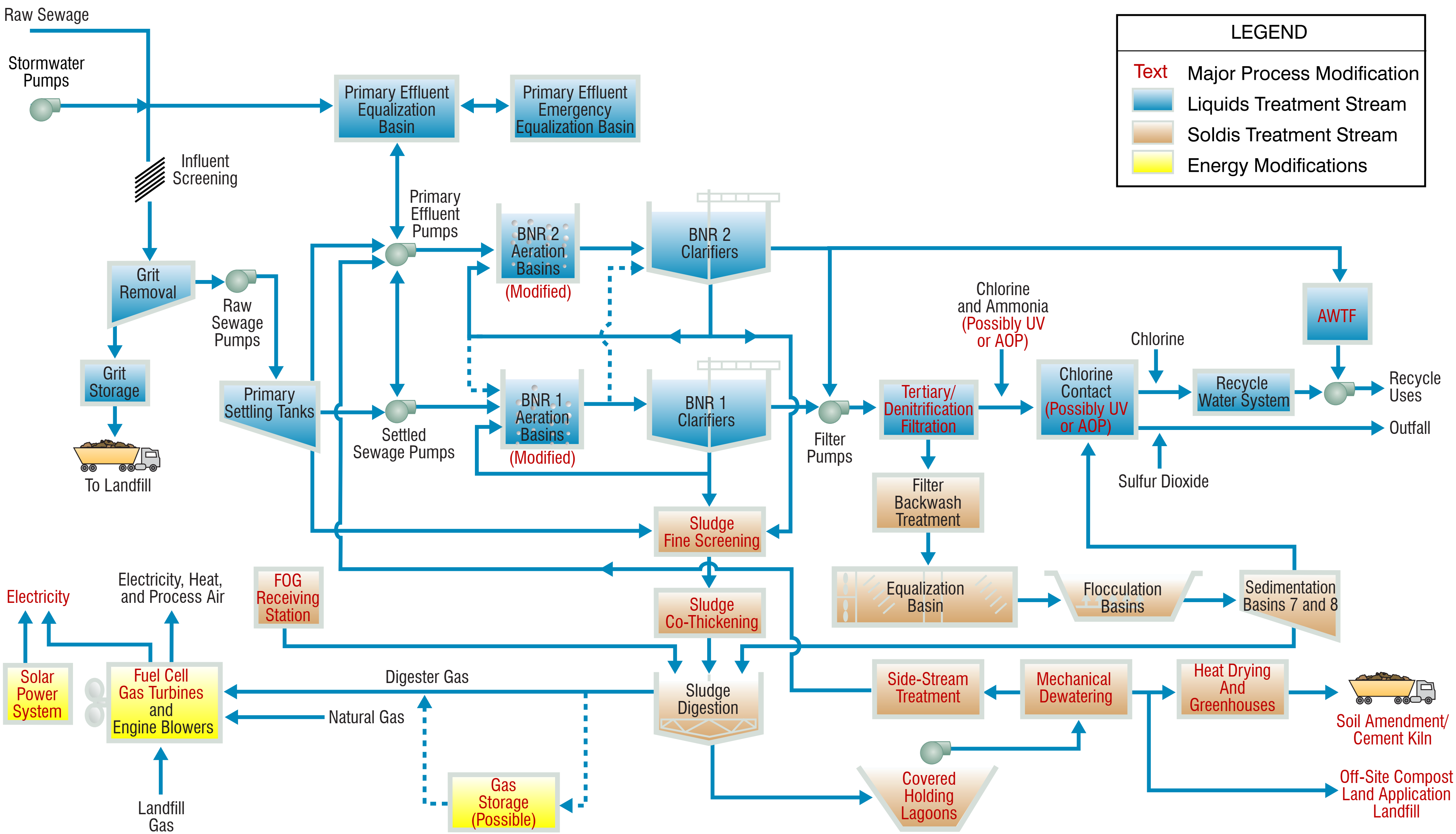
- Improved thickening that increases the digester feed concentration from under 4 percent to 5 to 6 percent. This reduces the number of digesters needed by four and provides a significant amount of digester volume for imported material. Imported feedstocks can include fats, oils and grease (FOG); food and food processing waste; and/or solids from other wastewater treatment plants.
- Phased rehabilitation of the existing mesophilic digesters.
- Addition of mechanical dewatering that will allow for diversification and increase the number of disposition options available to the WPCP.
- Replace the existing open sludge lagoons with a smaller area of covered lagoons. The recommended plan relocates the lagoons to the legacy biosolids area, which re-establishes the plant buffer on the east side of the WPCP.
- Greenhouses for drying a portion (10 percent) of the biosolids during the rainy season to increase flexibility and reliability.
- Flexibility to incorporate raw sludge pre-processing, thermal processing, dryers, and other future technologies into the biosolids program.
- Based on the experience of other large agencies, the plan recommends that three "50-percent disposition options" be developed to provide flexibility to divert up to 30 percent of the biosolids within 30 days to another disposition route.
- Conduct verification/demonstration projects for co-thickening in dissolved air flotation thickeners, digestion processes, import materials, digester mixing technologies, dewatering technologies, and drying technologies.
- Explore and develop facilities for import materials such as FOG, food and food processing wastes, raw solids from surrounding areas, and other import materials.
- Continue to pursue waste to energy opportunities similar to the Harvest Power gasification demonstration project that proposes to use wood chips combined with raw and digested solids.

Detailed descriptions of these projects, along with implementation timelines and planning level project cost estimates, are provided in PM 6.1 - CIP Implementation. The costs provided in this PM are for comparison of alternatives only, and should not be used for CIP planning.

The modifications to the plant are shown on the following updated simplified process flow schematic, entitled "Future WPCP Process Flow Schematic."

2.0 BACKGROUND

This section provides the background for developing biosolids treatment alternatives, which were based on the WPCP's 2040 Vision related to biosolids. This section includes the process used to develop the alternatives to be evaluated, site-specific considerations that



FUTURE WPCP PROCESS FLOW SCHEMATIC

SAN JOSE/SANTA CLARA WPCP MASTER PLAN

CITY OF SAN JOSÉ

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led to the program goals for the biosolids facilities, planning considerations, and planning triggers.

2.1 Development of Biosolids Treatment Process Alternatives

The following process was used to develop the biosolids alternatives:

1. Reviewed existing facilities and challenges through the following meetings and workshops:
   a. Brainstorm workshop at the WPCP on June 8, 2008.
   b. Project Team Brainstorming meeting at the Carollo office on September 8, 2008.
   c. Technical Advisory Group (TAG) Workshop at the WPCP on November 13 and 14, 2008.
   d. Community Advisory Group (CAG) Public Meeting at the WPCP on May 16, 2009.
   e. Project Team Brainstorming meeting at the BC office on July 1, 2009.
   f. Biosolids Alternatives Workshop at the WPCP on August 5, 2009.
   g. TAG Workshop at the WPCP on September 30 and October 1, 2009.
   h. Project Team workshop at Skidmore, Owings and Merrill (SOM) office on November 6, 2009.
   i. Meeting with Los Angeles County Sanitation District about its biosolids program.
   j. Project Team meetings at the Carollo office on December 3 and 15, 2009.
   k. Biosolids Workshop at the WPCP on January 7, 2010.
2. Considered individual treatment process requirements.
3. Reviewed linkages and integration of process recommendations.
4. Screened using “fatal flaw” criteria (see Table 1) and identified conceptual alternatives.
5. Selected viable alternatives using the full range of goals and objectives criteria as developed in PM 1.1.

Table 1 “Fatal Flaw” Screening Criteria (Pass/Fail)
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Technical	Land Use
Feasible at large-scale facility.	Provide for Endangered Species Act requirements.
Cannot reduce system reliability.	Address long-term sea level rise.
Must have the ability to meet future regulatory requirements.	Provide space allowance for existing and future treatment process.
Must be able to mitigate odor impacts.	Does not expand current biosolids footprint.
	Provide buffer to reduce aesthetic impacts.

2.2 Site-specific Considerations and Biosolids Program Goals

In developing the biosolids treatment alternatives, biosolids program goals were developed based on site-specific considerations. The following site-specific considerations were identified at the August 2009 workshops:

- Produce biosolids products with multiple uses.
- Maximize function of existing facilities by upgrading and improving facilities.
- Replace aging facilities that cannot be feasibly upgraded.
- Reduce the biosolids process footprint.
- Be a good neighbor by addressing odor, noise, and aesthetic concerns.
- Account for the impact of sea level rise on the WPCP (not included in this PM, see PM 5.4).

Based on the site-specific considerations, the following program goals were developed and presented to the City at the November 6, 2009, and January 7, 2010, Biosolids Workshops:

- Meet Class B biosolids out of the digesters at maximum month loading.
- Minimize use/disposal volume and cost.
- Maximize reuse.
- Reduce footprint.
- Increase bioenergy opportunities.
- Reduce odors.
- Increase flexibility in disposition options, which includes multiple disposal options (minimum of three 50 percent disposition options) with the ability to move 30 percent of the biosolids to a different disposition option within 30 days.
- Re-establish plant buffer.
- Investigate and incorporate innovative approaches.
- Reduce greenhouse gas emissions compared to the existing facilities.

2.3 Planning Considerations

The following five planning issues were identified in developing the biosolids treatment alternatives:

- Provide disposition flexibility in the biosolids program including mitigating the legacy biosolids and providing storage. Although the future biosolids program is not entirely dependent on mitigating the legacy biosolids area, completing this task in a timely manner will allow new biosolids facilities to be located in that area. Using the legacy biosolids area is most compatible with the land use planning alternatives and closest to the other biosolids treatment facilities. Biosolids storage will provide flexibility in the biosolids facility's overall operation and the disposition options used.
- Determine the future of solids processing, including sludge thickening, pre-processing, digestion processes, FOG/food handling, mechanical upgrades, and process improvements.
- Determine timing or schedule to incorporate dewatering and other new facilities into the biosolids process.
- Identify future solids processing technologies (i.e., reuse products such as off-site compost or fertilizer, energy production, dryers, and incineration) and their drivers and triggers (i.e., regulatory and ordinance changes).
- Determine if the WPCP should be part of a regional biosolids facility and/or if the WPCP should partner with a private entity for post-digestion processing.

These planning considerations are addressed in various sections throughout this PM. The recommended responses to these planning issues are based on the information available at this time. As more information becomes available and as technologies, regulations, and ordinances change, these planning issues should be revisited. At a minimum, the recommendations and progress should be reviewed and updated every five years so adjustments to the Master Plan and overall biosolids program schedule can be made.

2.4 Planning Triggers

Six categories of potential planning triggers for the Master Plan projects include:

- **Condition (Rehabilitation/Replacement)** – A condition trigger is assigned if the process or facility has reached the end of its economic useful life. This trigger is established based on the need to maintain that facility as operationally sufficient to meet mission-critical reliability and performance requirements.
- **Regulatory Requirement** – A regulatory trigger is assigned when the need is driven by local, state, or national regulatory requirements.

- **Economic Benefit** – An economic benefit trigger is assigned when a positive reduction in life-cycle costs (considering capital and O&M) can be achieved.

- **Improved Performance Benefit** – An improved performance benefit trigger is assigned when there is a benefit in improved operations and maintenance performance related to overall reliability and/or to reduced operational and safety-related risks.

- **Increased Flows/Loads** – An increased flow and load trigger is assigned when the need exists to increase capacity to accommodate increases in flows or loads into the WPCP.

- **Policy Decision** – A policy trigger is assigned when the reason is based on a management and/or political decision from the policy makers.

Policy decision triggers will primarily drive the Biosolids Management Plan, with the primary trigger being expanding the number of disposition options to meet the new policy of three "50 percent disposition options." This approach increases the City's flexibility with biosolids management and allows it to be proactive in meeting future regulatory changes that may occur.

3.0 PLANT MASTER PLAN GENERAL CRITERIA

This section presents the Master Plan layout guidance, 2040 projected wastewater flow rate, and 2040 projected solids loading information. This information is applied to the biosolids treatment alternatives developed in this PM.

3.1 Master Plan Layout Guidance

Some general principles apply with respect to plant layouts of alternatives. The most important of these are:

- Process requirements take priority over support facilities.

- Process areas are centrally located; support facilities are peripherally located.

- Space should be preserved or reserved for future needs.

- A buffer needs to be re-established.

- Piping and support system corridors should be accommodated.

- Major process piping should not be buried.

3.2 2040 Projected Wastewater Flow Rates

Historical plant influent data were analyzed to project future flows and loads. The analysis is described in detail in PM 3.8, Projected Wastewater Flows and Characteristics. As presented in PMs 3.8 and 5.1 (liquid treatment alternatives), the Master Plan flow rates used in evaluating and sizing the alternatives are:

- 190 million gallons per day (mgd) average dry weather influent flow (ADWIF).
- 200 mgd average daily maximum month flow (ADMMF).

The development of each plantwide biosolids alternative included estimating side stream flows and loads. These values were compared to the existing recycle flows and loads in the liquid treatment alternatives analysis (see PM 5.1).

3.3 2040 Projected Solids Loading Information

Table 2 shows the projected solids loading to the digesters based on the liquid stream analysis for combined primary sludge and waste activated sludge. The solids loading criteria are presented in five-year increments through 2040. The projected solids loadings are wastewater-generated solids only and do not include WPCP scum and grease, FOG, food and food processing waste, septage, or other feedstocks.

Table 2 Projected Solids Loadings to the Digesters
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Year	Average Annual (lbs/day)	Peak Month (lbs/day)
2010	300,000	399,000
2015	319,000	424,000
2020	339,000	451,000
2025	355,000	472,000
2030	374,000	497,000
2035	392,000	521,000
2040	412,000	548,000

4.0 BIOSOLIDS IMPLEMENTATION SCHEDULE

The Master Plan planning period is 30 years. An overall biosolids program schedule, divided into three implementation phases, is presented on Figure 1. Phase 1 represents the initial five-year Capital Improvement Program (CIP) for projects that need to be completed immediately. Phase 2 includes near-term projects and reflects when policy decisions would prompt a transition to alternate disposition options and away from the current lagoon/dry bed operation. A policy decision may be based on changes in the local landfill availability, alternative biosolids reuse, or land use opportunities. The color code scheme shown in Figure 1 is also used in other sections of this PM to represent when projects are projected to occur during the Master Plan program schedule.

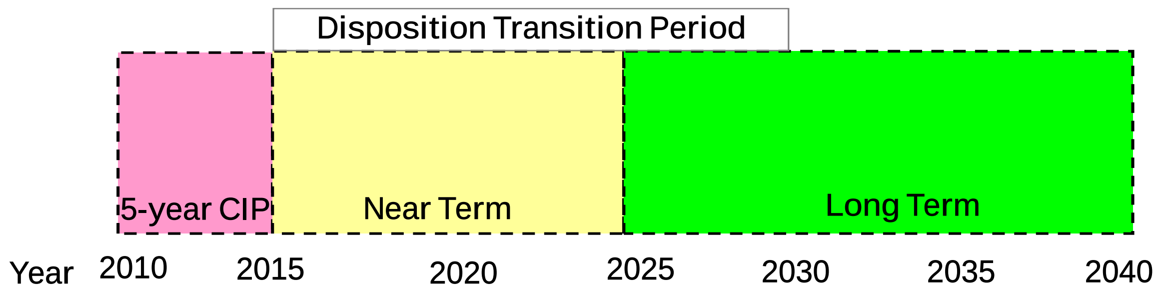

Figure 1 Biosolids Implementation Schedule

Newby Island Landfill provides a cost-effective disposition method for the WPCP biosolids. The WPCP biosolids are currently beneficially reused as alternative daily cover (ADC). Closing Newby Island Landfill, which could be as early as 2025 based on the existing filling rate, is a critical element of the 30-year biosolids implementation schedule and represents one of the key triggers that would require major changes in the way the WPCP handles biosolids. Because of the uncertain closing date and also potential changes in regulations and ordinances that may affect the continued use of biosolids disposition in landfills before 2025, Figure 1 shows a transition period from 2015 to 2030. This transition period reflects the time the WPCP must have alternative disposition options in place, although landfill bans on sludge could occur earlier. Therefore, the WPCP should investigate alternative disposition options before then. Alternative disposition options are discussed in Section 5.0 of this PM.

5.0 DISPOSITION ALTERNATIVES

This section summarizes potential WPCP disposition alternatives. Appendix A provides a more detailed discussion on the existing disposition, a survey of disposition alternatives used by other large California agencies and agencies outside of California, development of disposition alternatives, overall market and product assessment, and greenhouse gas analysis of the disposal routes.

5.1 Survey of Large California Agencies

Multiple biosolids disposition options are common for larger California agencies. Table 3 provides a list of biosolids disposition options for these agencies. These large California agencies do not necessarily have equal biosolids distribution between the disposition alternatives; however, diversification is important to provide flexibility.

Table 3 Biosolids Disposition Alternatives – California Agencies
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Treatment Facility	Total Biosolids Used/Disposed (dry tons/day)	Number of Available Disposition Alternatives
Los Angeles County Sanitation District – Joint WPCP	348	10
Los Angeles - Hyperion	185	5
San Diego Metro Biosolids Center	87	2
San Jose WPCP	85	1
Orange County Sanitation District	132	6
Sacramento Regional County Sanitation District	58	2
Fresno	43	3
East Bay Municipal Sanitation District	41	2
San Francisco Public Utilities Commission – Southeast Plan	38	5

5.2 Development of Alternative Disposition Options

Similar to the liquid treatment process alternatives being developed based on the discharge requirements to be achieved, biosolids process train alternatives are developed based on the disposition options for the final material. The disposition options define the desired or necessary products. Treatment options that will produce those products are identified, evaluated, and combined to form potential plantwide biosolids alternatives. Figure 2 shows a simplified process schematic of treatment trains and disposition options. The class of biosolids material shown in parentheses indicates what is required at the point of disposition. The treatment level needed to produce the class of biosolids required can be achieved through the combination of pre-processing of raw sludge, digestion, and post-processing of digested sludge. A more detailed discussion on disposition alternatives specific to the WPCP is provided in Section 5.3.

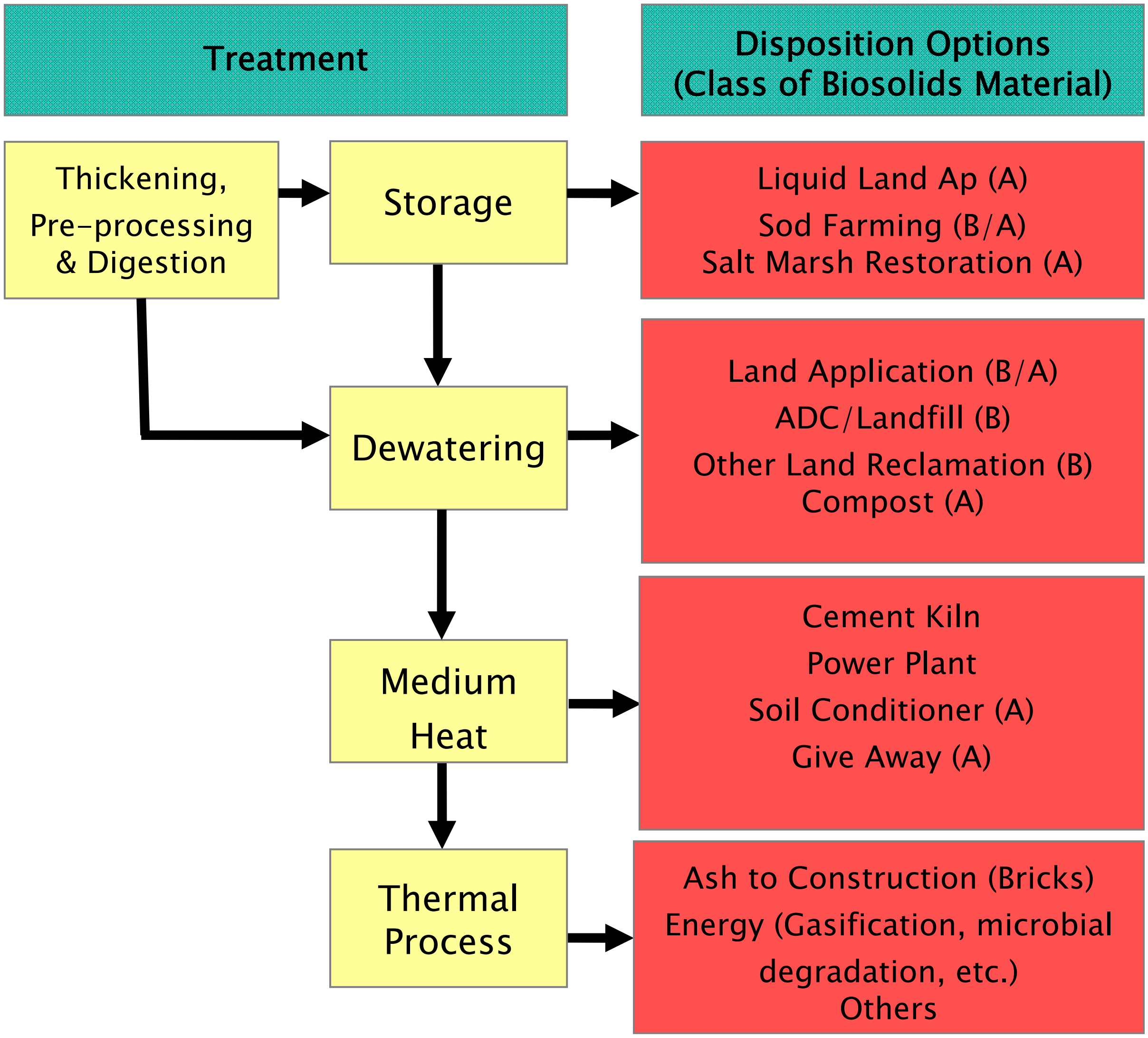

Figure 2 Treatment Trains to Produce Specific Biosolids Products

5.3 Disposition Alternatives

Details on all disposition alternatives investigated in this PM can be found in Appendix A. It should be noted that Appendix A only contains those disposition alternatives contacted for this investigation. There are other potential disposition options in Northern and Southern California. As shown in Table 4, the disposition options investigated for the California and Nevada sites vary significantly.

In the near-term, the WPCP could diversify by adding one or more of the available local disposition options such as local landfills including Newby Island, Vasco, and Manteca. The closest land application site that could accept the WPCP's current dried product (80 percent solids) is the Silva Ranch Land Application Site. By establishing multiple disposition options, procedures could be put in place to divert material between options if one becomes unavailable.

Table 4 2010 Biosolids Disposition Costs
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Product	Location	2010 Disposition Cost ($/dry ton)	($/wet ton)	($/yr)[1]
Current Operation	Newby Landfill	58[2]	23	1,420,000
Land App (Local)	Silva Ranch, Herald	50[3]	40	1,220,000
Landfill (Local)	Vasco, Livermore	55[3]	44	1,350,000
Landfill (Remote)	Salinas	74[3]	59	1,800,000
Landfill (Local)	Manteca	82[3]	66	2,010,000
Land App (Local)	Silva Ranch, Herald	160	40	3,910,000
Landfill (Local)	Vasco, Livermore	176	44	4,300,000
Composting (Off-Site)	Synagro, Merced	180	45	4,400,000
Landfill (Remote)	Salinas	235	59	5,770,000
Landfill (Local)	Manteca	263	66	6,430,000
Composting (On-Site)	SJ/SC WPCP	288	72	7,040,000
Composting (Off-Site)	Synagro, Kern	340	85	8,310,000
Land App (Remote)	Gerlach, NV	340	85	8,310,000

Notes:
(1) Cost based on all biosolids to this disposition option.
(2) Value calculated based on 80 percent solids dryness and 50 percent of the solids are soil due to current method of removing biosolids from the drying beds.
(3) Value calculated based on 80 percent solids, all other values calculated based on 25 percent solids.

In the long-term, the WPCP can further diversify with remote landfills, land application sites, and off-site composting and/or and involvement in local, commercial, or regional facilities. The local and remote locations in California and Nevada are shown in Figure 3.

6.0 REGIONALIZATION – THE BAY AREA BIOSOLIDS-TO-ENERGY PROJECT

The Bay Area Clean Water Association (BACWA) initiated a project in 2004 to evaluate alternatives for a regional biosolids facility in the San Francisco Bay Area. Using funding solicited from member agencies, BACWA completed a Phase 1 feasibility study and a Phase 2 alternatives and site location study. These studies concluded that a regional facility was feasible and could provide needed diversification for biosolids end use. The studies recommended a biosolids drying facility located at one of three sites in the San Francisco Bay Area.

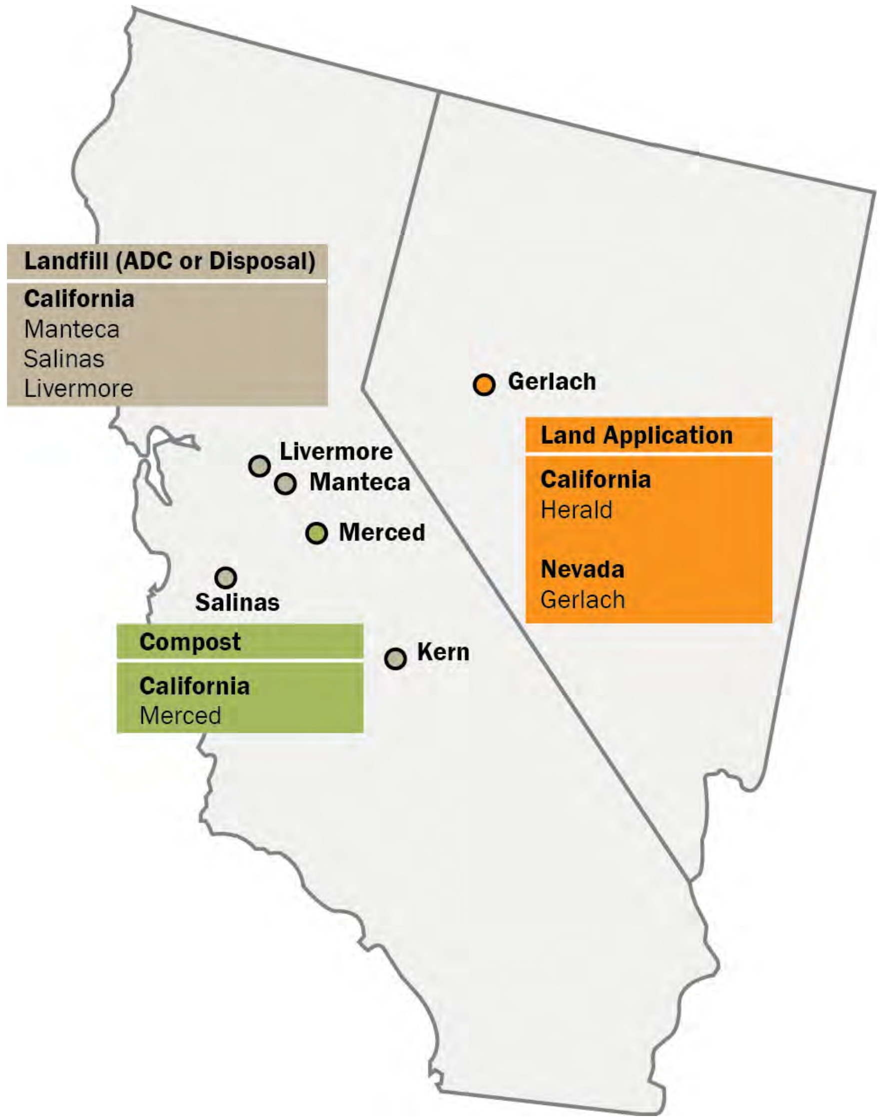

Figure 3 Potential Disposition Options for WPCP Biosolids in California and Nevada

In 2007, seven agencies formed a Joint Exercise of Powers Authority (JEPA) with Delta Diablo Sanitation District as the lead agency to pursue the next phase of the regional project. Initially, the scope focused on a biosolids drying facility; however, with the passage of Assembly Bill (AB) 32 and concerns over greenhouse gas emissions, the JEPA elected to seek alternatives to the dryer. They focused on a regional solution that could use biosolids as a renewable energy resource and minimize greenhouse gases and that would not be dependent on agricultural use of the biosolids.

Additional agencies subsequently signed on to the JEPA to form the Bay Area Biosolids to Energy (BAB2E) Coalition, which consists of 16 San Francisco Bay Area wastewater agencies. Plans are underway to develop the BAB2E Project. The Coalition issued a Request for Qualifications and received Statements of Qualifications from 16 teams that proposed various biosolids-to-energy technologies. The Coalition has short-listed three teams that will eventually receive a Request for Proposals to build a BAB2E facility in the nine-county Bay Area. The short listed firms are:

- Intellergy for a steam reformation plant to produce hydrogen.
- MaxWest for a gasification facility that would recycle heat from the gasifier but would not produce energy.
- Synagro for a dryer that would use waste heat from engines to dry biosolids that would be used as a fuel in a biomass plant.

The Coalition is establishing a governance structure suited to contracting for the regional facility and defining agency commitments of biosolids for the regional facility. This will lead to issuing a Request for Proposals to the short-listed teams. The Coalition is also working to secure a grant from the California Energy Commission. The grant may be used for constructing a facility to demonstrate steam reforming technology performance with biosolids.

The City has been tracking the progress of, and attended several meetings concerning, the BAB2E project. The City is not yet prepared to commit to participating in the project but will continue to monitor progress since the City plans to investigate two of the proposed technologies (drying and gasification).

7.0 SUMMARY OF CANDIDATE PROCESSES

A wide range of technologies exists for wastewater sludge/biosolids processing, and many may be feasible for the WPCP. Appendix B presents the processing technologies that were considered within the following categories:

- Sludge Screening.
- Thickening.
- Sludge Stabilization – Digestion and Non-Digestion Stabilization.
- Dewatering.
- Drying.
- Other Solids Processing Technologies.

The technologies presented in this PM include those commonly used in the wastewater industry (either in North America or Europe), along with technologies considered innovative and undergoing further improvements/development. These technologies must also exhibit promising features and have examples of full-scale experience at facilities similar to the

WPCP. Research-stage processes are not included in the alternative analysis or costs for the recommended implementation plan presented in this PM since it is premature to determine if these processes are suitable at the scale of the WPCP. Still, because many of the recommendations presented herein will not be implemented for a number of years, an updated technological assessment, which could include pilot testing, should be performed before final selection of a process or equipment.

7.1 Sludge Screening

Removing debris typical in wastewater is important relative to biosolids quality and its acceptability for reuse. A sludge screening versus raw influent fine screening evaluation was completed in PM 5.1. The analysis showed that sludge screening is significantly less in capital cost than fine screening of full plant influent. See PM 5.1 for analysis details.

Implementation of sludge screening is recommended when the following drivers are present at the WPCP:

- Land application is being practiced and recognizable debris in the biosolids is not desirable.
- Paper, plastic bags, etc. from open process tanks are incorporated into the sludge and plug heat exchangers at rates unacceptable, requiring sludge screening.
- Costs for digester cleaning are unacceptable, requiring sludge screening.

7.2 Sludge Thickening

This subsection discusses the sludge thickening and scum thickening analysis.

7.2.1 Major Master Planning Decisions

Key master planning decisions necessary relative to sludge thickening are:

- Whether or not to stay with existing treatment processes: in-tank thickening in the primary clarifiers and dissolved air flotation thickening (DAFT) for waste activated sludge (WAS).
- Whether or not to modify the process for co-thickening and/or chemical addition if the DAF thickening process is retained.

7.2.2 Thickening Options

Appendix B presents a description and discussion of seven thickening process alternatives that were considered. The thickening process alternatives include:

- Thicken primary sludge in primary clarifiers.

- Gravity belt thickeners.
- Dissolved air flotation thickeners.
- Centrifuges.
- Gravity thickeners.
- Rotary drum thickeners.
- Membrane thickeners.

7.2.3 Preliminary Screening Criteria

Thickening processes were screened based on the fatal flaw criteria presented in Table 1, the ability to make use of existing facilities to minimize capital costs, and the ability to increase the concentration of thickened sludge needed to maximize future capacity in the digesters.

7.2.4 Scum Thickening Options

Currently, scum is dewatered and hauled offsite (approximately 25 cubic yards per week (meeting with Dale Ihrke, et al September 17, 2009) in a semi-solid form at about 50 percent solids and disposed of at a landfill. An alternative is to co-thicken the scum with the sludge in the DAFT.

The existing DAFT tanks have a rated capacity equivalent to a plant flow of 225 mgd ADWIF based on the loading associated with co-thickening primary sludge and WAS. The capacity in excess of that required to thicken plant sludge could be used to thicken plant scum. Scum, as removed from the in-plant processes, is very dilute. The DAFTs have the hydraulic capacity to accommodate this additional flow and load. Benefits of thickening scum in the DAFT include:

- Eliminating operation of scum dewatering process.
- Eliminating the scum disposal fee at the landfill.
- Reducing truck hauling.
- Increasing volatile solids loading to the digesters; therefore, increasing digester gas production.
- Adding grease has also been reported to improve the digestibility of other solids.

7.2.5 Recommended Thickening Process: DAFT

In the August 2009 workshops, the following items were discussed and decided:

- PM 3.5 documents that the capacity of the existing DAFT exceeds the projected 2040 capacity needs for WAS thickening and for co-thickening WAS and primary sludge.

- Due to the available capacity and reported condition of the DAFT, the process will be retained for WAS thickening.

Plantwide biosolids alternatives will be developed assuming co-thickening in the DAFTs.

7.2.6 Pilot Testing

Co-thickening of primary sludge and waste activated sludge will be implemented on a full scale. Verification testing to optimize operating parameters such as saturation efficiency will be conducted. The DAFT process will be upgraded with a target of producing thickened sludge of 5.5 to 5.8 percent solids. This is the estimated concentration where digester hydraulic and organic loading limits converge. Co-thickening in DAFT would also allow plant grease and scum to be incorporated into the thickening process (with digester mixing upgrades).

7.3 Pre-processing

Appendix B presents a description and discussion of pre-processing technology alternatives that were considered. The pre-processing alternatives include:

- CAMBI.

- Disintegration.

7.3.1 Preliminary Screening Criteria

Pre-processing technologies were screened based on the fatal flaw criteria listed below:

- Reduce footprint of biosolids facilities.

- Maximize net energy production.

- Proven at large scale.

7.3.2 Recommended Pre-processing Technologies

Two CAMBI processes, which included WAS only and primary sludge and WAS, were carried forward for analysis. The CAMBI pre-processing system provides a number of advantages:

- Digester feed concentration is 8 to 12 percent, which requires fewer digesters.
- With fewer digesters needed for primary sludge and WAS, more digesters are available for FOG, food and food processing wastes, and other import materials. Alternatively, fewer digesters would be required for rehabilitation/restoration at potentially significant savings.
- Enhanced digestion is provided and a Class A product is produced if both the primary sludge and WAS are treated through the CAMBI process.
- Gas production is increased.
- Dewaterability of the digested sludge is improved even with low-energy devices like belt filter presses. (Aberdeen, Scotland produces greater than 30 percent cake using belt filter presses.)

The CAMBI system's complexity and numerous components are a disadvantage. Components include sludge screening, sludge feed storage, pre-dewatering, high-pressure steam system, multiple CAMBI vessels, post CAMBI cooling, and post CAMBI dilution system. Fixed covers are required on the mesophilic anaerobic digesters to address odor concerns.

The CAMBI system is economically attractive when no digesters exist or when there is limited space for future digester expansion. Because digesters already exist at the WPCP, rehabilitation was determined to be the less costly option (see Section 9.0 of this PM).

7.3.3 Pilot Testing

Pilot testing of pre-processing technologies may be part of the digester pilot testing discussed in Section 7.4.6. If alternative feed stocks such as food and food processing wastes are incorporated into the digestion process, pre-processing may be required.

7.4 Sludge Stabilization – Digestion and Non-Digestion Stabilization

This subsection discusses sludge stabilization alternatives.

7.4.1 Major Master Planning Decisions

Key planning decisions relative to sludge stabilization will address:

- Future digestion or non-digestion stabilization.
- Digestion modifications for the following process additions:
  - Enhanced digestion processes.
  - Blend/feed tank.
  - Pre-processing.

– Addition of FOG, food and food processing wastes, and/or other feedstocks.

7.4.2 Existing Sludge Stabilization Process

The existing sludge stabilization process is single-stage mesophilic anaerobic digestion. Table 13 in PM 3.5 presents the existing digesters' capacity. For the current digestion process based on the design criteria established in the Master Plan and assuming no improvement in thickened sludge concentration, thirteen digesters in service have an equivalent ADWIF capacity of 166 mgd without WPCP scum and grease addition (164 mgd with WPCP scum and grease addition). More aggressive design criteria could be evaluated in the detailed design phases of the upgraded projects, which may reduce the number of digesters needed. Also, since the digester upgrades will be phased, the operating performance of the upgraded digesters can be used to determine the total number of digesters needed for the 2040 Master Planning period.

Modifications to increase the digester capacity could include the following:

- Improving influent grit removal and add sludge screening to increase active sludge volume.
- Improving thickening performance and increasing digester feed concentration.
- Modifying the digestion process to thermophilic.
- Adding pre-processing.
- Adding digestion volume.

7.4.3 Digestion for Sludge Stabilization

Anaerobic digestion produces a stabilized material, reduces solids, and produces methane that is usable for power and heat. The continued use of anaerobic digestion as the sludge stabilization technology was discussed and recommended at all project brainstorming meetings, the initial and second TAG meeting, the August 2009 workshops, and the presentations in November 2009 and January 2010.

Alternatives with both mesophilic and thermophilic anaerobic digestion were analyzed. Of the two, thermophilic digestion offers greater volatile solids reduction at lower hydraulic residence times, which results in greater digester gas production, less digested solids to handle, and the potential for a Class A product. Conversely, thermophilic digestion has a higher heat demand that results in higher energy use and a more complex mechanical system. The higher heat requirement might be met by heat recovery from a combined heat and power system and recovery of heat from the thermophilic solids.

The selected digestion process is linked to and impacts the following:

- Capacity for processing imported feedstocks.

- Biosolids disposition options (reuse/disposal).
- Net energy production.

The 11 digestion process alternatives that were considered are presented in Appendix B. Appendix B also presents 17 alternatives for non-digestion stabilization that were considered but are not being carried forward due to the decision to maintain anaerobic digestion. These technologies should be reconsidered as they are refined and/or prove more feasible or economical, or if the WPCP needs or chooses to switch from digestion at a later date. Additionally, some of these processes remain candidates for post-digestion processing, which would include off-site composting and thermal processing, for producing a reusable recycle product or additional bio-energy.

7.4.4 Preliminary Screening Criteria

Stabilization processes were screened based on the fatal flaw criteria and the criteria listed below:

- Make use of existing facilities (to minimize cost).
- Minimize energy consumption.
- Maximize energy production potential.

7.4.5 Recommended Stabilization Process: Anaerobic Digestion

Although the recommended stabilization process is anaerobic digestion, variations of the anaerobic digestion processes and thermal processing with energy recovery (e.g., incineration, gasification, etc.) of digested sludge have been carried into the plantwide biosolids alternatives development. Thermal processing could be added after digestion. These alternatives are presented starting in Section 8 of this PM. Solids and energy balances were prepared for those plantwide alternatives carried forward.

7.4.6 Pilot Testing

Pilot testing related to the digester may include:

- Digester mixing technologies.
- Digester processes including mesophilic and thermophilic.
- Pre-processing technologies with digestion.
- Import materials.

7.5 Lagoon Storage

Lagoon storage is recommended for all plantwide biosolids alternatives. In addition to further stabilizing the biosolids, lagoon storage will increase the reliability and flexibility of the biosolids operation by providing a wide spot in the system.

The lagoons will be located in the biosolids legacy pond area and provide up to 180 days of storage. For the purposes of the Master Plan, it will be assumed that the lagoons will be constructed as six cells that can be operated in parallel or series depending on the storage requirements and process needs. The lagoons will be covered to collect methane and to lower greenhouse gas emissions. Covered lagoons also provide odor control with the collection of the off gasses produced.

7.6 Dewatering

The existing process train does not include mechanical dewatering. Digested sludge is stored in lagoons and subsequently dried in open air drying beds. It was concluded at the August 2009; November 6, 2009; and January 7, 2010, workshops that all plantwide biosolids alternatives include some form of mechanical dewatering.

7.6.1 Dewatering Technologies

Appendix B presents a description and discussion of five dewatering technology alternatives that were considered. The dewatering technologies include the following:

- Belt filter press.
- Centrifuge.
- Screw press.
- Rotary press.
- Plate and frame filter.

7.6.2 Preliminary Screening Criteria

Dewatering technologies were screened based on the fatal flaw criteria listed below:

- Proven at large scale with reasonable number of units in service.
- Ability to produce a product compatible with use/disposition options.

7.6.3 Recommended Dewatering Technologies

The plantwide biosolids alternatives evaluation includes centrifuge dewatering. Centrifuges are currently the most commonly applied and proven mechanical dewatering technology (especially at larger treatment facilities). Centrifuges will be the basis for sizing the facilities, layout, cost estimating, and energy balance. Generally, centrifuges for the size of the WPCP provide the best balance of higher dewatered solids and lower operation and maintenance. However, testing of alternative technologies is recommended.

For the alternatives analysis, two dewatering process upgrades are presented: 1) dewatering for facilities sized for 2020 average annual conditions, no redundancy, and 20 to 30 percent dewatered solids, and 2) dewatering for facilities sized for 2040 peak month flow, redundancy, and 25 to 30 percent dewatered solids.

The current implementation plan is to have DAFT co-thickening implemented by 2015 or 2016 with 5.5 percent thickened solids to the digesters. During peak conditions or when one centrifuge is out of service, the lagoons could be used as storage, air/solar drying beds could be used, or the centrifuges could operate at a higher throughput with dewatered solids at less than optimum percent solids of 15 to 20 percent instead of 25 to 30 percent. A dewatered solids loadout facility would also be included as part of this phase.

The dewatering scenario would include a total of six centrifuges, which includes one redundant unit. The covered lagoons would provide storage and equalization to allow for a more consistent feed rate and concentration to the centrifuges. The dewatered solids loadout facility from the first phase would be expanded to accommodate the additional dewatered solids.

7.6.4 Pilot Testing

The dewatering device selected will be based on an updated technology assessment and pilot testing performance. In addition to footprint and facility requirements, future changes to the plantwide biosolids scheme should include equipment testing and consider:

- Achievable dewatered cake concentration.
- Power, chemical, and wash-water requirements.
- Operation and maintenance requirements.
- Recycle stream characteristics (flow, SS, BOD, NH_3, and phosphorous).
- Bacterial reactivation and re-growth potential in the dewatered product.
- Odor or odor potential of the dewatered product.

7.7 Drying

Appendix B presents a description and discussion of five drying technology alternatives that were considered. The drying technologies include the following:

- Air/solar drying – open systems.

- Air/solar drying – within structures.
- Heat drying – graded pellet product.
- Drying using waste heat.
- Combined centrifuge/drying.

7.7.1 Preliminary Screening Criteria

Drying technologies were screened based on the fatal flaw criteria listed below:

- Reduce footprint of biosolids facilities.
- Reduce open air drying bed size.
- Maximize net energy production.
- Be proven on a large scale.

7.7.2 Recommended Drying Process

The existing drying process is open air/solar drying. The WPCP has committed to moving out of the existing earthen drying beds operation by moving to a new mechanical dewatering/drying process within the master planning period.

Also, a full-scale demonstration project with greenhouse drying of a portion of the biosolids will be included in the biosolids program. The demonstration project would be performed to determine the feasibility of scaling-up the technology for the size needed at the WPCP.

Based on current experience, belt drying and drum drying are proven technologies, but require significant fuel input and would not meet the Master Plan vision of increasing net energy production; therefore, heat drying is not being evaluated further as a process to treat all of the biosolids. However, medium heat dryers such as belt dryers and drum dryers are included for drying a portion (20 percent) of the biosolids to the extent of the available waste heat. The differences between belt dryers and drum dryers are as follows:

- Belt dryers operate at a lower temperature (190 degrees C versus 400 degrees C for drum dryers); and therefore, can use a lower grade thermal source for heating.
- Conveyance of the dried product from belt dryers is easier than the drum dryer because the product is 1/2- to 1-inch diameter versus a smaller spherical material for drum dryers.
- The floor space for a belt dryer and drum dryer is approximately the same for the same size unit. A belt dryer is larger than a drum dryer but with the ancillary equipment, drum dryers need as much space. However, the maximum capacity for

belt dryers is 60 percent of the capacity of drum dryers so if the maximum capacity required is greater than the belt dryer capacity, then more belt dryer units and more floor space will be needed.

- The building height for drum dryers is approximately 10 to 20 feet higher because a storage vessel to recycle a portion of the dried product back into the feed sludge is required.
- The maintenance for drum dryers is generally more because there is more ancillary equipment to maintain.
- The overall amount of energy required is approximately equal.
- Belt dryers may be safer to operate because of the lower operating temperature.
- Belt dryers are slightly less capital cost than drum dryers for the same size units.
- The dried product from a drum dryer has a higher market value because it is a homogenous spherical material that landscapers and golf courses prefer.

7.8 Thermal Processing

Appendix B presents a description and discussion of thermal processing technology alternatives that were considered. The thermal process alternatives are included as part of the non-digestion stabilization processes in Appendix B.

7.8.1 <u>Preliminary Screening Criteria</u>

Thermal processing technologies were screened based on the fatal flaw criteria listed below:

- Reduce footprint of biosolids facilities.
- Maximize net energy production.
- Be proven at large scale.

7.8.2 <u>Recommended Thermal Processing</u>

Most of the thermal processing technologies are in the early stages of development and are not proven at a large scale. Incineration was considered, but air quality restrictions will make permitting difficult; therefore, thermal processing is only being considered for long-term projects (after 2025).

The City is proceeding with a gasification feasibility and demonstration project. The City received four proposals for potential conversion technologies as part of their Demonstration Policy to promote a green vision. One of the proposals was from Harvest Power (HP) for a gasification process to process wood waste with digested solids and possibly raw sludge. The HP technology provider, Agnion, has similar full-scale projects in Germany. A tentative 3-acre location along the unimproved access road south of the WPCP has been identified for the demonstration unit, and will be confirmed as the feasibility analysis is completed.

Two consultants have been contracted to provide support for technical and economic analyses for the demonstration unit feasibility study. The study will start in April 2011 and construction of the demonstration facilities is expected to begin in May 2012.

A key part of the gasification project will be stakeholder input on project analysis and local feasibility. Several key stakeholders have expressed interest in providing input including the TPAC, the Master Plan CAG members, Palo Alto, and the Regional Biomass Collaborative. Other environmental groups and the BAAQMD will also be approached for their participation.

If digested sludge can be gasified with wood waste, fewer facilities downstream of the WPCP digesters would be needed. If raw sludge is used with wood waste, fewer facilities associated with solids processing and disposition at the WPCP would be needed.

The total cost of the demonstration project is $6.5 million, to be paid for partly with a $1.9 million California Energy Commission grant that was awarded to San Jose and Harvest Power in August 2010. The grant requires matching monies from the project partners, and venture capital monies may also be available.

7.9 Other Solids Processing Technologies

Appendix B discusses other solids processing technologies, including disintegration, nutrient removal processes, and the Cannibal® Process. These processes were not carried forward because they are in the relatively early stages of their development and have not been proven at a large-scale treatment plant.

7.10 Summary of Pilot Testing

A pilot program will be developed for biosolids processing alternatives. As discussed in the previous sections, a summary of the potential items for piloting include:

- Thermal hydrolysis and/or other pre-processing technologies (in pilot digester).
- Pilot digester(s) for digestion processes and confirming design criteria.
- Pilot digester along with dewatering technologies.
- Pilot digester along with mixing technologies.
- Dewatering technologies along with greenhouse dryers.
- Greenhouse dryers at the legacy biosolids area.

8.0 DIGESTER CAPACITY ANALYSIS

This section provides a sensitivity analysis that compares various hydraulic residence time (HRT) and volatile solids loading (VSL) to the number of digesters needed. It also summarizes the impact of increasing the digester feed concentration by co-thickening primary sludge and WAS, and discusses a digester implementation plan.

The analysis presented in this section is based on non-submerged steel fixed covers. A parallel effort to the Master Plan is evaluating submerged covers versus non-submerged covers. This parallel effort is at the pre-design level and it appears that submerged covers are feasible. This will be confirmed during the 10 percent design phase. If submerged covers are used, one less digester will be required. For the purposes of the Master Plan the more conservative non-submerged covers are used in the analysis.

8.1 Digester Capacity Sensitivity Analysis – HRT and VSL

The design criteria presented in PM 3.4 used a minimum HRT of 20 days and a volatile solids loading rate at maximum month of 0.15 pounds per day per cubic foot (lb/day/cf). The primary reason for using these conservative values was the uncertainty in the future biosolids process treatment train and the current WPCP standard operating goal of a 20-day HRT at maximum month.

The existing biosolids process treatment train includes lagoons with several years of storage downstream of the digesters. This storage provides operational flexibility of the mesophilic anaerobic digesters and a contingency volume in the event that the desired HRT is not met. Since all of the alternatives identified for the Master Plan include lagoon storage downstream of the digesters, it is reasonable to reconsider the 20-day HRT design criteria presented in PM 3.5. Figure 4 shows the number of digesters required at HRT values at 20 days versus 15 days, and volatile solids loading rates at 0.15 lb/day/cf versus 0.18 lb/day/cf for peak month loading rates and assuming non-submerged fixed steel covers and the digester volume does not include the cone bottom.

Figure 4 shows that four fewer digesters are needed if the HRT design criterion is reduced from 20 days to 15 days. If the primary sludge and WAS concentration is increased to the point where the volatile solids loading criteria govern, even fewer digesters are needed. The next section discusses using the existing DAFT in a co-thickening operation to increase the digester feed concentration to the digesters. More aggressive design criteria can be evaluated in the detailed design phase of the upgraded projects.

8.2 Co-thickening analysis

Figure 4 shows that by increasing the digester feed (primary sludge and WAS) concentration, fewer digesters would be needed. For the Master Planning design year of 2040, 14 digesters are needed at an HRT of 15 days with the existing digester feed concentration of 3.75 percent. If the feed concentration is increased to 5.4 percent, which is the value where the volatile solids loading rate governs for a 15-day HRT, 10 non-submerged fixed steel cover digesters are needed—a reduction of four digesters.

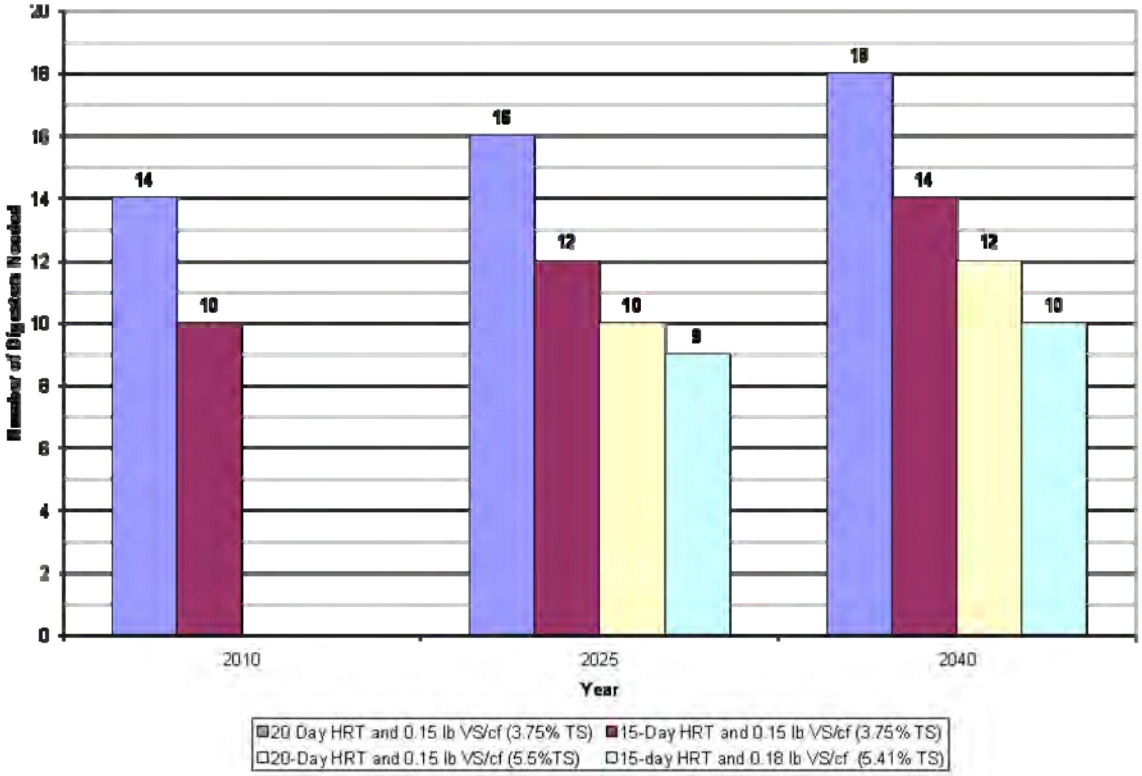

Figure 4 Digester Sensitivity Analysis

The cost of upgrading the existing DAFTs to be able to co-thicken is approximately $7 million. The cost to rehabilitate four non-submerged fixed steel cover digesters that would not be needed if co-thickening in the DAFTs is implemented is approximately $32 million. In addition to the capital cost savings, increasing the digester feed concentration will also reduce the energy needed for heating and pumping the sludge and will provide more digester volume available for imported material. Increasing the digester feed concentration may require that the existing mixing systems be replaced before implementing co-thickening because the existing mixing systems may not provide sufficient mixing for a thicker digester feed. If the available digester volume is used for imported feedstocks, some additional digesters would need to be rehabilitated. The addition of significant amounts of FOG and food and food processing wastes would require upgrading the digester mixing systems.

8.2.1.1 Digester Upgrades

The WPCP has 16 digester tanks, shown in Figure 5. Currently, 5 of the digesters—Digesters 2, 4, 5, 6 and 8—are not in service.

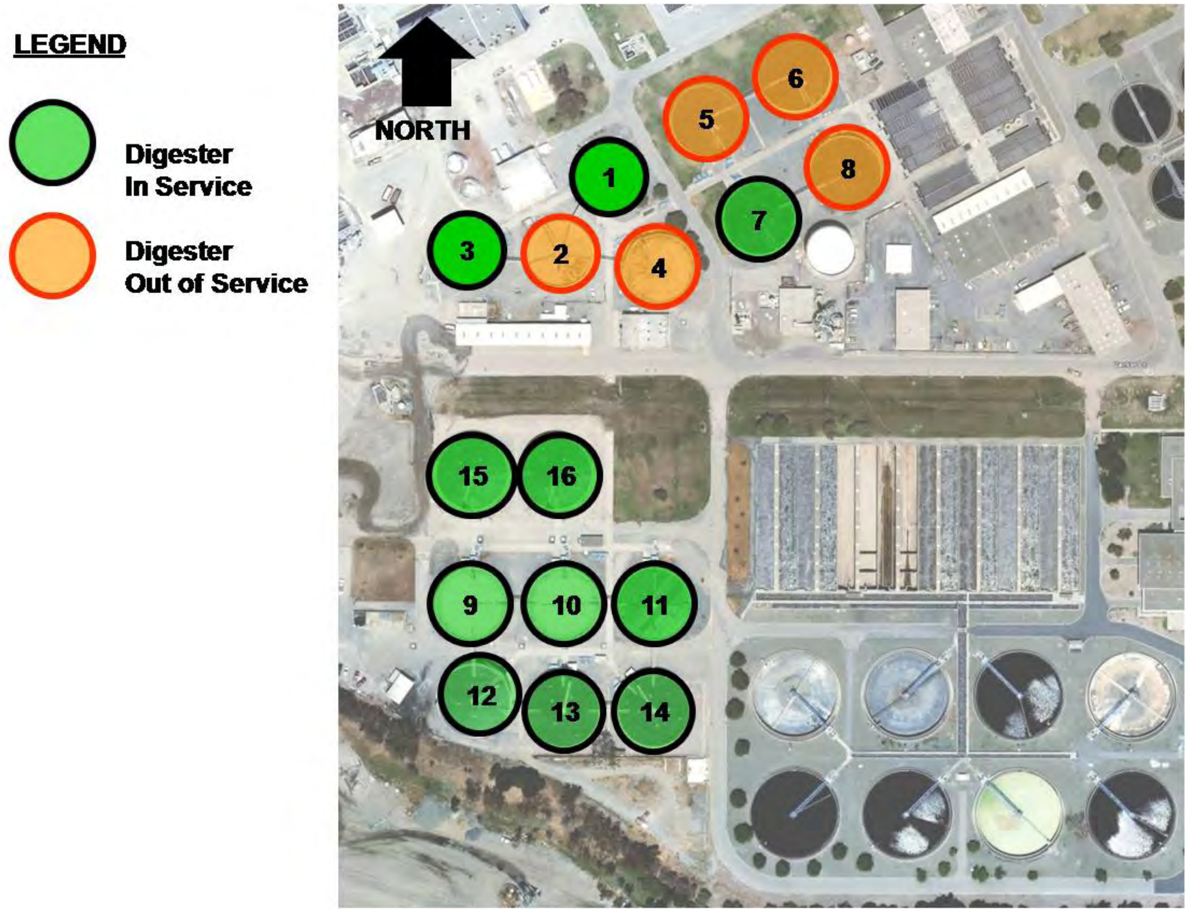

Figure 5 Existing Digesters in Service

Figure 4 shows that 10 digesters are needed for the 2040 ADMML (maximum month) loadings assuming a 15-day HRT and a volatile solids loading rate of 0.18 lb/day/cf. Two standby digesters are included in the 10 digesters. The number of digesters could change slightly depending on the cover type selected and the addition of import materials. For this analysis, it was assumed that a fixed steel cover would be used. If a floating cover is used, the number of digesters needed would increase by one to 11 digesters. If a submerged concrete cover is used, the number of digesters needed would decrease by one to nine digesters.

Figure 6 shows the 10 digesters recommended for rehabilitation for the 2040 ADMML loadings. Digesters 1, 2 and 3 were not recommended for rehabilitation because they are the smallest digesters and would require the most rehabilitation because of their age. These digesters could be available for alternative import materials, blending/equalization, or use as acid phase digesters. Digesters 4, 5, 6, and 8 are recommended for rehabilitation because they meet an immediate need at the WPCP to get additional digesters in service so active digesters can be taken out of service for maintenance and/or future rehabilitation.

Digesters 12, 13 and 14 are recommended because FOG/food receiving stations would most likely be located on the south side of the WPCP, which would reduce the distance for pumping. Digesters 7, 15 and 16 are the final recommended digesters. Digester 9, 10 and 11 could be used for alternative import materials.

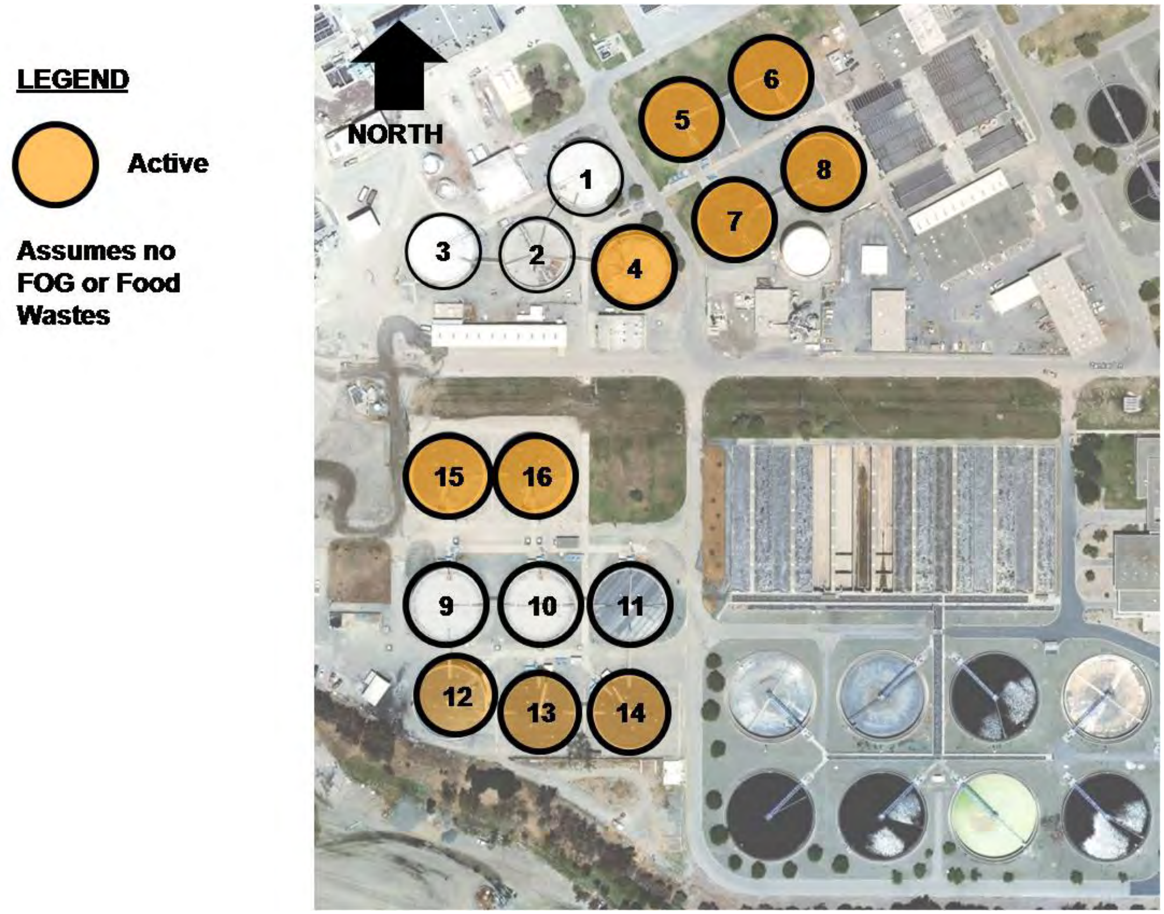

Figure 6 Recommended Digesters to be Rehabilitated for Primary Sludge and WAS Stabilization

9.0 PLANTWIDE BIOSOLIDS ALTERNATIVES

This section presents the plantwide biosolids alternatives for the WPCP and the assumptions used in their development. Also the analysis presented in this section is based on non-submerged steel fixed covers. A parallel effort to the Master Plan is evaluating submerged covers versus non-submerged covers. This parallel effort is at the pre-design level and it appears that submerged covers are feasible. This will be confirmed during the 10 percent design phase. If submerged covers are used, one less digester will be required. For the purposes of the Master Plan the more conservative non-submerged covers are used in the analysis.

9.1 Assumptions for Developing Plantwide Biosolids Alternatives

The following assumptions were used in developing and analyzing the plantwide biosolids alternatives:

- The legacy biosolids area will be available in 2016 for other biosolids facilities.
- Pre-processing alternatives assumed the use of the CAMBI technology for treatment of the WAS only and for both primary sludge and WAS stream.
- Digestion will be used and existing facilities will be part of the process.
- Lagoon storage of 180 days will be provided for all alternatives.
- Mechanical dewatering will be provided for all of the biosolids.
- The current air drying bed operation will no longer be used by 2025.
- Heat drying facilities will be provided for 20 percent of the solids.
- Greenhouse facilities will be provided for 10 percent of the solids.
- Multiple disposition options will be provided with a goal to have three 50-percent disposition options.

9.2 Alternative Evaluation

The alternatives evaluation was narrowed to a base case and four alternatives based on the results in Section 7.0. The alternatives include mesophilic anaerobic digestion, thermophilic anaerobic digestion, and two alternatives with pre-processing of raw sludge prior to digesters. The alternatives evaluated include:

- Base Case – Improve existing processes including co-thickening with DAFTs, mesophilic anaerobic digestion (MAD), rehabilitation of existing lagoons, and rehabilitation of existing air drying (AD) beds.
- CAMBI (WAS only) – WAS only DAFTs, CAMBI of WAS, MAD, covered lagoons (CL), and mechanical dewatering (MD).
- CAMBI (primary sludge (PS) and WAS) – Co-thickening with DAFTs, CAMBI, MAD, CL, and MD.
- Thermophilic Digestion – Co-thickening with DAFTs, thermophilic anaerobic digestion (TAD), CL, and MD.
- Mesophilic Digestion – Co-thickening with DAFTs, MAD, CL, and MD.

Covered lagoon storage for each alternative is 180 days of storage. Each of the alternatives except for the Base Case includes heat drying and greenhouse facilities.

Table 5 presents the solids production, gas production, heat demand, and energy consumption for each of the alternatives at 2040 ADMML and 15-day HRT.

Table 5 Comparison of Alternatives for Biosolids Treatment Alternatives – 2040 ADMML at 15 day HRT
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Alternative[(1)]	Number of Digesters Needed	Digested Sludge Disposition (dry tons per day)	Gas Production (cfm)	Heat Demand (MMBTU/hr)[(2)]	Energy Consumption (hp)
Base Case – Improve existing facilities	10	122	2,500	22	1,750
1 - CAMBI (WAS Only)[(3)] with MAD, CL, and MD	8	111	2,800	27	1,750
2 - CAMBI (PS and WAS)[(3,4)] with MAD, CL, and MD	5	111	2,800	28	2,100
3 - TAD[(5)] with CL and MD	10	111	2,800	42	2,000
4 - MAD with CL and MD	10	122	2,500	22	2,300

Notes:

(1) All alternatives include thickening improvements in the DAF except for Alternative 3 – CAMBI (WAS only).

(2) Some or all of the heat demand could be provided by heat recovery in a combined heat and power system.

(3) Calculations from CAMBI included in Appendix C.

(4) CAMBI (primary sludge and WAS) is the only alternative that produces a Class A product.

(5) Depending on the thermophilic anaerobic digestion process, this alternative may produce a Class A product.

MAD – Mesophilic anaerobic digestion.

TAD – Thermophilic anaerobic digestion.

MD – Mechanical dewatering.

CL – Covered Lagoons.

The following sections present additional information on the alternatives.

9.3 Footprint Requirements

Figure 7 shows the 2040 footprint requirements for the biosolids process treatment facilities downstream of digestion. The DAF co-thickening and digester improvements would use the existing facilities. Pre-processing would be sited near the digester facilities.

Figure 7
FOOTPRINT REQUIREMENTS FOR 2040
SAN JOSÉ/SANTA CLARA WPCP MASTER PLAN
CITY OF SAN JOSÉ

The future facilities are shown and recommended to be located in the legacy biosolids area. This location provides the greatest buffer from the areas to the east and south of the WPCP, which have the greatest potential for land development. Because of this, mitigation of the legacy biosolids area increases in importance.

Because the major land use planning alternatives assume that the legacy biosolids area and currently out of service ponds will be the site of future biosolids facilities, delay in mitigating the legacy biosolids area will impact the timing and subsequent land use (see PM 5.10 on viable land use alternatives and elements).

9.4 Net Present Value

Table 6 shows the 2025 net present value analysis for the base case and each of the four alternatives evaluated, respectively. The evaluation includes O&M costs, capital costs (based on 2010 dollars), net present value, annualized cost, and cost per dry ton for

Table 6 2025 Biosolids Treatment Costs(1)
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Treatment Alternative	O&M Costs(2) ($MM/yr)	Capital Costs ($MM)	Net Present Value ($MM)	Annualized Cost ($MM)	$/Dry Ton(3)	Comments
Base Case – Improve existing facilities	4.0	218	294	23	450	Maintains current operation.
1 - CAMBI (WAS Only) with MAD, CL, and MD	6.9	407	549	43	835	CAMBI is pre-processing alternative used for the evaluation. Other pre-processing technologies may be used.
2 - CAMBI (primary sludge and WAS) with MAD, CL, and MD	8.4	431	593	46	908	CAMBI is pre-processing alternative used for the evaluation. Other pre-processing technologies may be used.
3 - TAD with CL and MD	6.9	350	513	40	752	Thermophilic digestion increases gas production and may produce Class A.
4 - MAD with CL and MD	9.7	347	528	41	782	Without drying beds, less flexibility in disposition, thus more risk.

Notes:
(1) Costs do not include legacy biosolids area mitigation or existing sludge lagoon cleaning.
(2) Analysis for 2010 dollars. Cost projected to increase over existing due to increased loading and labor requirements because of new technologies.
(3) Includes treatment and disposition.

treatment and disposition. As expected, the base case is the least costly alternatives because it has rehabilitation of the existing lagoons and drying bed. The four alternatives are essentially identical from a cost perspective.

9.5 Greenhouse Gas Analysis

A greenhouse gas (GHG) emissions analysis of each alternative was completed and compared to existing and baseline conditions using Carollo's GHG emissions estimating tool. A summary of the detailed analysis is provided in this section. See Appendix A for the complete analysis. Figure 8 shows the results of the GHG emissions analysis for the biosolids alternatives in terms of CO_2e (excluding emissions related to the disposition or transport of the biosolids). The primary source of existing emissions is from the uncovered lagoons; however, the annual GHG emissions for each alternative will be reduced by almost 14,000 metric tons of CO_2e by covering the lagoons and capturing the methane for beneficial use.

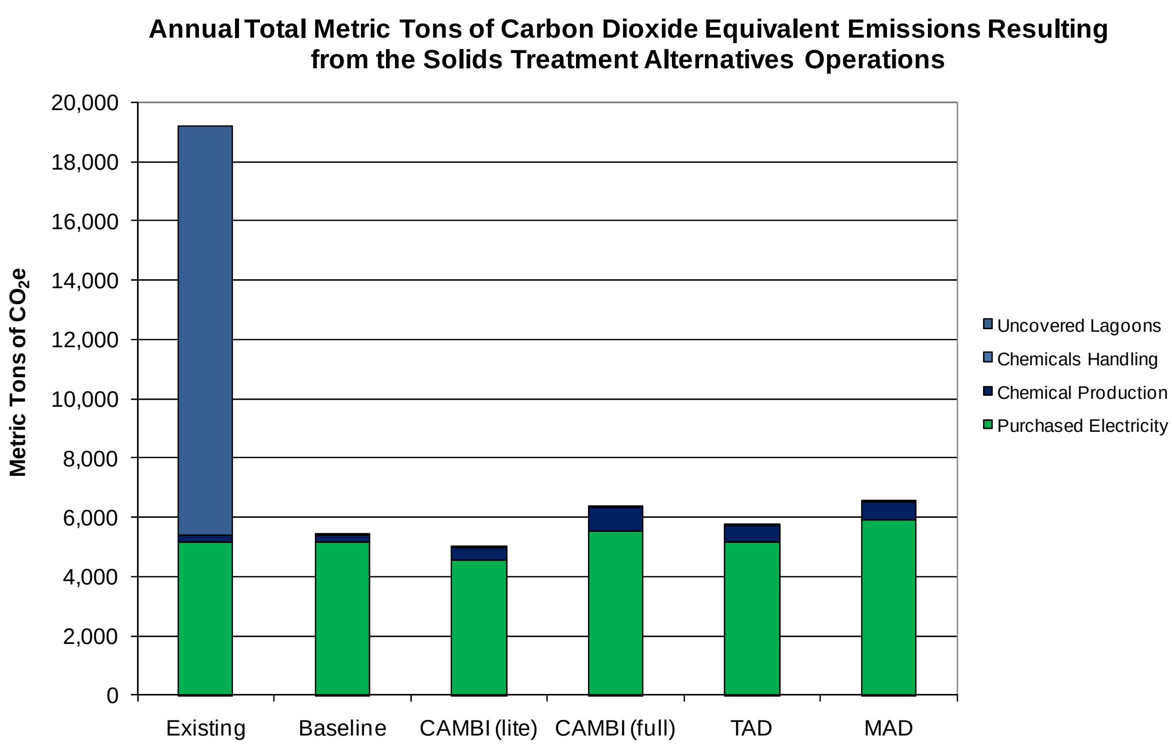

Figure 8 Annual Greenhouse Gas Emissions for Each Biosolids Alternative

9.6 Triple Bottom Line (TBL)

A TBL analysis was completed on the alternatives. Figure 9 shows a summary of the economic, environmental, and social aspects of the TBL analysis. The results indicate that the alternatives are relatively equal based on the TBL analysis.

	Base	CAMBI (WAS)	CAMBI (PS & WAS)	TAD	MAD
Economic – Annual Cost	●	◒	○	◒	○
Environmental – GHG	○	◒	◒	◒	◒
Social – Land Use	○	◒	◒	◒	◒

● **Best** ◒ **Neutral** ○ **Worst**

Figure 9 Triple Bottom Line Analysis

10.0 RECOMMENDED PLAN AND IMPLEMENTATION SCHEDULE

This section provides the recommended phasing plan and an implementation schedule for the biosolids program. This section includes a discussion on process staging, digesters to upgrade, and implications of adding FOG, food and food wastes, and other import materials.

10.1 Phasing Plan

Because 100 percent of the existing WPCP biosolids goes to the Newby Island Landfill as ADC, the closing of the landfill, which is projected to be as early as 2025, is one driver that requires the WPCP to consider alternatives to the current biosolids disposition. In addition, there is the potential for regulations or ordinances that may restrict the use of biosolids as ADC much earlier than 2025. Other drivers may cause the WPCP to move more quickly, including increasing operations flexibility, providing multiple disposition options, meeting City's diversification goals, ease of switching disposition options (i.e., the ability to move 30 percent of the WPCP biosolids to another disposition route within 30 days), and reducing offsite odors and increasing nutrient recovery.

Figure 10 presents the current biosolids process train (in blue) and the recommended phasing plan for the 30 year planning period. Table 7 presents a summary of the phasing elements. This plan, which includes five separate phases, presents a sequence of

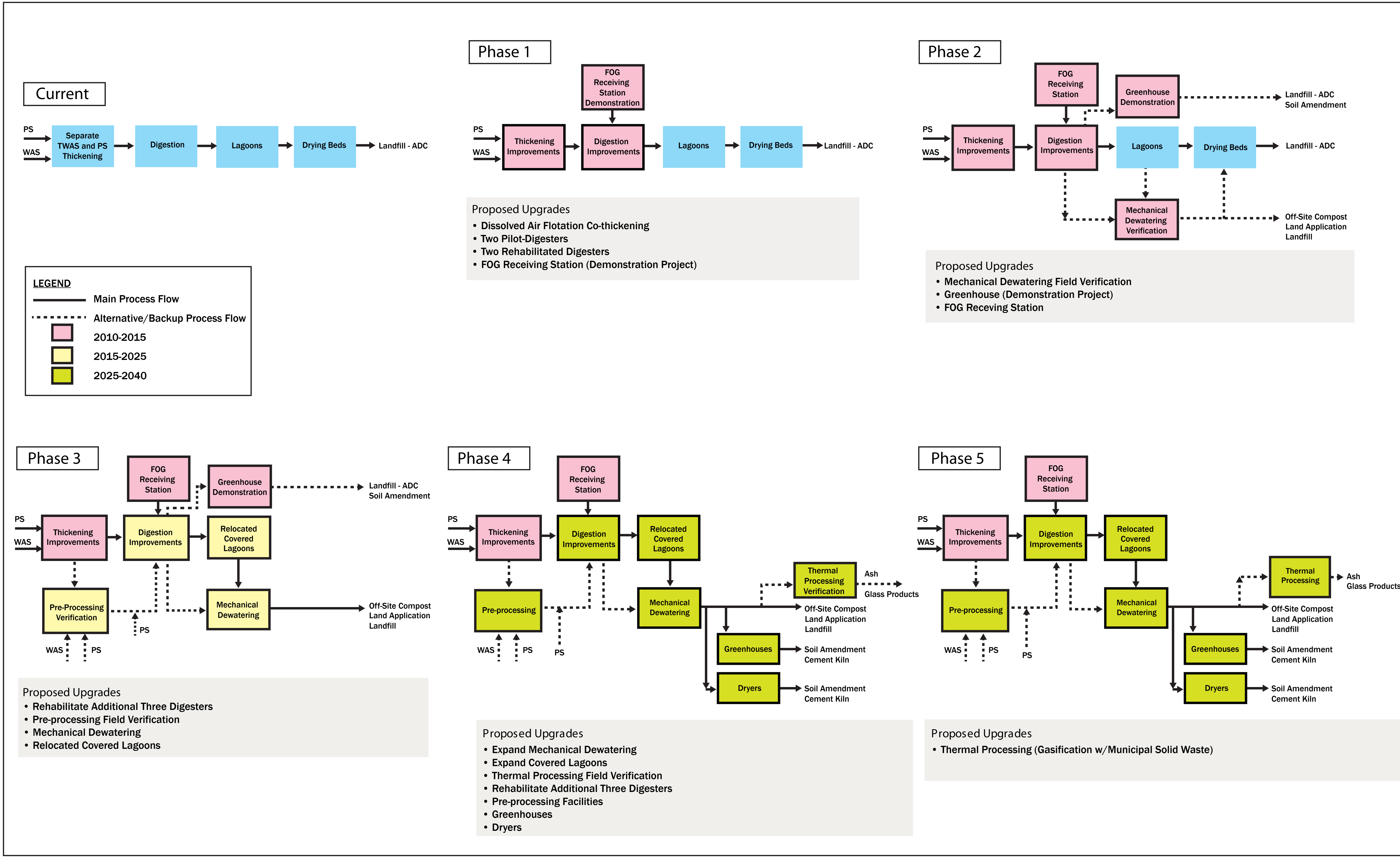

Figure 10 - Phasing Plan

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Table 7 Biosolids Treatment Phasing Plan
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Phasing Plan	Summary of Elements in Phasing Plan
Phase 1	Phase 1 elements consist of thickening improvements, digester improvements, and a FOG Receiving Station Demonstration Project. The WPCP's existing DAFTs will be upgraded to thicken primary sludge and waste activated sludge to a concentration of around 5.5 percent. The upgraded DAFTs will ultimately reduce the number of digesters needed. Four anaerobic digesters will be upgraded with submerged fixed concrete covers and mixers. Three different mixer technologies will be tested with the upgraded digesters. Also, various import materials may be tested in the digesters. A private firm has been contracted to install a FOG Receiving Station to test FOG in the WPCP digesters. The existing lagoons and drying beds will continue to be used with ultimate disposal to the existing Newby Island Landfill as alternative daily cover.
Phase 2	Phase 2 adds mechanical dewatering field verification, a greenhouse demonstration project, and a permanent FOG Receiving Station. Mechanical dewatering with centrifuges will be field verified. In the next phase, mechanical dewatering facilities will be designed for receiving the entire solids flow from the digesters. In addition, a greenhouse demonstration project taking flow from the anaerobic digesters will be conducted. If the FOG Receiving Station Demonstration Project is successful, a permanent FOG Receiving Station will be installed during this phase. With mechanical dewatering and the greenhouse dried product, additional disposition options to alternative daily cover such as soil amendment, off-site composting, land application, and landfilling will be available.
Phase 3	Phase 3 elements include rehabilitation of three more digesters, pre-processing field verification, mechanical dewatering, relocated lagoons with covers, and addition of an emergency biosolids storage area. Pre-processing of waste activated sludge or a combination of waste activated sludge and primary sludge will be tested. The primary goal of pre-processing will be to increase the digestability of the solids to improve gas production. Digested sludge storage with approximately 180 days of storage in covered lagoons will be provided. The covered lagoons will allow methane to be collected and re-used along with reducing the potential for odors. Disposition options will remain the same as those in Phase 2.
Phase 4	Phase 4 expands the digesters, mechanical dewatering facilities, and covered lagoons to the 2040 requirements. If the pre-processing facilities are successful and required, permanent facilities will be constructed. In addition, permanent facilities for greenhouses and dryers for a portion of the biosolids will be constructed. Field verification of thermal processing such as gasification will be conducted. The field verification could include municipal solid wastes. Additional disposition options available with the Phase 4 improvements include incorporation into ash to be used for bricks or glass products and dried biosolids to be used at a cement kiln.
Phase 5	Phase 5 constructs permanent thermal processing facilities such as gasification with municipal solid waste. Disposition options will remain the same as those in Phase 4.

improvements based on transitioning out of the current storage/drying operation by 2025. This is consistent with the earlier discussion regarding the change in disposition opportunities resulting from changes in use of landfills for ultimate disposal. Each phase of improvements is color-coded based on the schedule presented in Section 4 of this PM as follows: 1) current five-year CIP improvements (2010 to 2015) are shown in salmon, 2) near-term CIP improvements (2015 to 2025) are shown in yellow, and 3) long-term CIP improvements (2025 to 2040) are shown in green. Under each phase, the disposal options (which are presented at the far right of each phase) become more varied. The sequence presented in Figure 10 could change based on pilot and/or demonstration projects that will occur in the first five to 10 years of the 30-year plan.

10.2 Implications of FOG, Food and Food Processing Wastes, and Other Import Materials

FOG, food and food processing wastes, and other import materials were not included in this evaluation. A study conducted by EEC determined that for the year 2040, approximately 80,000 to 101,000 gallons per day of FOG is available from within the City, 20-mile surrounding plant service area, and scum and grease collected at the WPCP. It is assumed that 80 percent of the FOG would be disposed at the WPCP. On average, this could provide 80,000 lbs of total solids/day and 76,000 lbs volatile solids/day. This is approximately 19 percent of the 2040 average annual solids loading rate (412,000 lb TSS/day) and 15 percent of the 2040 peak month solids loading rate (548,000 lb TSS/day). If all of the FOG was disposed of at the WPCP, these values would increase to 32 percent and 24 percent, respectively. In addition to the FOG, the WPCP has 2,900 lbs of total solids/day and 2,800 lbs volatile solids/day of plant scum and grease that could contribute to the loading. At 2.89 million gallons (MG) of digester volume with submerged fixed covers, 1.0 to 1.7 digesters are needed for FOG and WPCP scum and grease. There are current plans to install a small pilot/demonstration FOG receiving station as part of the Phase 1 digester improvements.

The potential for food and food processing waste is even greater. The City-Wide Waste Stream Review projected that approximately 650,000 lb/day of food waste could be diverted to the WPCP. This is 58 percent higher than the 2040 average annual solids loading rate (412,000 lb TSS/day) and 19 percent higher than the 2040 peak month solids loading rate (548,000 lb TSS/day). There are no ongoing plans to take food or food processing wastes into the WPCP digester facilities.

Other potential import materials include raw sludge from the surrounding cities. The City of Palo Alto has inquired about hauling their raw biosolids to the WPCP. This import material could be as high as 100,000 lbs TSS/day at build out (2062). The raw biosolids would most likely be transported at a higher concentration and would need to be diluted before incorporation into the WPCP digesters. At 2.89 million gallon (MG) of digester volume with submerged fixed cover and 0.2 lbs VS/ft^3 loading, between one and two digesters would be needed.

11.0 SUMMARY

A summary of the major considerations and the impact on the overall strategic plan for the Biosolids Management Plan are presented in Table 8.

Table 8 Biosolids Treatment Alternatives Summary
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Future Considerations	Impact on Strategic Plan
Incorporate co-thickening with DAFTs into the biosolids program	DAFT co-thickening reduces the flow rate to the digesters, which increases the capacity of the digesters. Existing DAFT structures can be upgraded for co-thickening at an additional cost of $7 million (over the DAFT upgrade for WAS only) versus $32 million for rehabilitating four more digesters needed without DAFT co-thickening.
Aging digester facilities	Rehabilitate digesters with new submerged fixed covers, improve mixing, replace and relocate digester gas manifold pipe, improve heating system, and modify digester feed and withdrawal piping.
Incorporate fine screening of primary sludge and WAS	This was analyzed in PM 5.1. It is applicable here because removing debris from the waste stream will reduce digester O&M and provide higher quality biosolids making some disposition options more viable.
Incorporating pre-processing facilities into the biosolids program	With an increase in thickened sludge concentration and using higher loading criteria, the capacity of the existing digesters is more than sufficient for the projected sludge production, making three to six digesters available for import material. Pre-processing technology such as CAMBI will be considered based on the future volume of imported feedstocks.
Increase digester gas production and energy produced onsite	Consider receiving FOG, food and food processing wastes, and other imported material to maximize use of existing digester capacity and produce more digester gas. Implement digester improvements to maximize digester operation. Process changes such as thermophilic anaerobic digestion or pre-processing can be implemented to increase digester gas production. Heat produced can be used onsite for heat dryers and possibly off-site if an industry nearby needs heat.

Table 8 Biosolids Treatment Alternatives Summary
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Future Considerations	Impact on Strategic Plan
Continue use of lagoon storage in biosolids treatment train	Storage provides reliability and flexibility in digestion operation, dewatering, and biosolids disposition, especially for Northern California, which experiences extended periods of rain. Covered storage reduces greenhouse gas emissions and provides the ability to collect methane gas for use with the cogeneration system. Provide 180 days of storage for all alternatives.
Incorporate mechanical dewatering into the biosolids program	Many large wastewater agencies are using high-solids centrifuges to reduce the moisture content; therefore, centrifuges were used as a placeholder technology and testing of alternative technologies is recommended. Production of dewatered cake will increase available disposition options to include alternatives such as composting and land application.
Newby Island Landfill closing as early as 2025	The closing of the Newby Island Landfill has a significant impact on the biosolids program. Its closing eliminates what is currently the most cost effective disposition alternative for the WPCP.
Multiple and diversified disposition options will enhance flexibility	Increase disposition flexibility by entering into long term contracts with multiple disposition facilities that provide the WPCP with three "50-percent" disposition options. The agreements should provide the WPCP with the flexibility to change disposition options for 30 percent of the biosolids within 30 days. Multiple products and markets will further enhance flexibility and will require more staff time to manage and monitor the ongoing disposition options.
Most agencies are committing to recycling biosolids rather than disposing of biosolids	Disposition options such as soil amendment, composting, and land application that recycle biosolids rather than disposing of biosolids through landfilling are preferred.
More stringent regulations for Class B disposition	There is a general recognition that agricultural land application of Class B dewatered cake may not be a long-term biosolids management solution as available land application sites are shrinking. Local ordinances have increasingly limited the practice or attempted to ban it outright. Solano County requires that agencies land applying Class B solids in Solano County must divert a portion of their biosolids to Class A production or to a biosolids to energy process. Some county bans include Class A biosolids products. These more stringent regulations will increase competition at available sites and require longer hauling distance, which will raise transportation costs. Multiple disposition options will provide the flexibility needed for the WPCP.

Table 8 Biosolids Treatment Alternatives Summary
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Future Considerations	Impact on Strategic Plan
More stringent regulations for landfilling and ADC	There is limited ADC capacity at landfills and limited landfills accepting biosolids. Few landfills are permitted to accept biosolids and few choose to accept biosolids from outside their county. Regulations such as AB 2640 would impose a state tipping fee on all green material sent to landfills (Alameda County is considering adding fees to organic materials even if used as ADC) and San Joaquin Valley Unified Air Pollution Control District Rule 4565 is aimed at reducing emissions from landfills and essentially eliminates the use of cake biosolids as ADC. Trends could be against biosolids as ADC in the near and long term, forcing the WPCP to have other disposition options.
Participation in Regional Biosolids Facility	As the Regional Biosolids Facility develops, there may be opportunities for the City to participate in the facility and possibly locate the facility on the WPCP site. Excess heat from the facility could be used at the WPCP, especially if the biosolids are dried.
Incorporating a dried product	Dried products can be more desirable for biosolids disposition options. Dried products can be used as a soil amendment or a fuel. The phased approach provided in Section 10.0 allows incorporation of a dryer facility in the future.
Using biosolids as a renewable energy source	Thermal processes such as incineration, gasification, and others can be incorporated into the biosolids program. At this time, a biosolids to energy facility in the Bay Area would need to meet at least 23 air quality and emission criteria. The City is pursuing a gasification demonstration project with Harvest Power.
Need to consider sustainability, carbon footprint, and greenhouse gases	California State Bill AB 32 on global climate regulation will favor certain biosolids management practices. The existing open air lagoons are not recommended as part of the long term plan because their continued use will have a significantly higher greenhouse gas emission rate.
Public/political perception and opposition continues to be critical to biosolids management	Education on the benefits and value of biosolids as a resource must continue. San Jose should develop programs such as the National Biosolids Partnership model for a Biosolids Environmental Management Strategy to help with public perception and how biosolids are managed responsibly.
Emerging contaminants including pharmaceuticals, personal care products, and heavy metals	Questions about emerging contaminants and heavy metals in the biosolids continue to be raised by the public. Processes selected must meet all regulatory requirements. Production of exceptional quality biosolids should be the goal.

Table 8 Biosolids Treatment Alternatives Summary
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Future Considerations	Impact on Strategic Plan
Private sector involvement	Some wastewater agencies in California are relying on private sector involvement in their biosolids management programs downstream of dewatering including hauling, land application, composting, heat drying, product marketing and distribution, and thermal conversion processes.
Encroachment of development on southern, western, and eastern side of plant will reduce the buffer available at the WPCP.	Transition to mechanical dewatering from the existing air drying beds and implement aesthetic mitigation measures: Odor Control: Install fixed covers on the digesters, cover the lagoons, provide odor control on DAFTs and future dewatering facilities, drying facilities, greenhouses, and other potential odor sources. Noise and Visual: Contain equipment, pumps, motors, etc., where practical.

APPENDIX A – BIOSOLIDS REUSE AND DISPOSITION OPTIONS

APPENDIX A – BIOSOLIDS REUSE AND DISPOSITION OPTIONS

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1.0 REUSE AND DISPOSITION ALTERNATIVES

1.1 Current Biosolids Management Practices

The SJ/SC WPCP currently produces a Class A biosolids material through the combination of anaerobic digestion, lagoon storage and air drying. The current method of WPCP biosolids disposition is alternative daily cover (ADC) at the Newby Island Landfill, which is adjacent to the WPCP. Because the sludge is dried in soil drying beds, the material removed is part soil. Plant staff estimates that soil is between 40 and 50 percent by weight of the material removed from the drying beds.

One hundred percent of the biosolids produced at the WPCP go to the Newby Landfill. Beneficial reuse of biosolids as ADC is becoming more difficult as public opposition increases for using biosolids as ADC, emission regulations for volatile organic compounds from landfills becomes more stringent (e.g., San Joaquin Valley Unified Air Pollution Control District Rule 4565), and the trend to reduce compostable material in landfills increases (e.g., AB 2640 and Alameda County adding fees and taxes to organic material sent to landfills).

It is anticipated that the Newby Island Landfill will be closing around 2025 (Allied Waste Services of Santa Clara County website). This, along with the trends in California making it more difficult to continue with current WPCP disposition practice, will require the WPCP to find alternative disposition methods. It is recommended that multiple disposition routes be considered and that a strategy be implemented, which includes a minimum of three “50 percent disposition routes” to provide flexibility and reliability.

1.2 Recent Solids Characteristics

The solids characteristics most pertinent to biosolids recycling include solids concentration, metals concentrations, pathogen densities, and vector attraction reduction. Recent solids characteristics from the SJ/SC WPCP are described below.

The total solids concentrations for biosolids from the plant averaged above 65 percent during the 2002 through 2007.

Average metal concentrations for 2010 are shown in Table A-1, along with the 40 CFR 503.13 “Table 3” pollutant concentrations.

The WPCP achieved compliance with 40 CFR 503 Class A pathogen density requirements.

The WPCP achieved compliance with 40 CFR 503 vector attraction reduction requirements during 2007 by reducing volatile solids concentrations by 38 percent or greater in the anaerobic digestion process and through further stabilization in the lagoons. Table A-2 summarizes the 2007 results.

Table A-1	Average 2010 Biosolids Metal Concentrations San José/Santa Clara Water Pollution Control Plant Master Plan City of San José		
Constituent	**Average (mg/kg [a])**	**Pollutant Concentration Limit [b] (mg/kg [a])**	**Compliance?**
Arsenic	6.6	41	Yes
Cadmium	Non detect	39	Yes
Copper	170	1500	Yes
Lead	21	300	Yes
Mercury	0.57	17	Yes
Molybdenum	3.3	- [c]	Yes
Nickel	81	420	Yes
Selenium	3.5	100	Yes
Zinc	310	2800	Yes

Source:
[a] Milligrams per kilogram, dry weight basis.
[b] From 40 CFR 503.13, Table 3.
[c] Limit is under reconsideration by USEPA. Biosolids may not exceed 75 mg/kg molybdenum until a new pollutant concentration limit is established

Table A-2	Vector Attraction Reduction Compliance at WPCP, 2007 San José/Santa Clara Water Pollution Control Plant Master Plan City of San José	
Month	**Average Volatile Solids Reduction in Digesters [a], %**	**Compliance? [b]**
Jan	51	Yes
Feb	20	Yes
Mar	20	Yes
Apr	50	Yes
May	50	Yes
Jun	50	Yes
Jul	48	Yes
Aug	45	Yes
Sep	44	Yes
Oct	47	Yes
Nov	40	Yes
Dec	49	Yes

Source: .
[a] Van Kleeck Method used to calculate volatile solids reduction, except where noted.
[b] 38 percent or greater reduction required per 40 CFR 503.33(b)(1).

Nutrient monitoring is required for the land application of biosolids, so that the biosolids loading rate to the soil can meet the fertilizer needs of the crop that is grown. Because the WPCP biosolids are not land applied, nutrient data is not collected.

1.3 Industry Trends

General industry trends towards biosolids management in California's more urban locations include the following:

- Biosolids quantities are increasing due to population growth and increasingly tighter clean water regulations.
- Most wastewater agencies remain committed to recycling biosolids rather than disposing of them.
- There is a general recognition that agricultural land application of Class B dewatered cake is not a long-term biosolids management solution. Local ordinances increasingly limit the practice or ban it outright. Some county bans include Class A biosolids products.
- The shrinking inventory of permitted land application sites and increasing county restrictions in California have forced wastewater agencies to haul biosolids greater distances, raising transportation costs. Increased competition for available sites has increased application costs.
- Large wastewater agencies are increasingly turning to high-solids centrifuges for dewatering to reduce the moisture content of their biosolids and reduce hauling costs.
- Some wastewater agencies are converting to advanced anaerobic digestion processes, such as thermophilic or temperature-phased digestion, to achieve Class A pathogen status, increase volatile solids destruction, and increase biogas production.
- Large wastewater agencies in California are often relying on private sector involvement in their biosolids management programs downstream of the dewatering function, including hauling, land application, composting, heat drying, product marketing and distribution, and thermal conversion processes.
- Wastewater agencies are increasingly considering production of biosolids products with improved aesthetic qualities, such as compost or heat dried pellets, for their recycling programs.
- Wastewater agencies are pursuing other, sometime unique, outlets for biosolids besides agriculture, including biosolids as renewable fuel in cement kilns, or deep well injection in petroleum oil fields to enhance natural gas production.

- Wastewater agencies are identifying the need for, and pursuing, regional solutions to biosolids management.

1.4 Biosolids Markets and Disposition

This section considers potential outlets for current and potential future biosolids products produced by the WPCP, whether for beneficial use or disposal. The discussion begins with consideration of the characteristics of the products that could potentially be produced, followed by discussion of the potential markets for the products.

1.4.1 Biosolids Products

Biosolids products can take a number of different forms, as described below.

1.4.1.1 Dewatered Cake

Dewatered cake represents the most basic and most common form of biosolids products. Dewatered cake is produced using mechanical dewatering technologies, such as belt filter presses or centrifuges. Dewatered cake products typically consist of 85 to 70 percent moisture (15 to 30 percent solids) and have a gelatinous, bread dough consistency. The color, odor, and pathogen density characteristics of dewatered cake products are a function of the processes used to treat the biosolids prior to dewatering. Dewatered cake products can be produced that have pathogen densities that achieve Class A standards. The typical reaction by the general public to the overall appearance of dewatered cake varies widely from curiosity and fascination to suspicion and revulsion.

1.4.1.2 Soil Amendments

Dewatered cake biosolids can be mixed with various other materials and processed to create soil amendments (such as compost) or topsoil replacement products. The list of potential feedstock materials that can be used include green waste, wood chips, sawdust, sand, lime, cement kiln dust, wood ash, and others. Soil amendment products are generally treated to Class A pathogen density standards. The soil amendment class of products usually has a pleasant, earthy odor and pleasing overall appearance to the general public.

1.4.1.3 Dried Products and Fertilizers

Dewatered cake biosolids can be dried to form fertilizer products. Drying methods include solar drying and thermal drying. This class of products can take a wide variety of forms. Solar dried biosolids typically contain less than 40 percent moisture and can have a dusty, soil-like appearance. Solar dried products may meet Class A pathogen density standards. Solar drying is usually land-intensive; and therefore, may not be a practical option for an urbanized city such as San Jose.

Thermally dried biosolids products generally contain less than 10 percent moisture. The product appearance is a function of the drying technology used, and can range from uniform spherical pellets with little dust to angular, non-uniform, dusty products. The thermally-dried biosolids products generally have a slightly stronger, more pungent odor than the soil amendment products, but fewer odors than dewatered cake. The overall appearance of thermally-dried products is generally acceptable to the general public. Uniform, spherical products with low dust content are generally preferred over angular, non-uniform, dusty products.

1.4.1.4 Other Products

Several other types of biosolids products can result from specific biosolids treatment processes, including:

- Ash: The end product of biosolids combustion for energy recovery or disposal is ash.
- Lightweight Aggregate: Vitrification processes (e.g., Minergy) create a lightweight glass aggregate product.
- Fuel: Pyrolysis processes create char or oil fuel products.

1.4.2 Agricultural Land Application Market – Class B Biosolids

Agricultural land application refers to the use of biosolids in bulk as a soil amendment or fertilizer to grow agricultural crops. Biosolids are applied at or below the agronomic rates to ensure that the nutrients in the biosolids are used up by the crop, rather than accumulating in the soil and leaching to groundwater. The biosolids add organic matter to the soil, which is a valuable addition to many California soils that are typically very low in organic matter.

Class B biosolids that are to be recycled through agricultural land application generally take the form of dewatered cake. Land application of Class B dewatered cake has been attractive to wastewater agencies because it has been one of the lowest cost ways to manage biosolids. It has also become increasingly controversial in California and has been banned or restricted by a number of counties, as described in the previous section.

In light of the food processor policies towards biosolids, a farmer's use of biosolids could potentially affect the value of prime farmland where vegetables could be grown and marketed to food processors. Many farmers perceive that the potential benefits from using biosolids do not outweigh the risks associated with crop and land values. Therefore, much of the agricultural land application occurs on marginal ground where the growth of high-value crops is not possible due to soil quality characteristics. Low value crops, such as hay used for animal feed, are typically grown.

Land application of Class B biosolids is mostly accomplished by firms that specialize in biosolids management. The firms are under contract with the municipal wastewater agencies. The firms solicit interested farmers and obtain the required permits. The firm spreads the biosolids and completes the monitoring required by the permits. The farmer receives free fertilizer, but is generally not paid a tipping fee. Proactive public outreach is generally required in communities where land application is to occur because dewatered cake biosolids do not look or smell like materials commonly used in agriculture. Neighbors of land application sites may react with fear and concerns about the practice if not given proper information on the safety and benefits.

Agricultural land application is a seasonal market in Northern California. Land application activities are generally not possible (and may be prohibited by local regulations) during the wet season, November through April. Farm fields are usually too wet during this time of the year to allow access to the heavy equipment needed to spread biosolids. Dry season application (May through October) must be scheduled around the growth cycle of the crops; biosolids cannot be applied while a crop is being grown. Farm land that is not irrigated (dryland farming) is ideal for biosolids land application because biosolids can be applied throughout much of the dry season; the farmer plants his crop just prior to the wet season and harvests the crop in late spring or early summer.

Agricultural land application does not appear to be a sustainable biosolids management practice for wastewater agencies that serve large urban areas, such as the San Jose area and the greater Los Angeles area. Rural communities in California are becoming increasingly resistant to accepting waste products that are transported from distant urban centers, particularly with dewatered cake products. Agricultural land application of dewatered cake may provide a short-term outlet for biosolids, but should not be considered a permanent biosolids management solution. As counties located close to the San Jose place greater restrictions on agricultural land application of Class B biosolids plants will be forced to haul dewatered cake longer distances. Counties that ban or restrict Class B biosolids reuse may also limit Class A biosolids products.

1.4.2.1 **Dedicated Land Application Sites**

Land application on land owned by wastewater agencies appears to be more sustainable than land application on distant private property. Many small wastewater agencies in California apply their biosolids to property they own that is adjacent to or near the wastewater treatment plant of origin. Often these dedicated land application sites are located within the incorporated limits of the city that operates the site.

Dedicated land application sites are generally accepted by the local agricultural community, provided that they remain a good neighbor with respect to odors, dust, and other nuisance conditions. The agricultural community's concern over the fate of heavy metals in biosolids and soil contamination is addressed by permanent public agency ownership of the land.

Purchase of farmland outside the wastewater agency's county presents greater risk than development within the city or county of origin. Vallejo Sanitation and Flood Control Agency owns and operates a farm on Tubbs Island, located in adjacent Sonoma County. The award-winning project has a long, successful operating history. However, the City of Los Angeles' purchase of an established site in Kern County has not appeared to reduce Kern County resident's resistance to land application of biosolids originating from urban Southern California. The "Green Acres" farm is located within unincorporated Kern County, and is subject to the provisions of a land application ban that was approved by Kern County voters through the local initiative process in June 2006. Therefore, development of a dedicated land application site in another county presents considerable risk and is not considered feasible.

1.4.2.2 Exportation Out-of-State

Exporting biosolids out of the state of origin is or has been practiced by a number of large wastewater agencies, including the City of New York, District of Colombia Water and Sewage Authority, City of Los Angeles, and Orange County Sanitation District. Transport can be by truck or rail, depending on the haul distance. Biosolids from Southern California have been successfully exported by truck to several Arizona counties for beneficial use. However, Orange County Sanitation District encountered significant local opposition in 2003 when it began exporting biosolids by truck to Nye County, Nevada. The Sacramento Regional County Sanitation District received a proposal from a large, fully-permitted ranch located north of Reno (in Nevada) to accept biosolids transported by rail as a long-term (15 year) solution. The proposal was not accepted; however, it demonstrates that out-of-state exportation may be a viable alternative for Northern California wastewater agencies. Pursuit of out-of-state markets for Class B biosolids is not recommended at this time, but should be considered in the future if solutions located within California become infeasible or prohibitively expensive.

1.4.3 Agricultural Land Application Market – Improved Biosolids Products

Biosolids can be processed to create products with improved characteristics when compared with the existing Class B dewatered cake. The improved products can range from Class A dewatered cake to heat dried pellets, compost, or other soil amendments. The aesthetic qualities of this broad category of “improved products” vary widely, as will the marketability of the products for agricultural land application.

1.4.4 Class A Dewatered Cake

Upgrading treatment to produce Class A dewatered cake reduces the pathogen density in the biosolids, but does not improve the aesthetic qualities of the product. From a State and Federal regulatory perspective, Class A dewatered cake is a product that does not require regulation to protect human health and the environment. However, some counties in California have chosen to regulate (or ban) the use of Class A biosolids in agriculture within their jurisdictions. Similarly, food processing company policies against biosolids apply equally to all products irrespective of pathogen density or product aesthetic qualities. Therefore, the market for Class A dewatered cake is somewhat similar to the market for Class B dewatered cake, although with less regulation.

Neighbors of land application sites cannot distinguish between Class A and Class B dewatered cake products, because they look and smell the same. Therefore, production of a Class A dewatered cake product does not relieve responsibility for providing proactive public outreach to communities where application will occur.

1.4.4.1 Dried Biosolids - Pellets and Granules

The only Northern California heat drying facility in operation is located at the Sacramento Regional Wastewater Treatment Plant. Fertilizer pellets produced at the facility are used in bulk for agricultural purposes to grow animal feed crops within Sacramento County. The pellets are similar in size and shape to conventional granular fertilizer materials, and conventional spreading equipment is used. The use of the product is not regulated at the Federal, state, or local (Sacramento County) levels. The contractor that produces and distributes the product maintains a low profile. Nearby local biosolids bans (e.g., San Joaquin County, Delta Protection Commission) and food processing company policies do not discriminate between types of biosolids products; and therefore, apply to the heat dried pellet product. Nevertheless, use of the product in bulk agriculture appears to be successful.

The market potential for heat dried pellets in agriculture appears to be greater than for Class A dewatered cake due to the improved aesthetic qualities of the product. The product appearance and use resembles fertilizer rather than manure. The pellets can be produced to be similar in size and shape to conventional fertilizer materials. The product contains minimal moisture, so truck traffic is minimized. Conventional spreading equipment is used to apply the product. Neighbors of sites where the product is used are less likely to react negatively. The target market for the product would be similar to dewatered cake biosolids; marginal soils used to grow animal feed crops. Product revenue is expected to be minimal due to the low cost of competing conventional fertilizing materials, but the use of the product will likely prove to be more-acceptable to the receiving communities than dewatered cake.

1.4.4.2 Compost and Other Soil Amendments

State mandates to divert waste from landfills has resulted in large quantities of green waste compost flooding the soil amendment markets. Soil amendments are generally only used in agriculture to correct soil problems. The market for compost and other soil amendment products derived from biosolids in agriculture is expected to be limited due to the availability of competing products.

A subclass of biosolids soil amendment products has high residual pH values due to the use of alkaline materials (e.g., lime) in the treatment process. In some parts of the country, high pH biosolids products are popular with growers due to their need to raise the pH of acidic soils and the low cost of biosolids products compared with other liming agents. However, there is little market in Northern California for high pH biosolids products due to generally calcareous soils and availability of low cost liming products (e.g., sugar beet lime) that are more-readily accepted by the agricultural community than biosolids.

1.4.5 Landfill Markets

Biosolids products may be either disposed or put to beneficial use in landfills, as described below. A dewatered cake product is generally the most economical form of biosolids to dispose or use at landfills.

1.4.5.1 Disposal

Some landfills allow disposal of biosolids. Each landfill has its own requirements for biosolids disposal with respect to total solids content and specific chemical constituent concentrations.

1.4.5.2 Alternative Daily Cover

Some landfills are permitted to use biosolids as Alternative Daily Cover (ADC), as shown in Table A-4. At these landfills, biosolids are mixed with other materials to serve as a daily cover for the solid waste placed in the landfill, reducing the need to use soil for that purpose. ADC is considered to be a beneficial use, even though the materials are ultimately entombed within the landfill. ADC use is regulated by the California Integrated Waste Management Board, and is limited to 25 percent of the total landfill cover requirements. Therefore, there is limited ADC capacity available for use by Bay Area wastewater agencies.

1.4.5.3 Bioreactor Landfills

Bioreactor landfills are operated in ways to rapidly degrade organic waste. The increase in waste degradation and stabilization is accomplished through the addition of liquid to enhance microbial processes and increase the production of landfill gas. Air is also sometimes added to bioreactor landfills to enhance aerobic decomposition of organic wastes. The bioreactor landfill concept is very different from conventional sanitary landfilling practices and regulations that emphasize minimizing liquid addition and creating “dry tomb” conditions within landfills. The addition of the moisture, organic matter, and nutrients in biosolids to bioreactor landfills can potentially increase landfill gas production, which in turn can be used to produce electricity.

There is currently only one bioreactor landfill project in California, located in Yolo County, but the California Integrated Waste Management Board reports significant interest in utilizing bioreactor landfill technologies at other locations in California. The USEPA has proposed to issue a Federal rule that will allow states to issue site-specific research, development, and demonstration permits to landfills that will allow the addition of liquids to landfills. If the proposed regulations are adopted there may be more bioreactor landfill projects in California, which in turn could increase the number of landfills that accept biosolids.

1.4.5.4 Horticulture and Silviculture - Product Distribution and Marketing

High quality Class A biosolids fertilizer or soil amendment products can be distributed and marketed to horticulture and silviculture (tree farming) users. This broad category of users comprises most other users besides commercial agriculture.

1.4.5.5 Dried Pellet Products

The Bay Area Clean Water Agencies (BACWA, 2006) and Sacramento Regional County Sanitation District (SRCSD, 1996) have both conducted extensive studies to investigate potential markets for heat dried pellet biosolids products in Northern California. Both studies identified substantial market potential for high quality heat dried biosolids pellets. The potential markets include:

- Fertilizer blending operations;
- Parks and golf courses; and,
- Bagged retail sales.

The information from these studies indicate that potential market opportunities for biosolids produced by San Jose may be available. Furthermore, heat drying removes most of the moisture from the biosolids, reducing the total mass of product; and therefore, substantially increasing the radius of economical truck transport. SRCSD is currently the only producer of heat dried biosolids pellets in Northern California. The entire SRCSD product is used in bulk use in agriculture within Sacramento County; therefore, substantial market potential remains for other wastewater agencies.

1.4.5.6 Soil Amendment Products

The City of Santa Rosa currently operates the only biosolids composting operation in the Bay Area, processing approximately 5 dry tons of biosolids daily in an agitated bed system (City of Santa Rosa, 2003). The product is marketed in bulk to local users. Another notable compost producer historically was the East Bay Municipal Utility District, which operated a successful composting program for many years until their aerated static pile composting facility was shut down in the 1990s, primarily due to nuisance odor conditions.

Biosolids soil amendment products must compete with similar products produced from other feedstock, such as green waste compost. Some existing products are labeled as “not produced from biosolids”. The potential markets for biosolids soil amendment products include:

- Soil blending operations;
- Landscape contractors;
- Parks and golf courses; and,
- Bagged retail sales.

Solid waste agencies have been required to divert green waste from landfills to achieve mandated diversion goals. The result has been a major increase in the volume of compost produced in California, which in some cases has flooded markets.

1.4.5.7 Markets within the WPCP Service Area

High quality biosolids products could potentially be used on parks, golf courses, playgrounds, schools, and other landscaped areas within the WPCP Service Area. An inventory of publicly-owned acreage has not been developed for this master plan.

The demand would likely be highly seasonal, with most use occurring during the spring and autumn months. There would likely be less demand for a soil amendment product such as compost, due to the difficulty in effectively using compost products on established turf areas.

1.4.6 Land and Mine Reclamation Market

Biosolids have been used successfully to reclaim land damaged by mining operations, particularly in the mid-Atlantic area (Pennsylvania) and in British Columbia (Canada). The biosolids add vital nutrients and organic matter to the damaged soils, enhancing restoration efforts. Class B dewatered cake biosolids are added in a one-time application prior to seeding with a mixture of grasses and legumes. Research has found that a high application rate of biosolids is required to provide sufficient organic matter and nutrients to ensure a sustainable vegetative cover. The high application rate can result in a nitrate spike in underlying groundwater, but this is seen as less of a water quality problem in the states where the land reclamation activities are pursued than the surface water quality problems caused by lands disturbed by the mining activities.

There are currently no land or mine reclamation projects using biosolids in California, although significant land areas exist that are disturbed by mining operations. California has an anti-degradation policy towards groundwater that could prove to be an obstacle to the high rates of biosolids application found to be successful in the mid-Atlantic area. Significant effort would be required to obtain regulatory approvals in California, due to the lack of project precedent.

1.4.7 Construction Products Market

Potential markets for products created from vitrification processes are specific to the characteristics of the materials. Lightweight glass aggregate products from vitrification can be used in the manufacture of ceramic floor tile, abrasives, concrete additives, asphalt paving mixtures, or composite roofing shingles. Generally these types of processes have been implemented by private companies with long-term contracts to receive dewatered cake biosolids from wastewater agencies. The implementing companies are responsible for marketing the products they produce. Additional market study is highly recommended prior to substantial investment by the WPCP in a publicly owned and operated facility of this nature.

Beneficial uses for non-hazardous ash from biosolids incineration include use as an additive in the production of blocks used for erosion prevention, bricks, and novelty products. Neither of the two agencies using incinerators located in Northern California uses their ash in these ways. The two agencies are the Central Costa County Sanitary District (CCCSD) and the City of Palo Alto. The CCCSD disposes its incinerator ash in a landfill. The Palo Alto incinerator ash contains sufficient phosphorus to make it attractive as a soil amendment additive. Palo Alto therefore recycles its incinerator ash by transporting it to a soil blender, who mixes it with compost to form a soil amendment product.

1.4.8 Fuel and Energy Markets

Energy can be derived from biosolids or from biogas generated from biosolids processing, as described below.

1.4.8.1 Markets for Biosolids

Potential markets for products created from pyrolysis processes are specific to the characteristics of the materials. Char or oil fuel products from pyrolysis can potentially be used for energy production or in cement kilns. Generally these types of processes have been implemented by private companies with long-term contracts to receive dewatered cake biosolids from wastewater agencies. The implementing companies are responsible for marketing the products they produce. Additional market study is recommended prior to substantial investment in a publicly owned and operated facility of this nature.

Dried biosolids pellets have an energy content of approximately 9,500 BTU per pound and can potentially be used as fuel. Potential future markets for dried biosolids pellets include waste-to-energy facilities and cement kilns. The cement industry has recently become interested in biosolids as a renewable fuel source. User requirements are specific to each cement kiln. The combustion ash is integrated into the cement product.

Increasing interest in renewable energy sources could lead to increased production of biomass and bioenergy crops, such as hybrid poplar trees, corn for ethanol production, or seed crops to create the vegetable oils used in the production of biodiesel. The use of biosolids to grow these crops would be subject to local agricultural regulations and use restrictions.

1.4.8.2 Markets for Biogas

Anaerobic digestion processes create a biogas product, which is a mixture of methane and carbon dioxide. Biogas can be used as fuel in internal combustion or gas turbines that are connected to generators that produce electricity. Fuel cells are another technology that can be used to create electricity from biogas.

Biogas is considered to be a renewable energy source, and increasing awareness of global warming issues and rising fossil fuel prices is leading to increased interest in creating new sources of biogas and enhancing biogas production at existing anaerobic digestion facilities. Programs are being developed to enhance biogas production in wastewater treatment plant anaerobic digestion systems by direct addition of fats, oils, and grease (FOG) and liquefied food wastes. EBMUD has a successful program that incorporates trucked-in FOG and food processing wastes. South Bayside System Authority in Redwood City has been adding trucked-in FOG directly to anaerobic digesters since the 1990s.

1.4.9 Dedicated Land Disposal

Surface disposal of biosolids is practiced by several wastewater agencies in Northern California, including Sacramento Regional County Sanitation District, Dublin-San Ramon Services District, and Las Gallinas Valley Sanitation District. All of the surface disposal sites are located on treatment plant property. Biosolids are mixed into the soil at these dedicated land disposal sites at high rates. Vegetation is not grown, but soil microbes decompose the biosolids and use or transform much of the nutrients. The dedicated land disposal sites are lined or otherwise highly controlled, depending on the subsurface geological conditions.

The dedicated land disposal (DLD) process is regulated as a waste disposal site under State Title 27. Although use of DLDs eliminate the cost of handling and disposal during operation, there is a potential and unknown cost associated with ultimate closure of the DLDs. Due to the unknown future costs and regulation, this system is eliminated.

2.0 DISPOSITION ALTERNATIVES

This section presents disposition alternatives for the WPCP. Included in this section is a discussion on the existing disposition route, a survey of disposition routes used by large California agencies and agencies outside of California, development of alternatives disposition routes, and disposition alternatives.

2.1 SURVEY OF LARGE CALIFORNIA AND US AGENCIES

Multiple biosolids disposition routes are common for the larger agencies in California. The WPCP is unique among large wastewater agencies in California in that there is only one disposal route for biosolids produced at the WPCP. The Los Angeles County Sanitation Districts (LACSD) has ten routes for biosolids disposition. Table A-3 provides a list of biosolids disposition routes for the major agencies in California.

These large California agencies do not necessarily have equal distribution of biosolids between the disposition routes; however, diversification in options is important for their flexibility. Land application and landfill disposition are very common for California agencies. Composting and heat drying are proven technologies that an increasing number of agencies are exploring as disposition routes as well.

Table A-3	Biosolids Disposition Routes – California Agencies San José/Santa Clara Water Pollution Control Plant Master Plan City of San José	
Treatment Facility	**Total Biosolids Disposed (dry tons/day)**	**Number of Disposition Locations**
Los Angeles County Sanitation District – Joint WPCP	348	10
Los Angeles - Hyperion	185	5
San Diego Metro Biosolids Center	87	2
San Jose WPCP	85	1
Orange County Sanitation District	132	6
Sacramento Regional County Sanitation District	58	2
Fresno	43	3
East Bay Municipal Sanitation District	41	2
San Francisco Public Utilities Commission – Southeast Plan	38	5

A survey of several large agencies in the US outside of California was also conducted. The survey showed a different trend. Because there are less restrictions, U.S. agencies outside of California are less diverse in their disposition options. Five of the agencies in the survey have only one disposition option and Chicago Metro is the only agency in the survey to have three options. Landfill is not a disposition option for any of the agencies surveyed outside of California. Land application is the most prevalent option with composting and heat drying as the next most common options. Additionally, incineration is used at some facilities.

2.2 DEVELOPMENT OF ALTERNATIVE DISPOSITION ROUTES

As the liquid treatment process alternatives were developed based on the discharge requirements to be achieved, biosolids process train alternatives are developed based on the disposition options for the final material. The disposition options define the desired or necessary products. Treatment options that will produce those products are identified, evaluated, and combined to form the plant-wide biosolids alternatives. Figure A-1 shows a simplified process schematic of treatment trains and disposition routes. The class of biosolids material shown indicates what is required at the point of disposition. The level of treatment necessary to produce the class of biosolids required can be achieved through the combination of digestion, pre- and/or post-processing. A more detailed discussion on disposition routes specific to the WPCP is provided in Section 2.3.

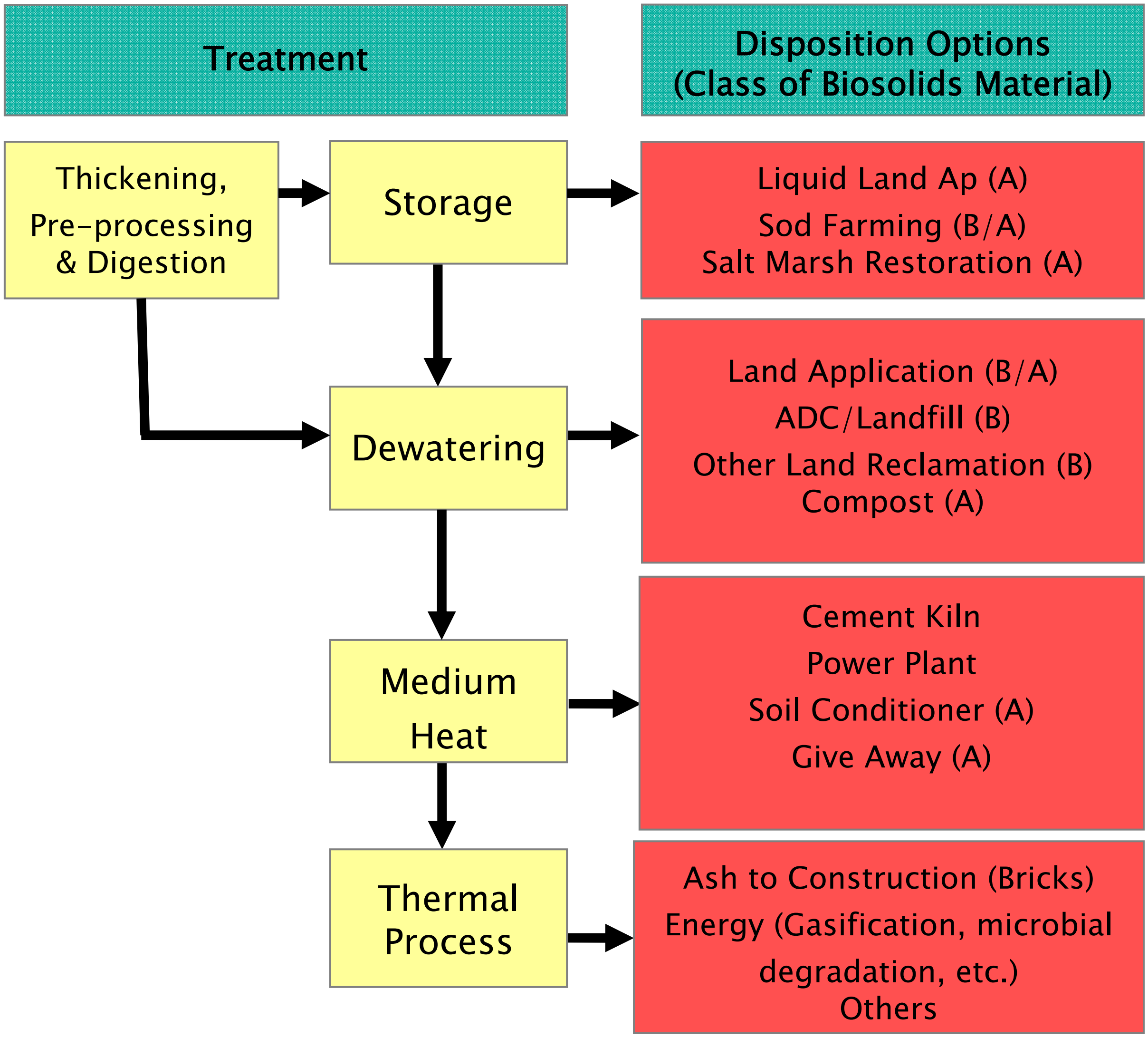

Figure A-1 Treatment Trains to Produce Specific Biosolids Products

There are also biotechnology disposition options available that are not shown in Figure A-1. These biotechnologies include bioplastics, biosurfactants, bioflocculants, biopesticides and enzymes, and biosorbents. Although these technologies have been around for many years, most of them are still not widely used as biosolids disposition methods on a large scale. (Brar, et al.) These technologies should be monitored as they advance and develop.

2.3 DISPOSITION ALTERNATIVES

There are several locations around California and one location in Nevada that offer viable disposition routes for the WPCP. Arizona also has a variety of disposition alternatives available; however, because of the distance from San Jose to Arizona, the City requested that the Arizona disposition alternatives not be explored further at this time. It should be noted that this analysis only contains those disposition routes contacted for this investigation. There are other disposition routes in Northern and Southern California.

The disposition options vary in cost (see Table A-4 for California and Nevada options). The cost for each disposition route depends on tipping fee and transportation costs. The transportation costs are associated with the distance travelled.

Table A-4 2010 Biosolids Disposition Costs
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

		2010 Disposition Cost		
Product	**Location**	**($/dry ton)**	**($/wet ton)**	**($/yr)[3]**
Current Operation	Newby Landfill	58[(1)]	23	1,420,000
Land App (Local)	Silva Ranch, Herald	50[(2)]	40	1,220,000
Landfill (Local)	Vasco, Livermore	55[(2)]	44	1,350,000
Landfill (Remote)	Salinas	74[(2)]	59	
Landfill (Local)	Manteca	82[(2)]	66	2,010,000
Land App (Local)	Silva Ranch, Herald	160	40	3,910,000
Landfill (Local)	Vasco, Livermore	176	44	4,300,000
Composting (Off-Site)	Synagro, Merced	180	45	4,400,000
Landfill (Remote)	Salinas	235	59	
Landfill (Local)	Manteca	263	66	6,430,000
Composting (On-Site)	SJ/SC WPCP	288	72	7,040,000
Composting (Off-Site)	Synagro, Kern	340	85	8,310,000
Land App (Remote)	Gerlach, NV	340	85	8,310,000

(1) Value calculated based on 80 percent solids dryness and 50 percent of the solids are soil due to current method of removing biosolids from the drying beds.
(2) Value calculated based on 80 percent solids, all other values calculated based on 25 percent solids.
(3) Cost based on all biosolids to this disposition option.

Disposition cost also depends on the dewatering/drying of the biosolids' product. Current operation at the WPCP produces a cake with 80 percent solids. Not all disposition routes, such as land application or composting, want or will accept a cake with 80 percent solids. Land application sites, such as the Silva Ranch Land Application Site, need special permitting to accept 80 percent solids. Composting requirements are such that anything over 40 percent solids will need additional moisture. Therefore, it will be necessary to provide a product with 20 to 30 percent solids for these alternatives.

In the near-term, the WPCP can diversify by adding one or more of the available local disposition routes such as Newby Island, Vasco, and Manteca. The local (closest) land application site that accepts 80 percent solids is Silva Ranch Land Application Site. A potential near-term disposition scenario could include diversification to an additional local landfill and a land application site (see Table A-5). By establishing multiple disposition options, logistics could be put in plane to divert material between options if another becomes unavailable. Table A-5 shows the estimated cost for each of the disposition routes assuming 80 percent of all biosolids produced to Newby Island Landfill and 10 percent each to Manteca and Silva Ranch.

Table A-5 Example Near-Term Multiple Disposition Options
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

		2010 Disposition Cost[1]		
Product	**Location**	**($/dry ton)**	**($/wet ton)**	**($/yr)**
Landfill (Local)	80% to Newby Landfill	58	23	1,136,000
Landfill (Local)	10% to Manteca	100	40	171,000
Land App (Local)	10 % to Silva Ranch	110	44	488,000
Total		**$67.40**	**$26.80**	**1,795,000**
Current Operation	**100% to Newby**	**58**	**23**	**1,420,000**

Note:
(1) Assumes that current method of drying is used with final product 50 percent biosolids/50 percent soil.

In the long-term the WPCP can further diversify with remote landfills, land application sites, composting and/or other commercial or regional facilities. The local and remote locations in California and Nevada are shown in Figure A-2.

2.4 OVERALL MARKET AND PRODUCT ASSESSMENT

Table A-6 presents a simplified assessment of the current markets for biosolids products in Northern California, as well as opinions of the future market potential. The table reflects the increasing wastewater industry awareness of limits to agricultural land application of biosolids and a needed shift to other markets.

Table A-7 presents the compatibility of various biosolids products with the future markets. A product that is compatible with multiple markets presents lower risk to the wastewater agency than a product that is compatible with only a few. The table shows that heat dried pellets and compost (including compost-like soil amendments) have the greatest compatibility with multiple markets.

The disposition methods used by other California agencies are summarized in Table A-8. The WPCP is unique among large wastewater agencies in California in that there is only one disposal route for biosolids produced at the WPCP. Other agencies have multiple disposition routes, even up to ten routes as is the case for the LA County Sanitation Districts. Large California agencies do not necessarily have equal distribution of biosolids between the disposition routes, however, diversification in options is important for future

Table A-6 Market Assessment
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Market	Current Market Assessment	Opinion of Future Market Potential	
Agricultural Land Application	Increasingly problematic, trending towards increased local restrictions and/or bans. Food processor policies render prime farmland unavailable. Best opportunities are on marginal soils growing animal feed crops.	<u>Dewatered Cake Products</u> Trends towards local restrictions and/or bans likely to continue. Class A cake market potential somewhat better than Class B cake due to reduced regulatory burden.	<u>Improved Products</u> More-likely to be accepted by receiving communities (compared to dewatered cake products) due to improved product aesthetics. Local restrictions and/or bans may apply to improved products. Dried products can be economically hauled further than cake products.
Landfill – ADC	Good, but limited ADC capacity available.	Increasing demands for limited capacity likely to continue as agricultural land application becomes less feasible.	
Landfill – Bioreactors	Currently no available projects in California.	Interest in renewable energy could increase number of bioreactor landfills. Proposed regulatory changes could increase number of bioreactor landfills available.	
Landfill – Co-disposal	Limited availability. Good back-up option.	Limited availability. Good back-up option.	
Horticulture and Silviculture – Distribution and Marketing	High quality product and active marketing required	High quality product and active marketing required.	
Land and Mine Reclamation	Currently no projects in California.	Lack of precedent in California. Regulatory hurdles to implementation.	
Construction Products	Currently no projects in California.	Lack of precedent in California. Markets are product-specific. Active marketing required.	
Fuel and Energy – Biosolids	Currently no projects in California.	Projects currently being developed in California. Regulatory mandates for power companies to increase renewable energy portfolios combined with rising prices for fossil fuels could significantly increase interest in biosolids as a fuel source. Cement industry interest in biosolids as renewable fuel source is increasing.	
Fuel and Energy - Biogas	Biogas commonly used to co-generate electric power and provide heat.	Increasingly valuable biogas uses for co-generation systems, fuel cells, and direct energy to dry biosolids.	
Dedicated Land Disposal	Practiced by several wastewater agencies in Northern California.	Dedicated Land Disposal sites at the San Jose WPCP may be better sited for other land uses.	

Table A-7 Product and Market Compatibility
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Products	Markets							
		Landfill						
	Agricultural Land Application	ADC	Bioreactors	Co-Disposal	Horticulture and Silviculture – Distribution and Marketing	Land and Mine Reclamation	Construction	Energy
Class B dewatered cake	♦	♦	♦	♦		♦		
Class A dewatered cake	♦	♦	♦	♦		♦		
Compost	♦	♦	♦	♦	♦	♦		
Alkaline soil amendment		♦	♦	♦				
Heat dried pellets	♦	♦	♦	♦	♦	♦		♦
Construction products		♦		♦			♦	
Char and/or oil								♦
Ash				♦	♦			

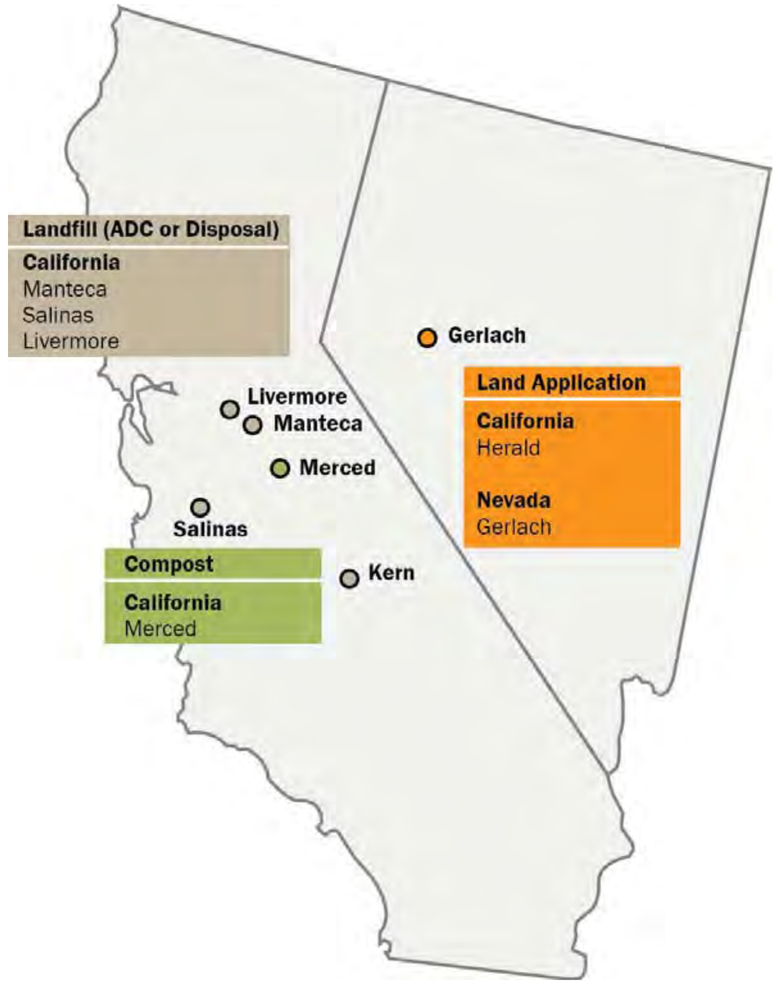

Figure A-2 Potential Disposition Routes for WPCP Biosolids in California and Nevada

flexibility. Land application and landfill disposition are very common for California agencies. Composting and heat drying are proven technologies that an increasing number of agencies are exploring as disposition routes as well.

Large agencies around the US show different disposition trends. Disposition methods of large U.S. agencies are shown in Table A-9. Land application is the most prevalent option with composting and heat drying as the second most common options. Additionally, incineration is used at two facilities. The U.S. agencies are less diverse in their disposition options than the California agencies. Five agencies have only one disposition option and Chicago Metro is the only agency to have three options. Landfill is not a disposition option for any agency.

There are many locations around California and one location in Nevada that offer viable disposition routes for the WPCP. Arizona also has a variety of disposition alternatives. Detailed information of the cost for various disposition methods and locations for the WPCP is provided in Table A-10.

Table A-8 California Agencies Biosolids Disposal Methods
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Agency	Treatment Facility	Total Biosolids Disposed (tons/day)	Land Application		Landfill Disposal or Cover (tons/day)	Biosolids Processing Facilities			Cement Kiln (tons/day)	Deep Well Injection (tons/day)	Surface Disposal (tons/day)	Number of Disposition Routes
			Biosolids Quantity (tons/day)	Disposal Site (County)		Composting (tons/day)	Alkaline Treatment (tons/day)	Heat Drying (tons/day)				
Los Angeles County Sanitation District	Joint Water Pollution Control Plant	348	34	Maricopa	81	181	37	0.2	6	0	0	10
			9	Yuma								
City of Los Angeles	Hyperion Treatment Plant	185	174	Kern	0	8	0	0	0	2	0	5
San Diego Metropolitan Wastewater Department	San Diego Metro Biosolids Center	87	13	Yuma	73	0	0	0	0	0	0	2
City of San Jose	San Jose / Santa Clara Water Pollution Control Plant	85	0	-	85	0	0	0	0	0	0	1
Orange County Sanitation District	Plant 2	71	25	Yuma	0	35	11	0.1	0	0	0	6
Sacramento Regional County Sanitation District	Biosolids Recycling Facility	58	0	-	0	0	0	17	0	0	42	2
City of Fresno	Fresno-Clovis Regional Wastewater Reclamation Facility	43	5	Merced	0	39	0	0	0	0	0	3
East Bay Municipal Utility District	Main Wastewater Treatment Plant	41	11	Merced	30	0	0	0	0	0	0	2
San Francisco Public Utilities Commission	Southeast Water Pollution Control Plant	38	10	Solano	22	0.4	0	0	0	0	0	5
			5	Sonoma								
			0.4	Merced								

Table A-9 U.S. Large Agencies Biosolids Disposal Methods
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Agency	Treatment Facility	Total Biosolids Disposed (tons/day)	Land Application	Landfill Disposal or Cover (tons/day)	Biosolids Processing Facilities			Incineration (tons/day)	Deep Well Injection (tons/day)	Surface Disposal (tons/day)
			Biosolids Quantity (tons/day)		Composting (tons/day)	Alkaline Treatment (tons/day)	Heat Drying (tons/day)			
Detroit Water and Sewerage Dept	Wastewater Treatment Plant	675	0	0	0	221	0	454	0	0
Metropolitan Water Reclamation District of Greater Chicago	Stickney Water Reclamation Plant (1,200 MGD)	425	162	114	0	0	150	0	0	0
New York City Dept of Environmental Protection	14 Facilities (total capacity = 1,805 MGD)	312	115	0	41	25	131	0	0	0
City of Houston	69th Street Wastewater Treatment Plant (200 MGD)	126	0	0	0	0	126	0	0	0
Milwaukee Metropolitan Sewerage District	Jones Island Wastewater Treatment Plant (330 MGD)	121	0	0	121	0	0	0	0	0
City of Phoenix	91st Avenue Wastewater Treatment Plant (150 MGD)	110	88	0	22	0	0	0	0	0
Denver Metro Water Reclamation District	Robert W. Hite Treatment Facility (140 MGD)	90	80	0	0	0	0	0	0	0
Miami-Dade Water and Sewer Dept	North, Central, & South plants (305 MGD)	90	90	0	0	0	0	0	0	0
City of Atlanta	R.M. Clayton Water Recycling Center (122 MGD)	75	0	0	0	0	0	75	0	0
King County (Seattle)	West Point Treatment Plant & South Treatment Plant (206 MGD total)	71	70	0	1	0	0	0	0	0

Table A-10 Summary of Costs for Various Disposition Methods and Locations
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Company/Facility	Contact	Status	Comments	Round Trip Mileage	Hauling Cost	Disposition Cost (Low)	Disposition Cost (High)
Hauling (Truck)							
S&S Trucking	Frank 510-383-3556 frank@snsands.com	Completed Emailed follow up questions on 12/16/09	Cost = $3.32/mile (per truck load of 24 wet tons) Round trip cost based on SF mileage and time frame of gate to gate 20 mins (pull in and 20 mins later have the load) Can get planning level costs if I send some mileage/sites	N/A	N/A	N/A	N/A
Roger's Trucking	n/a		Cost = $4.50/mile				
18 Trucking	n/a		Cost = $3.00/mile – SFPUC didn't qualify them due to their lack of experience and low price				
Sunset Scavenger	Robert Reed 415-330-1350 John Glaub 415-330-1300	Emailed John questions on 12/16/09	Cost = $4.74/mile				
Solid Solutions	Jeff 949-678-3153 Jeffthurber@yahoo.com	Completed Emailed follow up questions on 12/21/09	Cost = $3.34/mile – from SFPUC quote Mpg = 5.5 – 6.6 mpg Costs assume round trip mileage Out of town costs are sometimes a wash, there is a road tax in AZ ($0.15/mile) but diesel is much cheaper than in CA ($0.40/gal less)		$0.14 ton-mile Less than 60 miles - $7.50/mile Around 5 miles - $5/ton		
Hauling (Rail)							
Union Pacific	Creighton Reinhard 402-544-7957 402-598-7246 (cell) creinhard@up.com	Complete	- Assumed trip between WPCP and Yuma, AZ - Each tank car holds ~30,000 gallons which is 128 dry tons @ 25% - Costs given by UP were provided per car ($4908 for transload operation and $4305 for railing = $9216 total) - STCC 4029189		$72/dry ton @ 25%		
BNSF	Grant Wessel 209-513-7403 - cell grant.wessel@bnsf.com	Complete	Does SJ have equipment to load into rail cars? If not we'll need a transloader (~$500/car) Tank car capacity = 22 k – 32 k gal or 2000 lbs Who serves the rail spur? May have to truck from SJ to Warm Springs or Oakland Will not provide cost quote because UP serves both ends of trip		Potential costs include - Rail rate (BNSF to provide) - Loading/unloading - Lease of tank cars		

Table A-10 Summary of Costs for Various Disposition Methods and Locations
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Company/Facility	Contact	Status	Comments	Round Trip Mileage	Hauling Cost	Disposition Cost (Low)	Disposition Cost (High)
California Landfill, Land Application and Compost							
Altamont Landfill and Resource Recovery, Livermore, CA	Peggy 925-455-7301	Left Message		84 miles	$5.81/wet ton $22.35/dry ton @ 26% $32.28/dry ton @ 18%		
Vasco Road Sanitary Landfill, Livermore, CA	Joe 1-800-204-4242 209-547-7519	Completed	Cost = $25 to $35/wet ton depending on material quality. Open for 30 more years	54 miles	$3.74/wet ton $14.37/dry ton @ 26% $20.75/dry ton @ 18%	$25/wet ton $96.15/dry ton @ 26% $138.89/dry ton @ 18%	$35/wet ton $134.62/dry ton @ 26% $194.44/dry ton @ 18%
Salinas Valley Solid Waste Authority, Salinas, CA	Jose 831-775-3006	Left Message	Cost = $30/wet ton	172 miles	$11.90/wet ton $22.35/dry ton @ 26% $32.28/dry ton @ 18%	$30/wet ton $115.38/dry ton @ 26% $166.67/dry ton @ 18%	
Forward Landfill Inc., Manteca, CA	Joe 1-800-204-4242 209-547-7519	Completed	Cost = $30 to $40/wet ton depending on material quality. Open for 30 more years.	154 miles	$10.65/wet ton $40.97/dry ton @ 26% $59.17/dry ton @ 18%	$30/wet ton $115.38/dry ton @ 26% $166.67/dry ton @ 18%	$40/wet ton $153.85/dry ton @ 26% $222.22/dry ton @ 18%
Newby Island Sanitary Landfill, Milpitas, CA			Current Contract – $22.75/wet ton for ADC	14 miles	$0.97/wet ton $3.72/dry ton @ 26% $5.38/dry ton @ 18%		
Potrero Hills Landfill	Joe Lynch 707-432-4627	Completed	Cost = $25/wet ton. Open for 35 to 42 more years. Will start composting demonstration project next year.	156 miles	$10.79/wet ton $41.50/dry ton @ 26% $59.95/dry ton @ 18%	$25/wet ton $96.15/dry ton @ 26% $138.89/dry ton @ 18%	
Silva Ranch (land application) – South of Sacramento	John Pugliaresi 650-333-0729 cell	Completed	Cost = $30/wet ton (hauling + tipping)				
Synagro, Kern County (composting)	John Pugliaresi 650-333-0729 cell	Completed	Cost = $35/ton (hauling) + $50/ton (tipping) Not much capacity		$35/wet ton	$50/wet ton	
Synagro, Merced County (composting)	John Pugliaresi 650-333-0729 cell	Completed	Not much capacity	210 miles	Included in Disposition Cost	$40-45/wet ton	
Southern California (Delano?)	Suggested by Tule Farms guy					$55-$56/ton including hauling?	
Nevada Landfill/Land Application							
Orient Farms, Gerlach, NV			Cost = $14.13/wet ton Only take 1 to 2 truck loads per week but interested in more.	716 miles	Truck - $49.52/wet ton $190.47/dry ton @ 26% $275.13/dry ton @ 18% Rail -	$14.13/wet ton $54.35/dry ton @ 26% $78.50/dry ton @ 18%	
Arizona Land Application							
Central Arizona	Daniel Czecholinski, Biosolids Coordinator 602-771-4612		Does not see Arizona prohibiting import of Biosolids or making it difficult to land apply.	1488 miles	Truck - $102.92/wet ton $395.85/dry ton @ 26% $571.78/dry ton @ 18% Rail -		
Avagro Systems Inc.	Rob Fehrmann 520-271-7736 robfehrmann@comcast.net	Completed	25,000 acres in Poloma 15,000 acres in Eloy Mentioned dry lbs of nitrogen as limiting factor		$95/load – 1 load = 24.5 wet tons	$1-$3/wet ton for spreading – this doesn't include trucking, depends on distance to site	
Biosolids Management	Bob Regester 623-695-1292	Left message 12/11/09					
D&K Farming	Don King 602-228-2332	Completed	25,000 ton capacity, 20 miles from a rail station, usually have a 5 year contract with an option for a 3 yr renewal	40 miles (btw rail station in Buckeye to field)		Offloading - $2.50/ ton Trucking to site – $0.20/ton/mile	

Table A-10 Summary of Costs for Various Disposition Methods and Locations
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Company/Facility	Contact	Status	Comments	Round Trip Mileage	Hauling Cost	Disposition Cost (Low)	Disposition Cost (High)
			Land apply a few times a year, store on registered land – asked if we comply with all vector regs – I mentioned that the biosolids would be 25% solids			Land application - $3.50/ton	
Solid Solutions	Jeff 949-678-3153	Completed				Rough estimate of $40-$50 for rail transport, $10-$15 for land application, $10 transfer fee for trucking between rail and farm (all costs are $/wetton)	
Synagro West, Inc.	Ken Johnson 623-936-6328 John Pugliaresi 650-333-0729 cell	Message 12/15/09 Talked to John on 12/18/09	John to work on costs – there is land in Arizona and they have experience in doing this work				
Tule Ranch – Magan Farms	559-970-9432 cell	Completed	Doesn't think there is any chance that we can afford to rail down and land apply. Gave me a quote for picking up from rail and taking to farm but suggested that there are lots of costs we aren't capturing like specialized equipment for loading/unloading and water tight containers. He did this before for a plant in NY			$12-$15/ton for pick up at rail and transport to farm	
AgTech	Tony Whalen 928-341-9625	Message 12/16/09					
Mine Reclamation							
Asarco Mines	John Low 520-798-7715 Krishna	Sent email 12/21/09	Current reclamation efforts have only been at pilot scale however the mine is interested in future possibilities				

3.0 GREENHOUSE GAS ANALYSIS

A greenhouse gas (GHG) emissions estimate of each disposition route was completed and compared to the existing and baseline conditions using Carollo's GHG emissions estimating tool. This tool has been developed based on protocols aligned with the GHG Protocol Initiative[1] (e.g. The Climate Registry and Local Government Operations Protocol) and California's Regulation for the Mandatory Reporting of Greenhouse Gas Emissions.

The major GHG in the atmosphere is carbon dioxide. Other GHGs differ in their ability to absorb heat in the atmosphere. For example, methane (CH4) has 21 times the capacity to absorb heat relative to carbon dioxide over a hundred-year time horizon, so it is considered to have a global warming potential (GWP) of 21. Nitrous Oxide (N_2O) has 310 times the capacity over a hundred-year time horizon having a GWP of 310. Therefore, a pound of emissions of carbon dioxide is not the same in terms of climatic impact as a pound of methane or nitrous oxide emitted. Carbon dioxide equivalent (CO_2e) emissions are calculated by multiplying the amount of emissions of a particular GHG by its GWP (see Table A-11).

Table A-11 Greenhouse Gases and Their Associated Global Warming Potentials (GWPs)
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Greenhouse Gas	GWP* (unit mass CO_2e/unit mass of GHG emitted)
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310

* GWPs from the Intergovernmental Panel on Climate Change Second Assessment Report (1996) for a 100-year time horizon. These GWPs are still used today by international convention and the U.S. to maintain the value of the carbon dioxide "currency," and are used in this inventory to maintain consistency with international practice.

Figure A-3 shows a comparison of the GHG emissions for various disposition routes assuming an equal amount of biosolids (93 dry tons per day as projected for 2040) is transported to each facility. The GHG emissions can vary depending on the percent solids hauled, the hauling method, and the distance of the disposition route. For example, transporting biosolids by truck results in higher GHG emissions than transporting the biosolids by rail car. Also, the farther the travel distance, the greater the GHG emissions. The system boundary of this analysis did not include the GHG emissions generated or avoided at the end use/disposal site (i.e., emissions from the landfilled and composted material or emissions avoided through the offsetting of fertilizer use by land applying the

[1] An accounting protocol developed by the World Resources Institute and the World Business Council for Sustainable Development providing standards and guidance for companies and other organizations, which serves as an accounting framework for most protocols.

biosolids). Overall, the GHG emissions resulting from the disposition method and route shown in Figure A-3 are all less than 20 percent of the total annual GHG emissions generated by the biosolids alternatives.

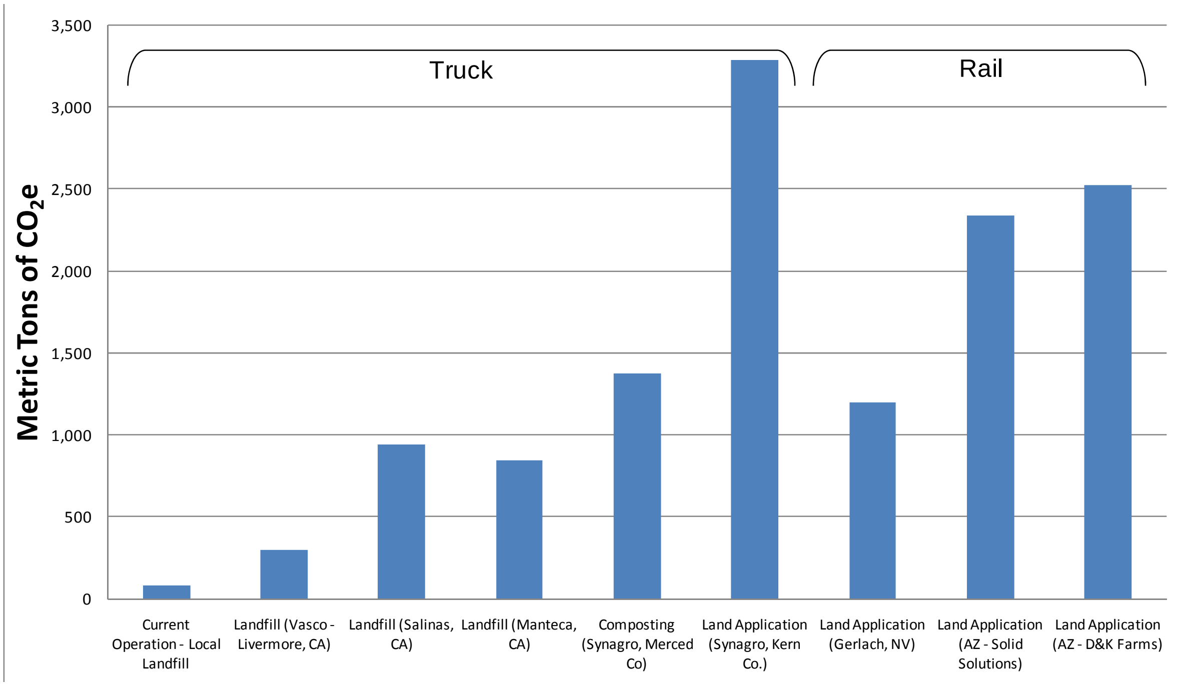

Figure A-3 Annual Greenhouse Gas Emissions for Biosolids Disposition Routes (only considering transportation)

It is recommended that multiple disposition routes, as well as a combination of different types of disposal or end use options, be considered (such as landfilling, land application, composting, etc). It is also recommended that the GHG emissions generated at the disposal/use site be considered. There are opportunities for offsetting the use of fertilizer with the application/use of biosolids, thus creating a GHG emissions offset by removing the need for producing fertilizer. This opportunity should be further investigated to identify the potential for generating carbon offset credits.

4.0 REFERENCES

Bay Area Clean Water Agencies. “Bay Area Regional Biosolids Management Program Initial Market Assessment”. April 2006.

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Sacramento Regional County Sanitation District. “Biosolids Heat Drying/Chemical Treatment Project”. May 1996.

Santa Rosa, City of. “Laguna Subregional Water Reclamation Facility, Biosolids Program Phase 2”. July 2003.

APPENDIX B – CANDIDATE BIOSOLIDS TREATMENT TECHNOLOGIES

APPENDIX B – CANDIDATE BIOSOLIDS TREATMENT TECHNOLOGIES

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1.0 CANDIDATE TREATMENT TECHNOLOGIES

This Appendix presents and describes a wide range of technologies that are available in the field of wastewater sludge/biosolids processing. Some or many of these may be feasible for use at the WPCP. The processing technologies are discussed within the following categories:

- Thickening Technologies.
- Digestion Stabilization Technologies.
- Non-Digestion Stabilization Technologies.
- Dewatering and Drying Technologies.
- Other Solids Processing Technologies.

The technologies discussed and evaluated here include those that are commonly used in the industry (either in North America or in Europe). This evaluation also includes technologies that are considered innovative and are undergoing further improvement/development, as long as they have promising features and there are examples of full-scale experience. In general, processes that are at the research or embryonic stage of their development are not included here, since it is too early to determine if these processes will ever move to full-scale use. Table B-1 summarizes the results of this evaluation.

Table B-1 Technology Screening
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Category	Technology	Screening Evaluation and Assessment	Further Evaluation Warranted?
Thickening	Thicken PS in clarifier	Better methods are available.	No
	Gravity belt thickener	In common use in North America. Good performance, and use for co-thickening service.	Yes
	Dissolved air flotation	In common use in North America. Good performance, and can use for co-thickening service.	Yes
	Centrifuge	Costly operation, and thickening performance not as good as other options.	No

Table B-1	**Technology Screening San José/Santa Clara Water Pollution Control Plant Master Plan City of San José**		
Category	**Technology**	**Screening Evaluation and Assessment**	**Further Evaluation Warranted?**
	Gravity thickening	Odorous process. Performance not as good as other options.	No
	Rotary drum thickening	Use for smaller WWTPs. Not as good a process for co-thickening.	No
	Membrane thickening	Not in common use.	Future
Digestion Stabilization	Anaerobic digestion - mesophilic	Most common sludge stabilization technology in North America.	Yes
	Pasteurization/mesophilic anaerobic digestion	Used in Europe historically. Now used at a few plants in North America. Class A product.	Future
	Anaerobic digestion – thermophilic	Increasing use in North America, including at some large plants in California.	Yes
	Temperature phased anaerobic digestion	Increasing experience in North America – benefit of additional volatile solids reduction. Can be Class A process with proper configuration.	Yes
	Acid/gas phased digestion (including 3-phase digestion)	Increasing experience in North America. Can be Class A with proper configuration. Can improve dewaterability.	Yes
	Class A Thermophilic Digestion – using batch or multiple stages.	Includes several advanced digestion process options to produce pathogen-free biosolids within the digestion process. Working at large plants in North America.	Yes
	Thermal hydrolysis/anaerobic digestion	Experience in Europe is increasing. Pilot tested at San Francisco in 2001. Class A process and high-solids cake.	Yes
	Aerobic digestion	Common for small plants and plants with only waste-activated sludge. High energy costs and only Class B pathogen reduction.	No

Table B-1 Technology Screening
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Category	Technology	Screening Evaluation and Assessment	Further Evaluation Warranted?
	Auto-thermal thermophilic aerobic digestion (ATAD)	Used at small plants and has had significant odor problems/ concerns. Class A process. Vertad process is similar to ATAD.	No
	Dual digestion	Consider with high purity oxygen plants. Can be Class A. City of Tacoma has had success. Odor concerns.	Future
	Anaerobic/aerobic digestion	Very limited experience – new research being conducted at Virginia Tech.	Future
Non-Digestion Stabilization	Alkaline stabilization (PSRP)	Rarely used at larger plants. Product use perceived as minimal in Bay Area and Northern California. Odor concerns. Creates larger mass of biosolids for transport and disposition, due to addition of alkaline amendments.	No
	Alkaline treatment (Class A)	Involves high pH, high temperature, and drying. Significant odor issues. Consider as Class A option for rapid implementation if situation warrants.	No
	Composting – unconfined	Space is available, odor potential is high, even with digested feedstock. Unconfined composting considered infeasible	No
	Composting – confined	Space/footprint is major issue; therefore, only small-scale operation is considered feasible. Extensive odor control would be required. Digested biosolids required as feedstock.	No
	Vermiculture	Lack of experience at required scale. Space requirements are significant.	No

Table B-1 Technology Screening
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Category	Technology	Screening Evaluation and Assessment	Further Evaluation Warranted?
	Slurry-Carb™ process	First facility built in Rialto, CA by 2008. Pressurized and heated reactions allows high-solids dewatering for energy value. Rialto facility product to be used in nearby cement kiln.	Future
	Pyrolysis	High-temperature processes to create char product and combustible off-gas for energy value. Public perception may be difficult to overcome.	Future
	Gasification	Limited experience and odor concerns. Testing work at Philadelphia has been troubling over the years.	Future
	Sludge-to-oil technology	Very limited experience. Process has been in development for at least 20 years.	No
	Thermal depolymerization and thermal conversion process	First plant at Carthage, MO working on turkey waste – no facilities using biosolids. Odor problems at Carthage facility.	Future
	Thermal processing with energy recovery	Destruction of organics and pathogens. Concerns from air quality perspective, and major investment required. Ash is the final product, usually disposed. Continues to be a successful process at approximately 50 US WWTPs. Public perception may be difficult to overcome.	Yes
	Thermal conditioning and heat treatment	Significant odor problems at these plants over time. Existing plants with this technology have been, and continue to be, phased out.	No

Table B-1 Technology Screening
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Category	Technology	Screening Evaluation and Assessment	Further Evaluation Warranted?
	Wet air oxidation in deep well	Small footprint is advantage. Very little experience. Possible advancements in future, but also risks from deep wells. Essentially, an ash is produced from the process. Odor may be crucial concern.	Future
	Irradiation	Pathogen reduction process, which can produce Class A. Not a stabilization process.	No
	High temperature melting and vitrification	Limited experience and odor potential. Perceived as high cost approach. Destruction of organics and pathogens.	Future
	Bio-brick production	Lack of experience at required scale. Involves high temperature processes. Advancements in technology are possible as costs for biosolids management increase.	Future
	Lagooning	Digested feedstock required. Odor issues would also be major concern.	No
Dewatering and Drying	Belt filter press	Very common dewatering process at scale required. Low-shear process. However, the technology has not achieved high solids content cake material, even with newer advancements.	Yes
	Centrifuge	Very common dewatering process at scale required. Achieves good cake solids content, but can be high-shear process with odor regrowth potential.	Yes
	Screw press	Relatively new process for biosolids, used at smaller plants to date. Low-speed machine with low-shear. A version of this process adds steam to produce Class A cake.	Yes

Table B-1 Technology Screening
San José/Santa Clara Water Pollution Control Plant Master Plan
City of San José

Category	Technology	Screening Evaluation and Assessment	Further Evaluation Warranted?
	Rotary press	Used at smaller plants – Number of units required for WPCP excessive	No
	Plate and frame pressure filter	Low-shear dewatering conducted in batches. Sludge/biosolids industry has had few installations, and most have been phased out. Newer technology using vacuum and heat provides Class A, but only used at smaller-scale plants to date.	Future (for newer form of these filters)
	Air/solar drying – open systems	Existing process. Odor problems.	No
	Air/solar drying – within structure	New, mechanical greenhouse-type systems. Odor must be highly controlled. Not yet proven at scale required. Might be implemented for portion of City's biosolids production, if space is available.	Yes
	Heat drying – graded pellet product	Digested feedstock required. Very high degree of odor control needed. Experience is increasing in North America, and considerable experience in Europe at required scale. Safety is an issue – particularly fire/explosion. Class A product.	Yes
	Heat drying – ungraded product	Digested feedstock required. With highly controlled systems and advances in dust control and safety, this type of heat drying may be feasible at the WPCP.	Yes
	Innovative Biosolids Drying	Use of waste-heat hot water stream from cogeneration needs to be explored for possible use with other innovative drying techniques using solar energy, belt drying or other technology.	Yes

Table B-1 Technology Screening San José/Santa Clara Water Pollution Control Plant Master Plan City of San José			
Category	**Technology**	**Screening Evaluation and Assessment**	**Further Evaluation Warranted?**
	Combined Centrifuge/Drying	Implemented in Europe, primarily as pre-processing before incineration. Not a Class A product.	Future
Other Solids Processing Technologies	Disintegration processes	Applied to thickened waste activated sludge, normally, to achieve greater volatile solids reduction in digestion. Processes being researched and tested in North America. Several facilities built in Europe and overseas in last 5 years.	Future
	Nutrient removal processes	Purposeful crystallization to remove phosphorus and perhaps ammonia from sludge streams. Crystals used as fertilizer material. Implemented overseas primarily.	Future
	Cannibal® process	Process to minimize sludge production. Not very conducive if plants have primary clarifiers and fairly low MCRT biological process. Has been implemented at small plants to date.	Future

APPENDIX C – CAMBI DESIGN CALCULATION

					Year 2025				
	Current Operation	Option A - thickening	Option B - WAS Cambi	Option C – Full Cambi Average Loads	2025 – Full Cambi Average Load	2025 – Full Cambi Peak Load	2025 – WAS Cambi Average Load	2025 – WAS Cambi Peak Load	2025 – Option A - thickening Average Load
Dry tonnes per day (peak)	118(154)	118(154)	118(154)	118(154)	171	228	171	228	171
Digester feed DS%	3.5%	4.4%	7.6%	10.5%	10.5%	10.5%	6.53%	6.53%	3.5%
HRT (required to get 60% VSR)	30	30	20	18	20[1]	13	15	12	22
Digestion Volume (does not consider one out of service conditions)			7.5 mGal	4.8 mGal	7.3 mGal Assume 3 digesters at 7.3 mGal in use	6.2 mGal (Assume 3 digesters at 7.3 mGal in use)	9.7mGal (Assume 4 digesters at 9.7 mGal in use)	9.7 mGal (Assume 4 digesters at 9.7 mGal in use)	26.4 mGal
No of Digesters required (does not consider one out of service conditions)	16	13	3	2	3	3	4	4	11
Qty of Cambi Reactors Required (no allowance for OOS)			4	6	9	12	4	5	
Qty of trains x Qty reactors Qty with OOS Req.			1 x 4 = 4	1 x 6 = 6	2 x 5 = 10 3 x 5 = 15	2 x 6 = 12 3 x 6 = 18	1 x 4 = 4	1 x 5 = 5	
DS% after dewatering	70% (beds)	25	32	35	35 %	35 %	32 %	32 %	25 %
Net Energy produced (Digester gas net of Cambi steam requirements)					1,600 ft3/min.		1,800 ft3/min.		1,000 ft3/min.
Pre-Cambi Dewatering (tons dry solids/day)					171	228	171	228	
Post Digestion Dewatering (tons dry solids/day)					91	120	91	120	
Tons of product/year (tons per day)	55,800	92,400	72,200 (200/day)	66,000 (180/day)	94,500 (259/day)		103,400 (283/day)		176,700 (484/day)
Land required for air drying liquid to 70% DS - acres	268	214	121	85	125		165		300
Land required for air drying dewatered cake to 70% DS - acres	27	27	9	7	10		13		40

1. Assumed existing digesters are 2.43 mGal each

[1] Assumes 3 digesters will be in service

	Year 2040				
	2040 – Full Cambi Average Load	2040 – Full Cambi Peak Load	2040 – WAS Cambi Average Load	2040 – WAS Cambi Peak Load	2040 – Option A - thickening Average Load
Dry tonnes per day (peak)	207	275	207	275	207
Digester feed DS%	10.5%	10.5%	6.53%	6.53%	3.5%
HRT (required to get 60% VSR)	15[2]	12	16	12	22
Digestion Volume (does not consider one out of service conditions)	7.3 mGal Assume 3 digesters at 7.3 mGal in use	7.3 mGal (Assume 3 digesters at 7.3 mGal in use)	12.1 mGal (Assume 5 digesters at 12.1 mGal in use)	12.1 mGal (Assume 5 digesters at 12.1 mGal in use)	31.2 mGal
No of Digesters required (does not consider one out of service conditions)	3	3	5	5	13
Qty of Cambi Reactors Required (no allowance for OOS)	11	14	4	6	
Qty of trains x Qty reactors Qty with OOS Req.	2 x 6 = 12 3 x 6 = 18	3 x 5 = 15 4 x 5 = 20	1 x 4 = 4	1 x 6 = 6	
DS% after dewatering	35 %	35 %	32 %	32 %	25 %
Net Energy produced (Digester gas net of Cambi steam requirements)	1,900 ft3/min.		2,000 ft3/min.		1,250 ft3/min.
Pre-Cambi Dewatering (tons dry solids/day)	207	275	207	275	
Post Digestion Dewatering (tons dry solids/day)	110	145	110	145	
Tons of product/year (tons per day)	114,300 (313/day)		125,000 (343/day)		213, 700 (585/day)
Land required for air drying liquid to 70% DS - acres					
Land required for air drying dewatered cake to 70% DS - acres					

[2] Assumes 3 digesters will be in service