March 8, 2021

AGENDA ITEM # 3

TO: Environmental Commission

FROM: Emiko Ancheta, Staff Liaison

SUBJECT: Climate Action and Adaptation Plan Update Status Report

RECOMMENDATION:

Receive update on Climate Action and Adaptation Plan (CAAP) progress

---

BACKGROUND

In 2013 the City of Los Altos adopted the Climate Action Plan in accordance with the State Assembly Bill 32 which required public agencies in California to implement measures to reduce greenhouse gas (GHG) emissions to year 1990 levels by 2020. Cities needed to adopt a plan to addresses carbon emissions and establish an implementation plan for programs and facilities. A Climate Action Plan (CAP) is the policy document that provides the framework to achieve those goals. Since the adoption of the 2013 CAP, two annual report updates were done in 2015 and 2016. The City Council continues to make the environment a priority and directed staff to update the CAP. In December 2020, the City entered into contract with EcoShift Consulting to prepare a Climate Action and Adaptation Plan (CAAP) for the City of Los Altos.

In January 2021, staff began working with the consultant and the Environmental Commission Subcommittee to develop the Los Altos CAAP. The following summarizes the scope of services.

Task I: Project Management: Consultant Project Team will develop a project management plan in conjunction with City staff. The consultant will use best practices in project management methodologies to ensure the project remains on-task and on schedule. **Task Deliverables** include Kick-Off meeting with City staff, ongoing Bi-Weekly conference call meetings with City staff, attendance at meetings and public hearings for the Environmental Commission and City Council, presentation materials and summaries for meetings and public hearings and Ad hoc communication.
Task II: Data Inventory, GHG Forecast and Vulnerability Assessment: Consultant Project Team will use ICLEI protocols for this project and ClearPath portal to conduct the inventories and forecasting. **Task Deliverables** include update of baseline GHG inventory workbooks, summary GHG Report detailing results of inventory and documenting any methodological changes, forecast municipal and community GHG emissions, update GHG emissions reduction targets, vulnerability Assessment assessing the threats of climate risks.
Task III: Review and Assess Relevant City Plans, Policies, Programs and Codes: Consultant Project Team will conduct a review of current City measures, followed by a systematic process to compile the City's current, relevant goals, strategies, actions, tactics, and recommendations. **Task Deliverables** include collection of all relevant existing GHG reduction efforts, quantify efforts using

agreed-upon emission factors, develop matrix detailing the City's current emissions reduction efforts, and explaining the relevance of existing policies to each other and to future CAAP measures, and policy framework matrix.

Task IV: Develop and Evaluate GHG Reduction and Climate Adaptation Measures: Consultant Project Team's roadmap process will identify critical pathways to achieving the City's climate goals, help identify issues and barriers to each pathway, and recommend mitigation strategies to overcome barriers. **Task Deliverables** include list of proposed CAAP measures, summary of transportation scenarios and list of VMT and GHG reduction policies for possible inclusion in the CAAP, adaptation strategies, list of measures and actions to attain City goals, threat matrix detailing types and degree of threats from the effects of climate change and reporting template for reporting on adaptation measures.

Task V: Prepare Draft Climate Action and Adaptation Plan: Consultant Project Team will deliver a comprehensive and robust CAAP that will be designed to be complementary to existing policies for reducing waste and energy use, reducing single occupancy- vehicle trips, and encourage healthy lifestyles. **Task Deliverables** include draft CAAP that includes Executive Summary summarizing report's purpose, methodology, findings, and recommendations, and materials for ongoing outreach and education.

Task VI: Finalize Climate Action and Adaptation Plan: Consultant Project Team will compile all feedback from the draft CAAP review and integrate comments into the final CAAP document. **Task Deliverables** include finalized CAAP, meeting with City to discuss how input and comments were integrated info final CAAP, attendance at 3 public meetings (1 EC meeting and 2 CC meetings).

Task VII: CEQA Compliance: Consultant will prepare an Administrative Draft IS/MND with the following components:

- Project Description
- CEQA Environmental Checklist Form
- Mandatory Findings of Significance
- Contacts and Bibliography
- Mitigated Negative Declaration or Negative Declaration
- Notice of Determination

DISCUSSION

The Environmental Commission CAAP sub-committee members, Bruno Delagneau, Raashina Humayun and Don Weiden attend CAAP meetings and provide support and input with staff and the consultant to develop the CAAP. Receive update on CAAP development progress and status.

Attachments:

A. CAAP Meetings Summary
B. CAAP Schedule Timeline
C. RWQCP- Regional Water Quality Control Plan in Palo Alto

Climate Action & Adaptation Plan Meetings Summary

CAAP Kick-Off (January 14, 2021):

- Introduction of lead City staff, Environmental Commission subcommittee and consultant team
- Input for the CAAP development included:
    - Two focus areas should be existing buildings and reducing water use (the City is considering an energy audit of existing buildings).
    - Tie aspirational goals to concrete actions with specific reasons for the recommendations provided.
    - HR has some alternative commute benefits in place, including alternative work schedules and a public transit pre-tax benefit.
    - Important to present the value proposition of the plan to residents and businesses (explain the costs & benefits) to gain buy-in.
    - Two important focus areas will be tracking & measurement of actions and defining the City's GHG reduction target(s).
    - Community outreach will be important to engage the community and obtain input.
    - Action items and measures should be simple and conveyable to create a consistent repeatable message.
    - Important to identify the key drivers and goals of the plan (regulatory, leadership, etc.), as well as identifying where and how to best invest resources to achieve the plan's goals.
    - An updatable GHG model would be preferable, as well as an investigation of land use-related mitigation measures, and an investigation of future and retroactive actions (ex.: building codes to influence energy intensity).
    - A focus should be on creating a bold plan that incorporates technological advances, as well as raising the visibility of the plan in the eyes of the public and decision-makers.
    - The Reach Codes will have a big impact on future energy use in the City.
    - Per-capita residential PV and EV charging adoption are high within the City - there is interest in going off-grid among some residents.
    - The collection of data and using it in an effective reporting format will be important in demonstrating the plan's ongoing success, as well as communicating local and regional benefits.
- A brief presentation was given by the consultant team on the phases of the plan and the role Fehr & Peers' TrendLab+ tool.

CAAP Bi-weekly Meeting (January 29, 2021):

- Definition of an innovative plan was discussed: A valuable starting point will be for the City and consultant team to exchange lists of plans they find interesting/important to this project and discuss (see attachment D). This could result in a menu of innovative plans, policies, etc. for consideration for this project.
    - National and international plans and measures should be considered, not just limited to local efforts.
- Potential areas of interest for innovations include:
    - Learning and building on the Open Streets events over the summer.

  - Community microgrids (potentially utilizing new Community Center).
  - Utilizing carbon sinks and carbon capture to become Carbon Negative.
- Guidelines for private owners as well as enforceable policies for City-owned land and buildings should be looked at when considering innovative measures.
- Planning for stakeholder engagement, the consultant team will send a list of requirements to the City so they can begin the planning process.
- Important to identify when to bring different stakeholder groups into the planning process. Bringing in different stakeholders at the right time will result in a more inclusive plan and help with the plan's adoption and implementation (ex.: downtown businesses will be impacted by changes to parking policies).
- The team discussed options for the timeframe for the Vulnerability Assessment (Mid Century vs End of Century). This should be determined by types of City infrastructure relevant to climate change. The original input from the City was that a Mid Century timeframe would be most appropriate.
- Alignment between the CAAP and the City's Emergency Preparedness Plan was discussed. Alignment between the CAAP and other City plans (current and future) in general will be an important consideration.
- The consultant team gave a brief intro to ClearPath. This will be the central GHG reduction planning tool, and also offers monitoring & reporting modules for ongoing use.
- An initial list of climate threats was reviewed (Flooding from creeks, Extreme Heat, Urban Heat Island effect, Wildfires, Air Pollution, and Drought). The consultant team will send this list to the City along with a framework for capturing stakeholder feedback on each threat. This is an important step in the Vulnerability Assessment.

CAAP Bi-weekly Meeting (February 12, 2021):

- Options for stakeholder engagement were discussed. Stakeholders identified are listed below.
  - The City has a Youth Commission that could be a good group to engage with.
  - The High School has a Green Team that engages regularly with the City Council.
  - Businesses will be important stakeholders (Anthony Carnesecca, Economic Development Coordinator).
  - Engage with groups that may be resistant to the measures in the final plan are important to engage with. Their concerns should be listened to and addressed.
  - Important Brown Act requirements to be strictly adhered to when considering meeting with commissions and committees as we plan outreach & engagement activities.
  - Engage the City Council in the process often to implement their feedback on goals, and development throughout.

    Stakeholder Groups:
    - Los Altos Property Owners Downtown
    - Los Altos Village Association
    - Los Altos Chamber of Commerce
    - Los Altos History Museum
    - GreenTown Los Altos
    - LAYCAT (Los Altos Youth Climate Action Team)

- Los Altos High School (Green Team Student Club)
- Los Altos History Museum
- LAUSD Outdoor Educator
- Orchard Commons Committee
- Grass Roots Ecology
- Block Action Teams (BATs)
- Los Altos Community Foundation
- Los Altos Rotary Club
- Environmental Commission
- Parks & Recreation Commission
- Youth Commission
- Complete Streets Commission
- City Council

- An overview of the Vulnerability Assessment survey was given - The short survey was emailed to meeting invitees and they were asked to complete it.
- An overview of the example CAPs and case study was given - Each has interesting or relevant features that should be considered for the CAAP.
- There was a discussion of the Nature Communication article, and the reply by ICLEI. ICLEI's methods are still relevant for this project, but the issues the article raises should be considered in the CAAP (making sure all emissions are captured, including considerations of consumption patterns, flights by municipal and community members, and the way VMT is calculated).

CAAP Bi-weekly Meeting (February 26, 2021):

- Outreach & Engagement options were briefly discussed. Tabling for Farmers' Market will begin in April or May. Several stakeholder groups were identified that could be good channels for sharing information and gathering feedback.
- The results of the Vulnerability Assessment Survey were shared. Climate hazards associated with temperature change were of highest concern, and flooding related to precipitation changes were also a concern.

Table 1: Average Scores and Ranking for Primary Climate Hazards

Primary Climate Hazards	Score
Temperature Increase	2.3
Precipitation Changes	1.7
Sea Level Rise	1.3

Table 2: Average Scores and Ranking for Secondary Climate Hazards

Secondary Climate Hazards	Score
Drought	2.7
Extreme Heat/Heat Waves	2.3
Wildfire	2.3
Air Pollution	2.3
Flooding (Riverine, Areal)	2.3
Urban Heat Island	1.8
Flooding (Coastal)	1.4
Landslide	1.2

- FEMA has flood maps for Los Altos - these will be included in document requests. The Stormwater Master Plan will also be included.
- An overview of asset & population categories for the Vulnerability Assessment was given. A survey will be distributed to gather feedback on the importance of each category.
- A table of local and regional GHG emission reduction targets was shared (see below). As the City considers different target options, it will be valuable to know what targets other municipalities have set. The updated GHG inventory, costs & benefits of different targets, type of target (% based vs absolute), and feedback from different stakeholder groups will also be important.

Climate Targets Table

Municipality/Source	Year	1st Target	2nd Target
IPCC	2018	45% below 2010 levels by 2030	Net Zero around 2050
EO-S-3-05/AB 32	2005/2006	1990 levels (or 15% below 2005 levels) by 2020	80% below 1990 levels by 2050
SB 32	2016	40% below 1990 levels by 2030	
Carlsbad CAP	2015	15% below 2005 levels by 2020	49% below 2005 levels by 2035
Mountain View CPR	2015	80% reduction by 2050	

Encinitas CAP	2018	13% below 2012 levels by 2020	41% below 2012 levels by 2030
Sunnyvale CAP	2019	56% reduction by 2030	80% reduction by 2050
Santa Monica CAAP	2019	80% below 1990 levels by 2030	Carbon Neutral by 2050
City of Alameda CARP	2019	50% below 2005 levels by 2030	Net Zero Emissions as soon as possible
Albany CAAP	2019	70% below 2004 levels by 2035	Carbon Neutral by 2045
San Francisco CAP	2019	Net Zero emissions by 2050	
San Rafael CCAP	2019	40% below 1990 levels by 2030	80% below 1990 levels by 2050
Menlo Park CAP	2020	Zero Carbon by 2030 (90% reduction, 10% removal)	
San Jose GHG Reduction Strategy	2020	40% below 1990 levels by 2030	
Oakland Equitable CAP	2020	56% below 2005 levels by 2030	
San Mateo CAP	2020	Reduce emissions to 4.3 MTCO2e per-capita by 2030	Reduce emissions to 1.2 MTCO2e per-capita by 2050
San Anselmo 2030 CAP	2019	45% below 2010 levels by 2030	80% below 1990 levels by 2050
Santa Clara CAP	updating now		

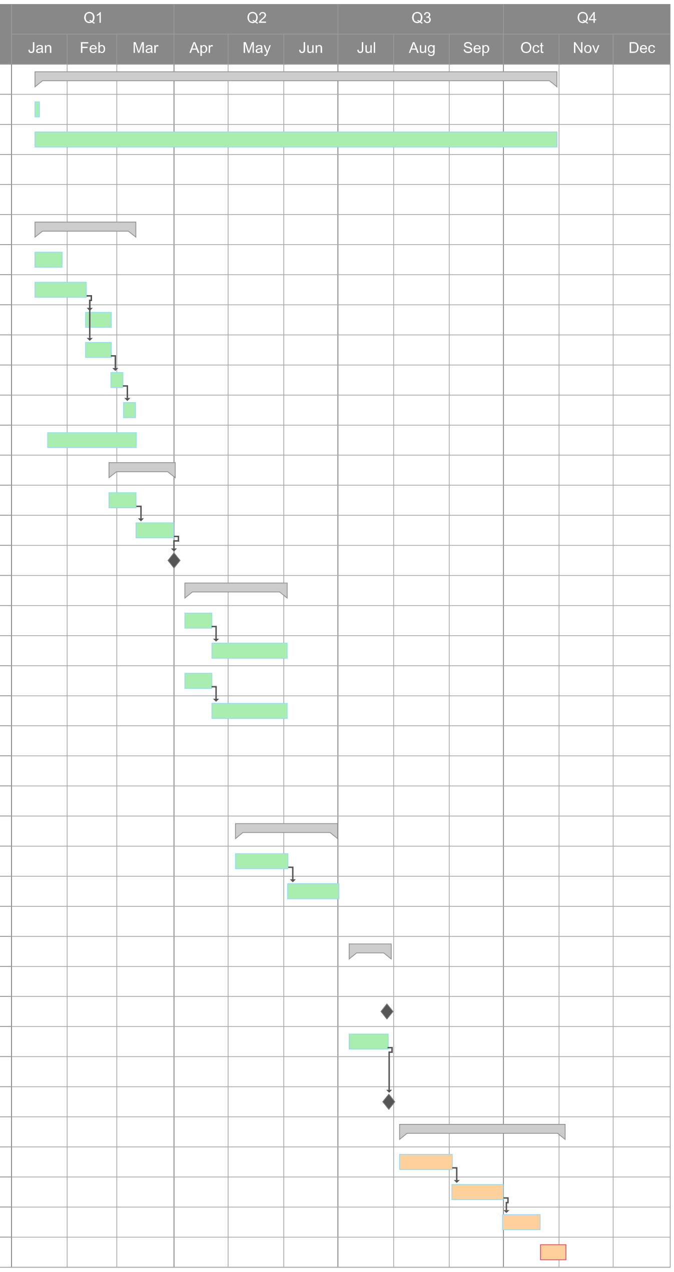
- The consultant team will be working to complete the updated GHG inventory over the next 2 weeks.

Attachment B

Los Altos CAAP

smartsheet

Task Name
Task I: Project Management & Meetings
Project Kick-Off meeting
Ongoing project management
Public meeting attendance
Public meeting agendas, presentation materials and summaries
Task II: Data Inventory & Forecast
Gather necessary data
Review and update existing inventories
Revised or additional GHG reduction measures
Quantify baseline GHG emissions
Forecast emission projections
Set new emission reduction targets
Vulnerability assessment
Task III: Review & Assess City Plans, Policies, Programs and Codes
Audit of City's policy framework
Quantify existing efforts
Matrix explaining relevance of existing policies to CAAP
Task IV: Develop & Evaluate GHG Reduction Measures
Identify GHG reduction measures
Quantify and assess GHG reduction measures
Identify adaptation measures
Quantify and assess adaptation measures
TrendLab+ scenario testing study session
TrendLab+ Customization
Reporting template for adaptation reporting
Task V: Prepare Draft CAAP
Prepare administrative CAAP draft
Prepare final CAAP
Attend 2 public meetings each with EC and CC
Task VI: Prepare CAAP
Prepare CAAP
Debrief session with City staff to explain how comments have been addressed
Attend 3 public meetings for final CAAP adoption (1 EC and 2 CC)
PowerPoint presentation for meetings
Certification of CAAP
Task VII: CEQA Compliance
Administrative draft IS/MND
Screencheck draft IS/MND
Public review draft IS/MND
Mitigation Monitoring & Reporting Program



ESA

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900 phone
415.896.0332 fax

www.esassoc.com

memorandum

date September 13, 2018

to Samantha Engelage, PE and Karin North – City of Palo Alto
Jason Warner, PE and Jimmy Dang, PE – Oro Loma Sanitary District

cc Adrien Baudrimont and Heidi Nutters – San Francisco Estuary Partnership

from Mark Lindley, PE; Scott Stoller, PE; Marisa Landicho, PE; and Matt Brennan, PhD, PE

subject Horizontal Levee Conceptual Designs for Palo Alto Regional Water Quality Control Plant

INTRODUCTION

This memorandum describes conceptual designs for horizontal levees at three potential locations in the vicinity of the Palo Alto Regional Water Quality Control Plant (RWQCP). The horizontal levee concept is an innovative and experimental approach with the goals to 1) create habitat for special status species by replicating freshwater seeps that historically occurred on gently sloping transitional zones into tidal marshes, 2) provide sea-level rise adaptation through accretion of freshwater wetland plant biomass, and 3) provide polishing-level treatment of wastewater prior to discharge to the Bay. The conceptual design approach builds on the experience gained through design, construction, and monitoring of the Oro Loma Horizontal Levee Demonstration Project in San Lorenzo, California.

A horizontal levee is a flood control levee with a gently sloping berm along the Bay shoreline which provides key transitional habitat between tidal wetlands and terrestrial uplands. Its target vegetation consists of grassy wet meadow and riparian scrub. This type of habitat has been decimated by development along the shoreline, yet is a high restoration priority for resource agencies (Goals Project, 2015). The horizontal levee includes habitat for endangered species found only along the Bay shoreline, such as the saltmarsh harvest mouse and Ridgeway's rails, by providing refugia during high water and connectivity between marshes. These slopes also provide accommodation space for tidal wetlands to adapt to sea-level rise by shifting landward. Historically, natural transition zones would be fed by freshwater seeps from the surrounding watershed. In today's highly modified and developed shorelines with stormdrain systems designed to efficiently route rainfall from developed areas, transition zones are disconnected from the natural freshwater supply. To replicate the historic freshwater seep, the slope's vegetation can be irrigated with highly treated wastewater effluent. As the effluent percolates through the vegetation and soil, nutrients and pollutants are removed, thereby improving the effluent's water quality before discharge to the Bay. A horizontal levee can also contribute to flood management by attenuating waves, allowing for flood control levees to be constructed with crest elevations up to two feet lower than conventional levees. Additionally, the horizontal levee provides erosion protection on the front side of coastal levees, limiting the need for rip-rap (rock) protection on the levee face. By encouraging sediment and biomass accretion, the vegetation supported on the ecotone can build the ground surface elevation, contributing sea-level rise resilience to both the habitat and flood management functions.

The desirability for horizontal levees from the ecological viewpoint has been understood for some time (Goals Project, 1999) but these features have not been included in many restoration projects to date. The horizontal levee approach using treated wastewater effluent and its role in increasing resilience to sea-level rise is more recent, with the Oro Loma project serving as proof-of-concept and continuing to provide insight from ongoing monitoring. Designs for the Palo Alto sites will extend the Oro Loma Horizontal Levee Demonstration Project experience to typical Bayland settings. In addition to tailoring the designs to Palo Alto-specific considerations, the Palo Alto sites have been selected for greater habitat and hydrologic connectivity to tidal marsh and the Bay, as well as integration with regional coastal flood protection. Since this approach is new, these sites would likely undergo extensive regulatory review to secure permits.

Funding for the development of conceptual horizontal levee designs comes from an Integrated Regional Water Management Program (IRWMP) grant obtained by Oro Loma Sanitary District (OLSD) and administered by the San Francisco Estuary Partnership (SFEP). The bulk of this grant supported design and construction of a pilot horizontal levee at the OLSD wastewater treatment plant in San Lorenzo. With a remaining portion of the grant, Environmental Science Associates (ESA), the engineering firm that led design of the OLSD project, has developed conceptual designs of horizontal levee projects for the City of Palo Alto. ESA has been assisted by Peter Baye, the plant ecologist from the OLSD project, City staff, and other stakeholders.

This memorandum incorporates and expands on the information presented in the Ecotone Slope Opportunities memo in January, 2018 (ESA, 2018) and serves to memorialize the rationale for the conceptual design decisions and discuss important issues to resolve in order to bring the project(s) to fruition.

SETTING

Much of the Palo Alto shoreline, while highly developed and altered, continues to sustain tidal marsh along San Francisco Bay in particular at the former harbor and adjacent to the Palo Alto Airport. Harbor Marsh and the Baylands Nature preserve are backed by levees and a closed landfill (Figure 1). Just behind these levees are significant City of Palo Alto infrastructure, including the City's RWQCP, airport, the Palo Alto Flood Basin, roads and light development. The existing levees limit potential flooding from the Bay for the City infrastructure, as well as buildings and other development extending landward of Highway 101. Although the levees prevent flooding, they are not engineered to meet FEMA accreditation standards. To improve these levees, the City has partnered with nearby cities and county flood agencies as a member of the San Francisquito Creek Joint Powers Authority (SFCJPA). The SFCJPA is currently planning levee improvements, as well as habitat restoration and recreation enhancements under its Strategy to Advance Flood protection, Ecosystems, and Recreation along San Francisco Bay (SAFER Bay) project. The SAFER Bay project includes FEMA-accredited levees that can accommodate an additional three feet of sea-level rise. Still in its feasibility phase, the SAFER Bay project is considering several levee alignments along the Palo Alto shoreline. The City is also in the process of updating the Baylands Comprehensive Conservation Plan, which provides guidance for managing City-owned open space property along the Bay shoreline.

The City owns and operates the RWQCP to treat and dispose of wastewater from the City and surrounding communities. In 2016, the plant received approximately 19 million gallons per day (mgd) of average dry weather inflow (City, 2017), provided primary through tertiary treatment, and routed its effluent to recycled water uses (approximately 0.5 mgd), Renzel Marsh (approximately 1 mgd), and the Bay (the remaining 17.5 mgd) (City, 2017). The RWQCP's recycled water permit allows for up to 9 mgd of recycled water. Some of the RWQCP recycled water is piped to the northern shoreline section of the City of Mountain View for that city's recycled water program. The RWQCP is currently designing a redundant, parallel pipeline to carry effluent to the Bay, to improve capacity when Bay water levels are high, conditions that will become more frequent with sea-level rise. This new pipeline may offer opportunities for diverting effluent to a horizontal levee or enable re-purposing of the legacy emergency outfall.

Effluent from RWQCP currently meets water quality criteria from its National Pollutant Discharge Elimination System (NPDES) permits (City, 2017) that are issued by the Regional Water Quality Control Board. The City, along with other Bay-area water treatment operators, is assessing the capacity of the plant's current treatment process to meet more restrictive criteria for nutrients, particularly nitrogen, that may be implemented with a future permit renewal. To meet future nitrogen criteria, the City is planning upgrades to the existing treatment process including adding denitrification filters to reduce total nitrogen content to approximately 15 mg/l (Carollo, 2012). A horizontal levee can provide additional nitrogen removal capacity while also reducing concentrations of emerging contaminants of concern including trace pharmaceuticals.

ORO LOMA HORIZONTAL LEVEE - STATE OF THE ART

The horizontal levee demonstration project constructed at the Oro Loma wastewater treatment facility is a proof-of-concept project that incorporates several project elements, some that are common to future projects and some that are specific to the operational and research objectives of that particular facility. The essential elements of a horizontal levee include:

- Flood Control Levee – Comprised of compacted silt and clay soils with relatively low plasticity and low permeability to protect adjacent property from flood risks. Flood control levees typically incorporate relatively steep slopes to limit the amount of material required for levee construction.

- Horizontal Levee (i.e. Ecotone Slope) – A broad flat slope located adjacent to a flood control levee that is comprised of soil and planted with native wet meadow and/or riparian scrub vegetation and irrigated with freshwater seepage and/or shallow (approximately 1 mm) continuous or pulsed flow. Along a tidal marsh the horizontal levee above the marshplain (at ~MHHW) up to the 10-year or 100-year high water elevation. To provide high tide refugia habitat, the slope should be as flat as possible, generally a minimum of 10h:1v or ideally, flatter ranging from 30-100h:1v.

- Water Source – To support the habitat benefits of an ecotone, the slope requires some level of irrigation with freshwater. At minimum, irrigation during the rainy season into the spring would be required to mimic the fresh water seepage that historically supported this habitat. In the context of the Palo Alto RWQCP, a consistent source of treated (at least secondary-treated), nitrified, and disinfected wastewater can be used to irrigate the slope.

- Distribution System – Reliable system to deliver varied, but consistent flowrate and to evenly distribute water across the face of the ecotone slope. The distribution system could require controls to manage flow rates and to provide alternating periods of discharge and drawdown to vary saturation levels of surface soils.

- Treatment Zone – For wastewater polishing, a high permeability subsurface layer of gravel (or similar) substrate that extends for a specified width that provides a reducing environment for biologically-mediated processes to treat the constituents in the wastewater. Because the nitrate concentrations in the Palo Alto RWQCP effluent are anticipated to be below 15 mg/l (as N) following the planned treatment plant upgrade, nutrient polishing would not be a primary project goal. However, there are other polishing treatment benefits such as the reduction of emergent constituents of concern (i.e. pharmaceuticals) that may warrant research focus and could be important for the project. The treatment capacity of the horizontal levee could be adjusted to meet the agreed upon project goals.

- Segregated Treatment Cells – Hydraulically isolated cells that can allow for delivery to support varied saturated/unsaturated conditions and/or to implement various treatments to test and advance the state-of-the-art.

An overview of Oro Loma horizontal levee design:

- Pretreatment of secondary treated effluent prior to distribution to the horizontal levee includes nitrification and denitrification in free surface wetland. Disinfection is not currently included in the pretreatment process.

- A containment berm constructed to similar standards as a flood control levee. The containment berm forms a basin to contain up to 7.5 million gallons of primary treated effluent during extreme wet weather events.

- Total horizontal levee width is 456 linear feet, separated into 12 cells with 2-feet wide compacted clay berms. Each cell is 38 feet wide. The slope is approximately 3.3% (30h:1v) and length of ecotone and treatment zone is 150 linear feet. The length of the slope is divided into three (3) segments by a full-depth gravel mixing and sampling trench, every 50 feet to allow for flows to redistribute evenly across the cell to minimize preferential pathways.

- Horizontal levee substrate varies per cell for experimental purposes. The typical section is between two to three feet thick with 6-inches of drain rock for seepage at the bottom overlain with a 6-inch layer of sand and then one to two feet of top soil - either fine (clay loam) or coarse (layers of sand loam and clay loam). Drain rock and sand were blended with wood chips and the top soil was blended with wood fines to provide a carbon source to support biologic treatment processes.

- Horizontal levee cells were graded with two treatment approaches. Nine of the twelve cells incorporated a flat cross section to evenly spread water across the cell. Three of the fine-grained cells were graded to produce shallow swales and depressions to better mimic natural transitional ecotones with shallow freshwater wetlands.

- Vegetation communities also vary per cell for experimental purposes and encompass native wet meadow herbaceous, riparian scrub, and freshwater wetland species.

- Pump stations that allow for variable flow rates to be applied to the slope and that allow for greater flow rates to be applied on one or more days in three to four day cycles to mimic variable hydrologic conditions to support alternating periods of saturation and unsaturated conditions.

- Each cell is equipped with flow meters and valves to allow for fine tuning of flows delivered to specific cells.

Operations:

- The ecotone at Oro Loma was irrigated with freshwater pumped from a local well from early 2016 through the spring of 2017 to support plant establishment while construction of other project elements was completed.

- Beginning in April 2017 treated wastewater was routed through the free surface wetland and applied to the horizontal levee. Initial flow rates were approximately 70,000 gpd through November 2017 with flow applied consistently each day.

- In November 2017, flowrates were reduced to approximately 50,000 gpd to try to keep flows within the subsurface drain layers to the extent possible.

- From November 2017 through May 2018, flows to individual cells were adjusted to try to manage/maximize the ratio of subsurface flow to surface flow.

- Beginning in November 2017, Oro Loma implemented a bypass within the free surface treatment wetlands to deliver wastewater with nitrate concentrations ranging from 18 to 32 mg/l to test application of higher nitrate levels to the horizontal levee.

- June through August of 2018, flows were further reduced to approximately 30,000 gpd to maintain nearly 100% subsurface flows in the nine flat treatment cells.

At Oro Loma, removal of nitrate and trace organics has occurred primarily within the subsurface. Shallow surface flows have demonstrated relatively limited treatment efficiencies possibly due to the shorter residence times and relatively limited biological treatment. It's possible that as a surface layer of organic material develops surface treatment efficiencies may improve. Another important observation is that most of the removal has occurred in the upper portion of the high permeability drain layer within the horizontal levee. Even with the higher nitrate levels, very high treatment efficiencies have been demonstrated within the subsurface. Within the first 9-10 feet in the subsurface, nitrate levels are reduced by at least 90% (to non-detectable levels in many cells) and trace organics are reduced by 40% to greater than 90% depending on the constituent. This suggests that wastewater polishing could be spread over a longer and thicker, but narrower sub-surface treatment zone within the slope to achieve higher effluent throughput for the same total area.

The Oro Loma Ecotone Demonstration project was designed with capacity to deliver an average of up to 100,000 gpd to the horizontal levee with a daily maximum of up to 400,000 gpd. The project has been operated to deliver 30,000-70,000 gpd to 1.7 acres spread across a 456 LF horizontal levee. Delivery rates at the lower end of this range, 30,000 gpd (18,000 gpd/acre or 66 gpd/LF), have minimized overland flow and resulted in substantially higher removal rates.

It's possible that the hydraulic loading rate could be increased if the hydraulic conductivity and/or the depth of the drain layer substrate were increased or if the slope of the treatment zone was steepened. The drain rock treatment layer at Oro Loma is 0.5 feet thick. The conceptual design for Palo Alto proposes to increase the drain rock depth to one foot and to steepen the slope to 5% (20h:1v), which could increase the hydraulic loading rate up to 200 gpd/lf. Additionally, the design could be refined to improve hydraulic conductivity by incorporating separation fabric to limit intrusion of fines into the drain layer.

The vegetation establishment at Oro Loma has exceeded all expectations. Nearly 100% native cover has been observed and the vigor of the plants irrigated with the nitrogen content in the treated effluent has been beyond that seen on any other project. The revegetation leaders at Save the Bay have commented that the plants are growing as if on steroids due to the abundant water supply and high nutrient loads.

Moving forward to develop the next generation of the horizontal levee for Palo Alto, we would like to take into account the following lessons learned to advance or improve the process:

- Effective treatment is concentrated in the subsurface drain layer and correlated with hydraulic residence time requiring a relatively short distance of subsurface flow to achieve relatively high treatment efficiencies. Increasing the thickness of treatment media and steeping the slope of the treatment zone to increase subsurface flowrate should allow for increased volumes of treated wastewater.

- Since treatment volumes are also limited by hydraulic conductivity, increasing and/or maintaining the porosity of subsurface media could also increase treatment volumes.

- Vegetation for habitat creation and accretion – in particular willow have thrived at the Oro Loma demonstration with unforeseen impacts due to root growth into distribution pipes and potentially limiting the porosity of the subsurface drain layer. Planting of willow should be limited to maintain a sufficient distance from distribution lines and the upper portions of the treatment zone. Ecologists from Save the Bay indicate that willow roots can travel laterally up to 30 feet seeking water sources.

PALO ALTO PROJECT OBJECTIVES

The City of Palo Alto has identified the following objectives for the horizontal levee, in order of priority:

- Restore rare and historic ecotone transition slope habitat along the Bay's shoreline for special status species.

- Adapt to sea level rise by providing a transitional ecotone slope that will support freshwater plants to build organic soils to keep pace with some level of sea level rise and to allow wetland habitat bands to migrate up slope with rising water levels.

- Provide tertiary-treated wastewater to enhance ecological functionality of horizontal levee. The RWQCP intends to upgrade the treatment plant to denitrify all effluent and discharge at no more than 15 mg/l nitrate. Additional treatment by the horizontal levee would be an added benefit, but not relied upon to meet potential future permit requirements.

Additionally, the horizontal levee would advance the design of horizontal levees allowing for continued monitoring and research, including:

- Advance the state-of-the-art for horizontal levees for wastewater polishing, habitat creation, sea-level rise adaptation, and flood management.
- Advance the current permitting paradigm to allow for discharge of polished effluent from a horizontal levee into an adjacent tidal marsh connected to San Francisco Bay.
- Monitor effect of salt water at the toe of the horizontal levee on ecology and wastewater polishing.

SITE SELECTION

Several sites along the Palo Alto shoreline were considered as possibilities for a horizontal levee, but were not recommended for additional planning. Although a horizontal levee may be feasible at these sites, they are not as well-suited as the three recommended sites. In some instances, these other sites offer good opportunities for a horizontal levee, but will need to coordinate with the SAFER Bay project. As the SAFER Bay project advances, that project will likely include some of these other horizontal levee opportunities.

The pros and cons of these sites are summarized in Table 1 below.

Table 1. Sites considered for additional planning

Site Description	Pros	Cons
Embarcadero Road	• Proximity to RWQCP • Water availability (legacy emergency outfall connects to proposed levee) • SAFER levee permitting process will include project impacts	• Coordination with SAFER levee planning process could impact implementation schedule
Duck Pond	• Project size and complexity is limited • Proximity to RWQCP – could run new effluent line to site • Could provide plant nursery at existing Save the Bay location to support future horizontal levee implementation	• Limited benefit for SLR adaptation to protect infrastructure •
Pond A1	• Project proponent (South Bay Salt Ponds) currently designing ecotone slope that could be converted to a horizontal levee through the application of recycled water or treated wastewater • Would significantly increase habitat benefits of current restoration plan • Could tie in to Shoreline irrigation line and potentially rely on groundwater pumped from the nearby Shoreline complex	• Recycled water available adjacent to Pond A1 is not ideal water source (expensive, requires dechlorination, limited capacity) • Routing treated wastewater from RWQCP would require new pipeline and significant costs • Complicated implementation process with multiple agencies and jurisdictions

Site Description	Pros	Cons
Adjacent to existing RWQCP outfall	• Available wastewater effluent • Adjacent to shoreline and tidally-influenced	• Substantial impacts to jurisdictional tidal marsh wetlands – likely compensatory mitigation requirement under current regulatory policy • Adjacent to existing Palo Alto Airport which could limit habitat value and create conflicts with increased bird use
Seasonal wetlands between airport runway and existing levee	• Could tie into potential SAFER levee alignment along airport/runway creating horizontal levee connected to existing marsh habitat • Limits impacts to adjacent jurisdictional wetlands related to the RWQCP option (above)	• Adjacent to existing Palo Alto Airport which could limit habitat value and create conflicts with increased bird use
Palo Alto Flood Basin	• Large existing wetland area • Adjacent to Renzel Marsh and wastewater effluent pipeline	• Cross-jurisdictional (multiple cities and regulatory agencies involved) • SAFER levee alignment relative to the flood basin currently undetermined (location of levee determines if horizontal levee is connected to tides/shoreline and other parameters) • Substantial impacts to jurisdictional wetlands – likely compensatory mitigation requirement under current regulatory policy
Renzel Marsh	• City looking to enhance public access and habitat • Wastewater effluent currently feeding this marsh	• Isolated from shoreline and tides • Substantial impacts to jurisdictional wetlands – likely compensatory mitigation requirement under current regulatory policy requiring large mitigation efforts

The three alternative sites that warranted additional consideration were the Embarcadero Road Site, the Duck Pond Site, and the Pond A1 Site. Conceptual designs were developed for each of these sites as described in the following section and shown in the attached design figures.

Based on an initial review of these concepts, the Embarcadero Road site emerged as the most practical project tor the RWQCP to pursue in the near term. The primary drivers included:

- Proximity to the treatment plant, which reduces water supply costs, enables use of treated effluent and also simplifies operations and maintenance.

- The project would be primarily on uplands adjacent to existing tidal marsh allowing for implementation with minimal impact to existing marsh habitat.

- The project would be located on property that is owned by the City of Palo Alto, simplifying jurisdictional issues.
- The horizontal levee added to a comprehensive levee improvement project (SAFER Bay) would directly improve the flood protection for the RWQCP including protection from rising sea levels. Additionally, implementing a horizontal levee along the planned SAFER Bay levee improvements could allow the SAFER Bay levee to be constructed with a lower crest elevation due to the wave attenuation benefits associated with the horizontal levee.

The Duck Pond site also warrants serious consideration. This site has some of the same benefits as the Embarcadero Road Site such as proximity to the RWQCP and land ownership. However, this site is not adjacent to existing marsh habitat which limits its utility for meeting the City's primary objective of creating ecotone transition habitat for special status species. Additionally, the Duck Pond site would provide a limited benefit for sea level rise adaptation because the Duck Pond basin is connected to the Bay through a culvert/tide gate structure with muted tidal exchange. However, the potential for creating a native plant nursery that could support restoration of ecotone transitional habitat around the Bay provides a powerful driver for this site. The City indicated that Save the Bay, which operates the native plant nursery at the site, could function as a viable project sponsor at this location. The RWQCP would be willing to supply treated effluent to support a project at this site.

The Pond A1 Site also has good potential for implementing a horizontal levee. However, this site has a lower potential for direct involvement from the RWQCP primarily because it is further from the plant than the other two sites. The existing supply of treated effluent to this site is a recycled water line to the Shoreline Golf Course. This line has a limited capacity and recycled water would require dechlorination prior to application to the horizontal levee. There could be an opportunity to utilize groundwater pumped from the Shoreline Park as a water source for a Pond A1 project as discussed below. In addition, the South Bay Salt Ponds Project is currently pursuing an ecotone slope on the proposed levee at the site, and would be a viable sponsor for a potential project at this site.

CONCEPTUAL DESIGN

The conceptual designs for the potential Palo Alto horizontal levee alternatives integrate the design approach and the lessons learned from the Oro Loma Ecotone Demonstration Project.

The horizontal levee envisioned for this project consists of the following key design elements: a water supply system, site grading to create a broad transitional slope, a permeable treatment layer for wastewater polishing, and vegetation planting. Since these elements would be common across the possible project sites, design considerations for these elements are described in this section. The key design elements influence one another, so they also need to be integrated with one another. For example, the volume of water supply needs to be appropriate for conveyance capacity of the permeable treatment layer and to support the native vegetation. Other factors, such as, integration with existing and proposed infrastructure (such as trails and levees) scalability, environmental permitting, and monitoring, have been considered in developing conceptual designs.

Water Supply System

Water supplied to the horizontal levee provides irrigation to support target vegetation species, and as such, should meet the water quality needs for the vegetation. In addition, the water that leaves the slope needs to meet water quality requirements for discharge to the Bay.

For the Embarcadero Road and Duck Pond alternatives, final effluent from the Palo Alto RWQCP would supply the horizontal levee. At later stages of design, the water supply system will need to specify details such as connections to the existing RWQCP piping and the distribution system for plant irrigation. For purposes of the conceptual design, the focus is on water supply in terms of volumes, quality, and main pipeline alignment.

Design Flowrate

The quantity of water supplied to the horizontal levee will depend upon:

- **Available effluent** – The horizontal levee can be utilized to provide wastewater polishing under normal dry flow conditions. Alternatively, the horizontal levee and vegetation community can be designed around utilizing excess flows during the rainy season into spring to allow for other, higher uses of recycled water during the dry season. The supply should be achievable for sustained periods that can be integrated with the RWQCP's typical wastewater treatment process. We assume that the point of compliance will remain unchanged (i.e. at the treatment plant discharge up gradient from the horizontal levee), since this system is still experimental and in the developmental stage. At this time, the RWQCP has identified 3 MGD of environmental flows dedicated to improving nearshore habitat including horizontal levee(s), Renzel Marsh, and shallow water discharge. The 3 MGD of flow available for environmental flows is more than enough to support all of the three horizontal levee alternatives developed for Palo Alto (Embarcadero Road, Duck Pond and Pond A1).

- **Irrigation demand** – At minimum, this demand is a function of the irrigated area and the vegetation's evapotranspiration within the irrigated area. In general, the irrigation demand provides a lower limit on the required level of effluent to be applied to the slope and is not a limiting factor in the design. Typically, the design seeks to maximize the flowrate that can be effectively treated by the system which significantly exceeds the minimal irrigation demand required to maintain the vegetation community. The availability of excess treated wastewater significantly increases plant growth rates which can improve habitat quality.

- **Hydraulic Loading Rate** – The hydraulic loading rate refers to the maximum flowrate distributed along the top of the horizontal levee (i.e. gallons per day per linear foot) that can effectively be treated by the horizontal levee. Optimizing the loading rate is a secondary objective of this project. At Oro Loma, the horizontal levee's treatment capacity appears to be limited by the hydraulic conductivity (flowrate per unit area) of the subsurface treatment zone rather than hydraulic residence time required by the biological processes. Effective treatment of the wastewater has been limited to flows that pass through the subsurface treatment zone. Whereas, flows along the surface have had limited treatment efficiencies. The conceptual design seeks to incrementally increase the hydraulic loading rate by increasing both the hydraulic conductivity and the depth of the substrate, as well as, steepening the slope of the treatment zone.

- **Seasonality** – Treatment removal rates and evapotranspiration rates also have a seasonal component, with evapotranspiration and, to a lesser extent, treatment efficiency, decreasing with cooler temperatures. During the wet season, precipitation can deliver enough water that may affect peak conditions, particularly if it causes above-ground flow of wastewater. For reference, at OLSD, 1 inch of rain/day approximately matches the daily effluent volume and 4 inches rain/month (wet season average) is 12% of monthly effluent volume; 8 inches rain/month (wet season extreme) is 25% of monthly effluent volume). While the native vegetation that would establish on the horizontal levee are adapted shallow surface flows, the extra water delivered by rainfall could impact treatment efficiencies for polishing treated effluent within the subsurface.

- **Design Flowrate –** The Palo Alto project would be designed to supply a variable flowrate to the horizontal levee with lower and upper bounds used to experimentally evaluate performance and advance the state-of-the-art. The lower bound should be at or above the irrigation demand and the upper bound should be moderately above the hydraulic conductivity of the treatment media. The flowrate will be a function of the hydraulic loading rate and the length of the horizontal levee. Additionally, since the primary goals for the Palo Alto project would be related to creating habitat for special status species and sea level rise adaptation, delivery of treated effluent should also be tailored to support a complex, heterogeneous native plant community by fluctuating between saturated and unsaturated conditions in the upper soil layers.

Water Quality

The water applied to the horizontal levee would need to have a suitable quality for the slope's vegetation and also need to comply with effluent discharge requirements set by the regulatory agencies. The water quality criteria will be determined in collaboration with regulatory agencies, primarily the Regional Water Quality Control Board, as well as the wildlife agencies. These criteria will consider effluent quality that is tolerable to the ecotone vegetation and beneficial uses of the receiving waters.

The horizontal levee will receive influent which has undergone tertiary treatment including nitrification, partial denitrification in the future, dual media filtration, and disinfection within RWQCP's facilities. Even with this advanced level of treatment, there are several constituents that could pose a risk to the treatment effectiveness and vegetation health.

Extremely high nitrate concentrations can impair vegetation growth and may impact the nitrate removal capacity of the gravel treatment layer. As discussed above, nitrate concentrations up to 30 mg/l have not adversely impacted either the vegetation communities or the nitrogen removal effectiveness of the system at Oro Loma. However, higher nitrate levels have only been applied for a limited period during the winter and spring of 2018 and additional monitoring through the summer months are required. We recommend data from Oro Loma be evaluated and future recommendations be incorporated into the Palo Alto horizontal levee design. RWQCP effluent currently has average nitrogen concentrations at just over 30 mg/L (HDR, 2016). The RWQCP is planning an upgrade including partial denitrification to reduce total nitrogen levels to about 15 mg/l. These improvements are planned to be implemented as early as 2021 which could align with implementation of a horizontal levee project. If lower nitrate levels are preferable for the horizontal levee, options to reduce nitrate concentrations could include: blending with other water sources and/or additional treatment for the effluent stream routed to the horizontal levee.

While higher salinity levels (as measured by total dissolved solids or TDS), concentrations of 800-900 mg/l, can damage foliage for a number of native upland plant species (City, 2017), vegetation species intended for the horizontal levee typically have some salinity tolerance and are not likely to be affected by these relatively low salinity levels. The RWQCP is planning to upgrades to the treatment facility that may include removal of TDS through advanced filtration methods.

The recycled water that is delivered to the Shoreline complex adjacent to the Pond A1 alternative (tertiary treated meeting Title 22 standards) is chlorinated prior to discharge from the RWQCP. While chlorine is not considered toxic to plants, it does interact with organic matter to form chemicals collectively known as disinfection byproducts that are known to adversely affect aquatic ecosystems. It is anticipated that recycled water would need to be dechlorinated prior to application to a horizontal levee. The RWQCP has limited capacity to supply recycled water which is relatively expensive to produce, and it should be directed to the highest and best use.

Distribution System

The main pipeline will deliver effluent from existing RWQCP piping to the horizontal levee project site(s). As shown in Figures 1 and 5, two main pipe networks already convey effluent from the RWQCP and could be the starting point for a connection to the horizontal levee. These networks include:

- two existing Bay outfalls and a third proposed Bay outfall heading northeast from the RWQCP
- recycled water pipelines, primarily configured to serve the Shoreline area in the City of Mountain View

A new main pipeline to the horizontal levee will need to consider the physical connection to existing pipelines, pipeline capacity, right-of-way, and potential conflicts with other utilities and infrastructure (such as the proposed SAFER coastal levee).

Horizontal levee Design

The conceptual design for the Palo Alto horizontal levee integrates the successes and the lessons learned from experience at the Oro Loma site. There are three sites that are being considered for implementation as shown in Figure 1 – Embarcadero Road (Figures 2-6), Duck Pond (Figures 7-8), and Pond A1 (Figure 9-12), which are described in greater detail below. The design elements described in this section are common to each location. The horizontal levee will consist of 1) a levee (or berm) on the landward side for flood protection, 2) a treatment zone, and 3) a habitat transition zone. The conceptual design of each of these elements was based on several factors including tidal inundation and datums, adjacent land use and topography, and proposed future use of the area.

Datums

Using data from the NOAA station at Coyote Creek (NOAA 9414575) and the Palo Alto Yacht Harbor, the following tidal datums were used for the Embarcadero Road Shoreline, Duck Pond and USFWS Pond A1 sites. Since the Duck Pond experiences a muted tide signal, tidal datums were estimated with professional judgement for the conceptual design effort. We recommend that a tide gage be set up to measure the tide range and surveys of existing vegetation at the site be performed if design at the Duck Pond proceeds.

Table 2 – Tidal Datums

Tidal Datum	Embarcadero Road Shoreline/ USFWS Pond A1 (feet NAVD)	Duck Pond (feet NAVD)
Mean higher high water (MHHW)	7.5	5.5-6.5
Mean high water (MHW)	6.9	
Mean tide level (MTL)	3.3	
Mean low water (MLW)	-0.3	
Mean lower low water (MLLW)	-1.5	-1.0-0.0
Diurnal Tide Range (MHHW – MLLW)	9.0	5.5-7.5
100-yr flood stage **	10.8	10.8
10-yr flood stage **	10.2	9.5
Note: Tidal Datums are from Coyote Creek with the exception of the 10- and 100-yr flood stage, which are from the Palo Alto Yacht Harbor		

The tidal datums were used to set the horizontal levee elevations. The horizontal levee is designed to be a freshwater transitional zone to the tidal marsh. For the Embarcadero Road and Pond A1 locations, the lower end of the treatment area is situated between elevation 8.0 and 9.5 feet NAVD, which is 0.5 to 2.0 feet above MHHW. For the Duck Pond location, the lower end of the treatment area is situated at approximately elevation 7 feet NAVD to account for the muted tide that this site experiences. These elevations will be refined through the design process to incorporate appropriate sea-level rise projections and other considerations. For instance, the treatment zone could be raised or possibly flattened to 30h:1v to raise the lower end further above MHHW depending on concerns related to salt water impacts on biological treatment efficiency.

Embarcadero Road Horizontal levee

The Embarcadero Road site has been identified by the City of Palo Alto as the preferred location to move forward for additional study and design to support ultimate implementation. The full build out vision is presented in Figure 2 which shows the project including three main sections of horizontal levee and irrigated ecotone slope:

1. The preferred Phase 1 project is located in the central portion of the Embarcadero Road site just south of the Environmental Volunteer's Center and includes about 800 LF of horizontal levee and irrigated ecotone slope along the planned SAFER levee alignment.

2. The Harbor Road leg south of the central Phase 1 reach includes about 940 LF of horizontal levee and irrigated ecotone along the planned SAFER levee alignment.

3. The northeast leg includes about 860 LF of horizontal levee and irrigated ecotone along Embarcadero Road northeast of the Environmental Volunteer's Center.

This conceptual alternative includes sections of horizontal levee in areas with wider existing uplands that include a permeable treatment zone and flatter slopes that can provide wastewater polishing in addition to the transitional habitat benefits. In areas with a relatively narrow band of uplands, this concept includes irrigated ecotone slopes which are designed around a steeper 10h:1v slope to provide some habitat benefits while limiting fill in existing wetlands.

The Embarcadero Road project can be supplied with treated wastewater that could be delivered either directly from the legacy emergency outfall or with smaller pipe connected to the RWQCP that could be sleeved through the legacy outfall alignment shown in plan view on Figures 2 & 3.

The preferred Phase 1 project includes about 590 LF of horizontal levee and an additional 210 LF of irrigated ecotone as shown in more detail on Figure 3. Conceptual cross sections for the horizontal levee portions of the Phase 1 project are presented on Figure 4. This portion of the Embarcadero Road site offers the widest upland corridor, which can support a horizontal levee with a relatively flat 20-30h:1v treatment zone and a 30-50h:1v high marsh ecotone below the treatment zone which would create relatively wide transitional slope along the adjacent Harbor Marsh. The landward side of the horizontal levee and ecotone slope is bounded by the planned SAFER levee backed by Embarcadero Road (Figure 4, Sections A-B). In Sections A-B, the full height of the SAFER levee is shown along with the potential to lower the height of the levee by up to 2 feet accounting for the wave attenuation from the existing Harbor Marsh and proposed horizontal levee. As the upland band in this area narrows to the north near the Environmental Engineer's center and to the south towards Harbor Road the horizontal levee would transition to a steeper irrigated ecotone designed to provide habitat benefits while forgoing the wastewater polishing function offered by the horizontal levee. The 590 LF of horizontal levee is anticipated to be able to polish up to 118,000 gpd of treated wastewater. The irrigated ecotone would require up to about 400 gpd on average to support vigorous plant growth which could be supplied by either treated wastewater or a separate water source.

The Harbor Road leg of the project as shown on Figure 2 also abuts the planned SAFER levee and includes about 210 LF of horizontal levee with about 730 LF of irrigated ecotone along areas with a relatively narrow band of existing upland habitat. Conceptual cross sections for this reach of the project are presented on Figure 5, Section C and D. Section C shows a representation of the horizontal levee along this reach with a lower and steeper treatment zone at 20h:1v and a steeper transitional slope along the Harbor Marsh to limit fill within the existing wetlands. Section D provides a representation of the irrigated ecotone slope with a 10h:1v slope extending down and filling a portion of the Harbor Marsh. Along this reach, the SAFER levee would require fill within the existing wetlands, and the ecotone would require additional fill in the marsh. However, we anticipate that the ecotone would allow for the SAFER levee to be built with a lower overall height and section due to the wind wave attenuation provided by the ecotone slope. The ecotone section would require up to about 2.5 feet of fill in the existing marsh beyond the steeper proposed SAFER levee section and most of the marsh fill would support native high marsh transitional vegetation. The 210 LF of horizontal levee along Harbor Road is anticipated to have a treated wastewater polishing capacity of up to 42,000 gpd and the irrigated ecotone would require up to about 1,200 gpd of treated wastewater or a separate water source to support vigorous native vegetation.

The northeast leg of the project along Embarcadero Road includes a short 130 LF section of horizontal levee and about 730 LF of irrigated ecotone as shown on Figure 2. Conceptual sections for this reach are presented on Figure 6. This reach is north of the proposed SAFER levee alignments in an area of relatively low ground at about the 10-year water level. The conceptual sections illustrate two potential options to improve flood protection along this reach including either construction of a low berm along Embarcadero Road or raising Embarcadero Road to just above the 100-year water level. The short section of horizontal levee would also incorporate relatively steep slopes of 20h:1v within the treatment zone with a somewhat flatter transitional section to meet the adjacent Harbor Marsh. Raising Embarcadero Road would allow for the horizontal levee and irrigated ecotone to be somewhat flatter and could allow for a longer stretch of horizontal levee as areas that would only support a steeper 10h:1v irrigated ecotone could be expanded to support a horizontal levee allowing for increased habitat benefits and wastewater polishing. As shown, the 130 LF of horizontal levee could polish up to 26,000 gpd, and the 730 LF of irrigated ecotone would require up to about 1,200 gpd of treated wastewater or a separate source for irrigation.

In total, the full build out Embarcadero Road alternative could polish up to 186,000 gpd of treated wastewater along 930 LF of horizontal levee and require up to 2,800 gpd of treated wastewater or a separate source for irrigation. Well below the 3 MGD of treated wastewater available from the RWQCP.

The Embarcadero Road alternative would also require relocating existing public access trails. The conceptual cross sections show the existing trail moved upslope to the upper limit of the ecotone/horizontal levee slope adjacent to the planned SAFER levee or the berm/raised Embarcadero Road in the northeast leg. Alternatively, it could be possible to locate the trail along the SAFER levee top or perhaps allow the trail to jog up and down slope between the levee and upper edge of the ecotone to provide some variation of elevation and views. The relocated trail is shown as an 8 feet wide corridor that would be paved with aggregate base or a decomposed granite surface. One concern would be the close proximity of the public access to the habitat supported by treated wastewater and the potential for the public to go off trail. Public access could be controlled by incorporating strategic plantings along the trail that would restrict access to the treatment areas and sensitive habitat. Other projects have also utilized fencing – either a chicken wire fence to limit dog access or a two cable fence to demarcate the limit of the public access while allowing more open access for endangered species and other wildlife.

Duck Pond Horizontal levee

The Duck Pond site would allow for a horizontal levee project that could support a nursery for Save the Bay to provide native plant material for future high marsh and riparian scrub transitional revegetation efforts throughout the Bay Area.

The conceptual design is presented in plan view on Figure 7 and sections on Figure 8. The site has the capacity to construct two segments of horizontal levee of approximately 525 linear feet combined, with an anticipated treatment capacity of up to 105,000 gpd. The horizontal levees were limited to areas that did not impact existing marsh and could achieve a 50-foot long treatment zone at a 20-30h:1v slope above elevation 7 feet NAVD. The concept as shown on Figure 7 represents a fairly large project footprint that could be adjusted as needed to avoid existing buildings or other valuable infrastructure.

To achieve the necessary horizontal levee dimensions, a new berm would be built up to elevation 10 feet NAVD or possibly higher depending upon revised tidal datums and goals for flood protection in this area. The treatment zone would extend from approximately elevation 9.5 down to 7.0 feet NAVD. Below the treatment zone, the horizontal levee would extend at a 30h:1v slope or flatter to match local MHW or MHHW within the muted tidal basin (assumed at elevation 6 feet NAVD).

The Duck Pond site could be supplied with treated wastewater routed from either the legacy emergency outfall as described for the Embarcadero Road alternative or from the proposed primary outfall that will be routed around the Palo Alto Airport as referenced in the plan view Figure 1.

The existing access trail could be moved to the top of the proposed berm to maintain existing public access.

Pond A1 Horizontal levee

The Pond A1 site is considerably larger than the Embarcadero Road or Duck Pond sites as shown on Figure 1. Given the current 60% design for the Pond A1 restoration under development by the South Bay Salt Ponds Project, the site has the capacity to construct two long segments of horizontal levee as shown on Figures 9-11. The Pond A1 60% grading plans include construction of an ecotone transitional slope up to elevation 9.0 feet NAVD which would represent the lowest potential elevation to support high tide refugia habitat. The horizontal levees were limited to areas in the 60% grading plan that included transitional slopes that were 30h:1v or flatter as shown in the conceptual cross sections on Figure 12. To build upon this design while improving habitat values and keeping the treatment zone above MHHW, the concept proposes to extend the treatment zone up to elevation 11 feet NAVD. Below the treatment zone, the ecotone would continue at a 20:1 slope until it matches the proposed ecotone grade. Pond A1 West and East offer a combined horizontal levee of about 1,850 LF with an anticipated treatment volume of up to 407,000 gpd.

The Pond A1 site has several recycled water pipelines in the vicinity that could supply the horizontal levee as referenced in the plan view Figure 9. The RWQCP currently supplies water for the City of Mountain View's recycled water system (Carollo, 2012). This recycled water is used in buildings and to irrigate a golf course and other areas of Shoreline Park. Even accounting for other plans to expand recycled water use, both the RWQCP and the City of Mountain View believe there is unallocated recycled water supply that could be used for the Pond A1 horizontal levee. The actual amount of unallocated supply, as well as the existing pipeline's capacity to deliver this supply will need to be determined. However, since recycled water is relatively expensive to produce and has a high market value, the RWQCP may want to reserve this water for paying customers. Additionally, using recycled water would require adding a dechlorination process prior to application to a horizontal levee.

The existing recycled water supply system to Mountain View includes several sections that approach the Pond A1 shoreline, as shown in Figure 9 and briefly described below:

- **Primary Supply Pipeline** – The 24-inch main pipeline follows East Bayshore Road and then Garcia Avenue. A new extension of approximately 2,500 feet could connect to the west side of Pond A1 (off Figure 9 to the southeast).

- **Marine Way Spur** – An existing 6-inch diversion from the primary supply pipeline extends to the corner of Casey Avenue and Broderick Way. A new extension of approximately 1,250 feet could connect to the west side of Pond A1.

- **Shoreline Irrigation System** – This system, which is pressurized by its own pump and can also draw from potable and pond storage, includes an existing 10-inch water main that approaches Pond A1. A new extension of approximately 800 feet could connect to the east side of Pond A1.

- **Historical Shoreline Pipeline** - A historical recycled water pipeline, which is currently de-commissioned, runs from the primary supply pipeline and then along the Pond A1 shoreline. New extensions of approximately 100 feet could connect to most of the Pond A1 shoreline.

Further discussion with the City of Mountain View is needed to identify the condition and capacity in these pipes.

An alternative water supply for the horizontal levee could be groundwater pumped from Shoreline Park. Shoreline Park is constructed on a closed landfill site. Normal operation is for groundwater to be pumped from the perimeter outside of the landfill footprint. Depending on water quality, the groundwater is either sent to the RWQCP for processing or discharged to surface water (City of Mountain View, 2013). The City of Mountain View Department of Public Works is responsible for the landfill operation and could be approached regarding interest and capacity in supplying groundwater to the horizontal levee.

Wastewater Treatment Zone

All three conceptual alternatives include a similar wastewater treatment zone that has been developed to account for the lessons learned at Oro Loma to allow for an incremental increase in treatment volumes per linear foot of horizontal levee. The proposed treatment zone is presented on Figure 13. At this early stage, the proposed treatment zone incorporates the following elements (described from the highest elevation to the lowest):

- A distribution channel & trench offset about 10 feet from the relocated trail or tie in with the levee/berm core. The offset limits reducing the prism of the levee/berm core to help maintain the flood control functions of the core. Additionally, the offset provides a buffer between public access and the distribution of treated wastewater.

- A 5-feet wide distribution channel & trench backfilled with drain rock to route treated effluent to the subsurface treatment layer. The shallow channel (~0.25-foot deep) would allow for treated effluent to be distributed across the ecotone via open channel and subsurface gravity flow to help limit the need for perforated distribution pipes which have experienced problems related to clogging at Oro Loma. Oro Loma utilized a 2-feet wide distribution trench, and the wider trench proposed here would allow for distribution of increased effluent volumes.

- A 1-foot thick sub-surface drain layer separated top and bottom with a geotextile separator fabric to limit intrusion of fines into the drain layer. The drain layer is anticipated to include a mix of drain rock (or other highly permeable material) and wood chips to provide a carbon source. The 1-foot thick drain layer is twice as thick as the drain layer incorporated at Oro Loma, and is anticipated to allow for at least double treatment volume per linear foot due to the increased thickness and more resilient separation barrier.

- A 1.5-feet thick ecotone soil layer to support native vegetation underlain by a 0.5 feet thick sand filter layer to further help limit migration of fines into the subsurface drain layer. The ecotone soil and sand filter layers would be blended with composted wood fines for labile carbon to help support biological treatment.

- A 5-feet wide discharge trench to allow the subsurface flows to migrate from the drain layer into the ecotone soils down gradient from the treatment zone and as shallow surface flows.

- The subsurface treatment zone is currently shown as 40 feet long plus 5 feet wide trenches at the upper and lower limits for a total treatment length of 50 feet. Current monitoring results show that the subsurface treatment reaches maximum efficiencies at 10 feet in total flow length. As we understand more about the residence time and how the Oro Loma demonstration evolves regarding treatment efficiency, it's possible that the length of the treatment zone can be reduced to optimize the design for cost effectiveness.

- Below the treatment zone, the ecotone habitat zone would incorporate a 2 feet thick layer of ecotone soil blended with composted wood fines to provide a source of labile carbon.

Project Site Grading

To facilitate implementation of a horizontal levee pilot at Palo Alto, the sites considered in this memo avoid or limit adding fill in existing wetlands. This approach will help streamline implementation by simplifying the permitting process. Factors to consider when designing grading include:

- Where needed for the target vegetation, grading would position the horizontal levee at appropriate elevations relative to and just above the Bay tide range, and be sloped to provide gravity drainage.

- In addition to adjusting the ground surface, grading may include replacing or amending the top two to three feet of soil. This would provide appropriate substrate conditions (e.g. organic/nonorganic composition, grain size, hydraulic conductivity) to support the native vegetation and water treatment.

- The grading also needs to integrate with current and planned flood management strategies. For example, the horizontal levee should be planned to not interfere with existing or proposed coastal flood protection levees (including the SAFER levee and/or Pond A1 levee) nor to impair existing drainage pathways.

Additionally, the grading plans could include some complexity similar to natural upland to tidal marsh transitions. It could be possible to incorporate coarser soils along wider, higher sections of the ecotone, and finer grained soils within valleys or coves that drain into swales with depressional wetlands to better mimic natural ecotones and freshwater seeps.

Ecotone Vegetation Planting

Based on observations at remaining ecotone reference sites on the Bay shoreline, the target plant community is a mix of wet meadow and riparian scrub/shrub habitat. Eighteen species were planted and have mostly flourished at the OLSD pilot project. These species can serve as an initial planting palette with demonstrated capacity to provide the preferred habitat and treatment. In addition, reference sites local to Palo Alto, such as the area just west of Harbor Point parking lot, may provide additional insight for selecting and propagating plant species. At OLSD, this vegetation palette has yielded plant heights ranging from two feet to more than twelve feet high, with some species likely to grow higher. When placing specific species, the plant layout should consider proximity to public access, such that taller vegetation does not unduly impact views, space, and safety for recreational users.

These ecotone vegetation species require physical conditions which are largely determined by the water supply and grading design elements, as discussed in those sections above. In turn, the planting extent and capacity to process effluent needs to be coordinated with the water supply rate and quantity. To thrive and outcompete terrestrial non-native species, the wet meadow and riparian species benefit from more water than just precipitation alone. Along natural transitional slopes, incidental rainfall is augmented by surface runoff and shallow ground water flow originating in the surrounding watershed. Although initial data from OLSD indicates that ecotone vegetation thrives at an irrigation rate on the order of 18,000 gpd/acre and 66 gpd/LF, alternate irrigation rates may be achievable, depending on such factors as site geometry (length, width, slope) and subsurface hydraulic conductivity.

Since refinements for vegetation planting design are still evolving, the planting may consider different treatments across the project area. These treatment variations could include different vegetation types and substrates integrated into a more complex topographic grading plan, such that questions related to water treatment (e.g. nitrogen removal rates) or habitat (e.g. preferences of special status bird species) could be monitored and evaluated. Additional monitoring might also assess alternate irrigation cycles, removal rates as a function of flow path length, slope width, and potential habitat changes in downstream salt marsh due to increased freshwater discharge.

Thus far, the plantings at Oro Loma have not required significant maintenance. However, the Oro Loma horizontal levee was planted at a 1-foot on center plant spacing. This high-density spacing was implemented to allow the Oro Loma experiment to proceed as soon as possible by allowing near complete aerial coverage within the first year of planting. This high density also allowed for the native plants to generally out compete non-native species. At Oro Loma, with a continuously saturated hydrologic regime, willow and bulrush/cattail are beginning to out compete many of the other planted native species, and some non-native species including pampas grass have begun to colonize the site. With a primary goal to provide critical habitat for special status species, the Palo Alto horizontal levee may try to target a more varied hydrologic regime with alternating cycles of saturated and unsaturated surface soils to support a greater variety of native transitional plant species and to help limit non-native plants. Additionally, occasional inundation with salt water from the Bay during king tides and storm surges will also help to limit non-native plants along the ecotone.

Planting methods

OLSD was successfully planted using seeds and seedlings collected from wild plants, propagated in nurseries and raised beds, and then planted with some assistance from volunteers. Assuming sufficient nursery capacity is identified, these methods should be transferable and scalable to other sites. Possible improvements to these planting methods which may achieve similar results at greater scale and lower cost include reduced lower planting density augmented with hydroseeding or drill seeding to infill the remaining area and mechanical distribution.

Although the planting is anticipated for irrigated areas above regular tidal inundation, the vegetation is close enough to the Bay to be exposed to salinity, in the form of spray, seepage from saline soils, or infrequent flooding. So, plants selected for the ecotone should have some tolerance for salt or brackish inundation. Planting would be likely limited to elevations above monthly tidal inundation. Below this elevation, the vegetation would transition to tidal marsh species that can accommodate regular saltwater inundation (e.g. cordgrass, pickleweed). These species are already present adjacent to the proposed horizontal levee project areas and typically establish on their own from sources conveyed by the tides and do not usually require planting. To transition between the lower edge of the horizontal levee and adjacent existing tidal marsh, the planting palette might be expanded to include high marsh vegetation such as gumplant (Grindelia stricta) and saltgrass (Distichlis spicata).

CONCEPTUAL DESIGN COST ESTIMATES

Construction cost estimates for each conceptual alternative were prepared based on our experience at Oro Loma and on other wetland restoration projects. The cost estimates considered critical construction components related to mobilization, SWPPP (environmental compliance), earthwork (cut, fill, placement, compaction), import of rock and other materials, infrastructure improvements (pump stations, pipelines, and discharge appurtenances), trail relocation, and revegetation (seeding and planting). At the conceptual level these costs are relatively rough "ball park" estimates as many details related to each conceptual alternative are not well defined, and as designs are further developed unanticipated constraints and requirements could significantly change (usually increase) potential project construction costs. In particular, details related to connections to the RWQCP including required turnouts, pump stations, controls, etc. and pipelines to potential horizontal levee sites are roughly estimated, but the actual details of the work required are not known at this conceptual level.

Additionally, the cost estimates include projected construction costs and do not include engineering (restoration design, geotechnical, MEP), permitting and CEQA related costs or costs related to staff time by a project proponent. Finally, operation and maintenance costs for RWQCP staff to operate the treated wastewater distribution system, parks staff for trail maintenance, and revegetation maintenance are not included at this stage. These costs should be mainly used to compare alternatives with the understanding that the costs will likely change as designs progress.

The estimated costs are provided in 2018 and 2021 dollars in summary in Table 3 below and in detail on the attached Table 4.

Table 3 – Estimate Construction Costs for Conceptual Alternatives

Conceptual Alternative	2018 Construction Costs	2021 Construction Costs
Embarcadero Road – Phase 1	$1,465,000	$1,650,000
Embarcadero Road – Build Out (including Phase 1)	$2,869,000	$3,230,000
Duck Pond	$2,306,000	$2,590,000
Pond A1	$3,231,000	$3,630,000

Notes: Cost Estimates include a 35% contingency.
2021 estimate includes a 4% per year escalation over the 2018 estimate.
Cost estimates should be considered as a +/-30-50% level of accuracy at this conceptual stage.
Pond A1 costs reflect tie in to the existing recycled water supply lines and does not reflect the costs of recycled water or dechlorination. If a dedicated line is required, the costs for Pond A1 would increase significantly.

PERMITTING STRATEGY

As noted in the 2018 Basin Plan Triennial Review, the receiving waters downstream of many Bay Area wastewater treatment plants include recently restored wetlands or areas that will be restored to wetland habitat in coming years. In many circumstances, using the treated wastewater as a source of freshwater for restored wetlands and ecotone transitional areas would provide a net environmental benefit by increasing the amount of freshwater and brackish wetlands and supporting vigorous native transitional vegetation for birds and wildlife dependent on such habitats. Using treated wastewater in this fashion as a source of freshwater was identified as an important climate change response strategy in the Baylands Ecosystem Habitat Goals 2015 Science Update to "restore estuary-watershed connections that nourish the Baylands with sediment and freshwater" (2018 Basin Plan Triennial Review - San Francisco Bay Region Brief Issue Descriptions April 2018, pp. 10-11).

As part of the review, RWQCB staff are exploring an update of Regional Board Resolution No. 94-086 "Policy on the Use of Wastewater to Create, Restore, and/or Enhance Wetlands." The current Resolution 94-086 policy is now over 20 years old. Much has been learned about wetland restoration over the intervening years and the hydrology and topography of the San Francisco Bay has been changing as vast areas of former salt evaporation ponds are being restored to marsh under the San Francisco Bay Salt Pond Restoration Project.

This review is anticipated to also clarify permitting requirements for wastewater discharges into wetlands, develop near-shore permitting strategies for discharges to wetlands and sloughs. RWQCB would also evaluate and provide guidance about what level of treatment is appropriate for effluent discharged into wetland habitats, including consideration of contaminants of emerging concern (e.g., flame retardants, personal care products, microbeads and nano particles).

Establishing NPDES permits for discharging wastewater in wetlands is complicated by a variety of regulatory issues; RWQCB would explore those regulatory issues and identify policy options, and potentially evaluate issues associated with discharge prohibition exemptions in the Basin Plan and could address Beneficial Use designation associated with creation of new wetlands. A discussion of regulatory interpretations to be explored with RWQCB is provided below, as well as a specific discussion of key issues to be addressed for amending existing wastewater treatment plant NDPES permits to accommodate horizontal levee projects.

Regulatory Interpretations

From a regulatory standpoint, it would be most conservative to assume that an NPDES permit (or amendment to an existing NPDES permit) would be required. However, the issue of Clean Water Act (CWA) applicability to pollutant discharges to groundwater that ultimately reach surface water, in more that de minimis quantities, is currently being litigated and being investigated by USEPA (see excerpt below):

SUMMARY: *The Environmental Protection Agency (EPA) is requesting comment on the Agency's previous statements regarding the Clean Water Act (CWA) and whether pollutant discharges from point sources that reach jurisdictional surface waters via groundwater or other subsurface flow that has a direct hydrologic connection to the jurisdictional surface water may be subject to CWA regulation. EPA is requesting comment on whether the Agency should consider clarification or revision of those statements and if so, comment on how clarification or revision should be provided.*

A more creative permitting interpretation would be that application of secondary effluent to a horizontal levee is simply a land application or land disposal project, subject to simple water reclamation or waste discharge requirements. The discharge may just be subject to various BMPs, such as: how much flow can be applied, where, and when. This approach would need further investigation and discussion with RWQCB, as Title 22 prohibits the discharge to receiving water of recycled water use for irrigation (other than "incidental" runoff as can occur with other irrigation systems). Another approach could be the establishment of a Low Threat Discharge General Permit within San Francisco Bay Region 2; several other RWQCBs have this General Permit in place, and it could be applied to horizontal levee projects. Finally, one could potentially make a case that the secondary or tertiary treated effluent, applied at specified rates and conditions, after a period traveling through the subsurface environment, contains de minimis levels of constituents of concern, and does not need further monitoring and/or permitting (like a septic tank and leach field). These potential regulatory interpretations should be explored with RWQCB.

Existing NPDES Permit Amendment: Key Issues and Approaches

The most expedient permitting approach would be the modification of a wastewater treatment plant's existing NPDES permit to accommodate releases via the horizontal levee slope. There are several approaches or key issues that would need to be addressed for successful permit modification, and these would be negotiated with RWQCB on a case by case basis. However, central to permit modification would be the use of the Basin Plan's exemption to the shallow water discharge prohibition. RWQCB's review should focus on: 1) the overall environmental benefits of these projects, and 2) review of potential incremental impacts (if any) that could occur to beneficial uses identified in the Basin Plan related to shifting from an existing shallow water discharge to discharge to a horizontal levee. The treated effluent will continue to meet the requirements associated with the RWQCP's permitted shallow water discharge prior to application to the horizontal levee.

The regulatory issues would revolve around what if any additional limitations would be required to allow for a near-shore shallow water seepage type discharge. As such, the applicant would need to work with RWQCB to demonstrate that water quality released to/from horizontal levee slope would continue to: 1) meet California Toxic Rule (CTR) requirements; 2) meet applicable toxicity requirements; 3) meet Basin Plan Anti-Degradation requirements; 4) provide an equivalent level of protection; 5) and/or provide a net environmental benefit.

Horizontal Levee projects at Palo Alto can expect to go through similar review and negotiations with RWQCB about application of the exception to the Basin Plan Discharge Prohibitions. It would appear that framing a holistic description of a horizontal levee type project should qualify for an exception given that it should truly provide a "net environmental benefit." A net environmental benefit (NEB) is probably the broadest and most highly regarded exemption. Demonstrating a NEB may also help minimize/offset the need for other regulatory/permitting requirements. Once more data are available on the Oro Loma Horizontal Levee effluent quality, it can likely be demonstrated that in general horizontal levees would provide a higher level of treatment, and therefore an equivalent level of protection, which would comply with the lowest hurdle: an exemption from the Basin Plan discharge prohibitions.

It is anticipated that monitoring data from Oro Loma will demonstrate that that nitrate can be treated with exceptionally high efficiencies and that other constituents are similarly reduced in concentration compared to those in the secondary effluent applied to the Horizontal Levee. Soil microbes would probably degrade many of the other organics in the secondary effluent before it would reach the Bay, again reducing loadings compared to a direct discharge of secondary effluent at the currently permitted levels for a shallow water discharge. There is also the argument to be made that the mass of pollutants discharged via the horizontal levee slope is at most the same, and almost certainly lower, than the mass that would have been discharged to the Bay via a direct secondary effluent shallow water outfall discharge.

With respect to the need for effluent limits, potentially mass limits or de minimis mass loading findings could be applicable to address the Water Quality Based Effluent Limitations (WQBEL) issues. Due to the dispersed nature of the discharge from horizontal levee slopes, it is anticipated that mixing zones/initial dilution approaches would not be appropriate. For the first few horizontal levee projects, it is likely that RWQCB would require a Reasonable Potential Analysis (RPA) to be completed to confirm that remaining concentrations are below California Toxic Rule (CTR) Water Quality Objectives (WQOs) such that effluent limits would not be required. These key issues would need to be reviewed with RWQCB staff as part of the case-by-case review and permit negotiation previously noted.

REFERENCES

Carrollo, 2012. Long Range Facility Plans Report. Palo Alto Regional Water Quality Control Plant, Palo Alto, CA.

City of Mountain View, 2013. Shoreline Landfill Master Plan Study Session Memo. Public Works Department, Mountain View, CA.

City of Palo Alto, 2017. 2017 Pretreatment Program Annual Report. Palo Alto Regional Water Quality Control Plant, Palo Alto, CA.

ESA PWA, 2012. Oro Loma Wet Weather Equalization, Treatment Wetland, and Ecotone Demonstration Project, Initial Feasibility Study. (with Dr. Peter Baye). Oro Loma Sanitary District, San Lorenzo, CA.

ESA PWA, 2013. Oro Loma Demonstration Project, Preliminary Design Report. Oro Loma Sanitary District, San Lorenzo, CA.

SFEI, 1999. Baylands Ecosystem Habitat Goals. SFEI Contribution No. 330. US Environmental Protection Agency, San Francisco, CA. S.F. Bay Regional Water Quality Control Board, Oakland, CA.

SFEI, 2015. The Baylands and Climate Change. Baylands Ecosytem Habitat Goals Science Update 2015. California State Coastal Conservancy, Oakland, CA.

ATTACHMENTS

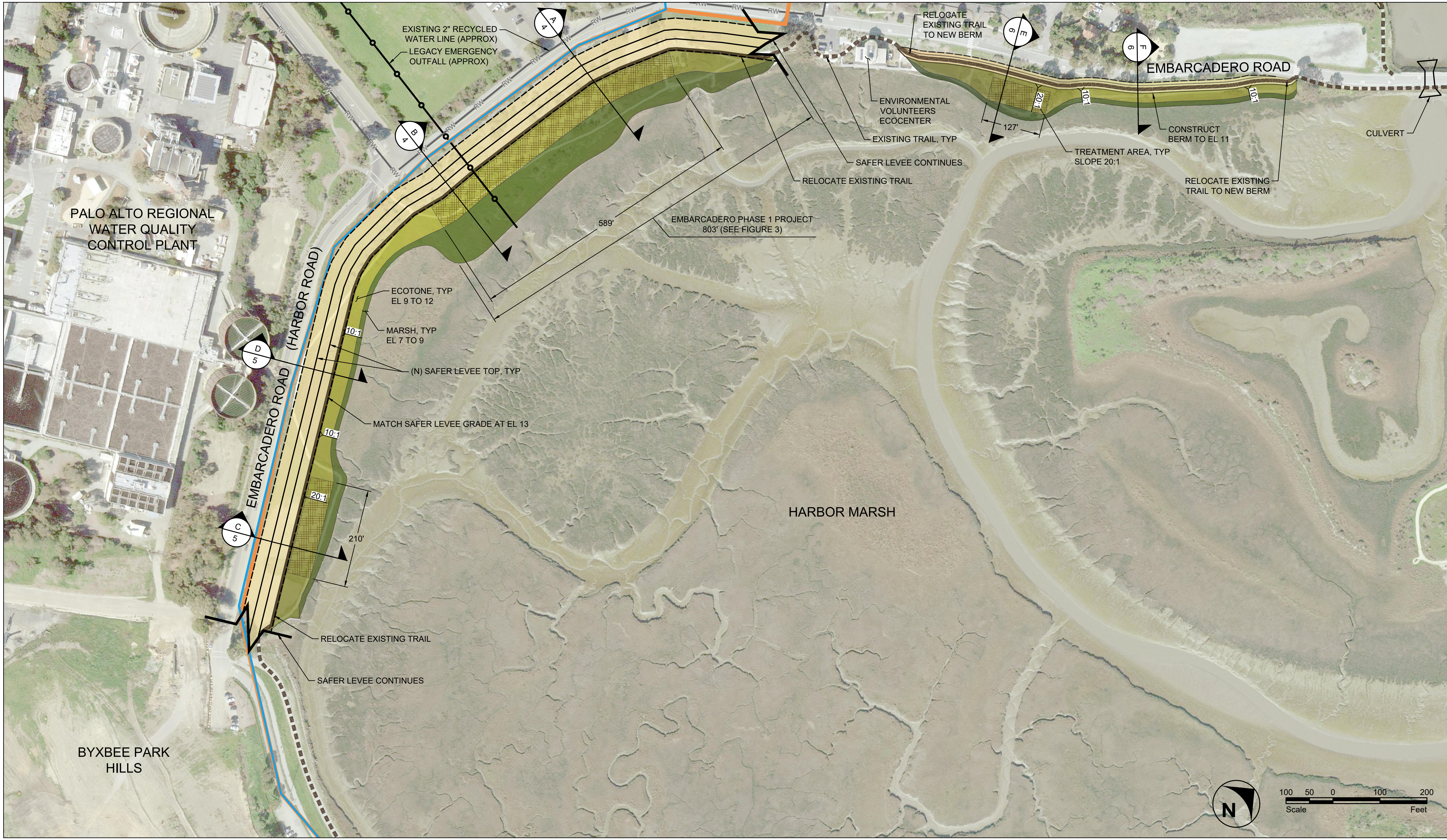
DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\OVERVIEW.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:57:11 PM

NOTE: AERIAL ORTHOIMAGERY FROM NORTHROP GRUMMAN (2015), AS DOWNLOADED FROM USGS EARTH EXPLORER DATABASE. IMAGERY WAS COLLECTED BY NORTHROP GRUMMAN BETWEEN FEBRUARY 20 TO FEBRUARY 24, 2015.

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 1
SITE LOCATION MAP

ESA



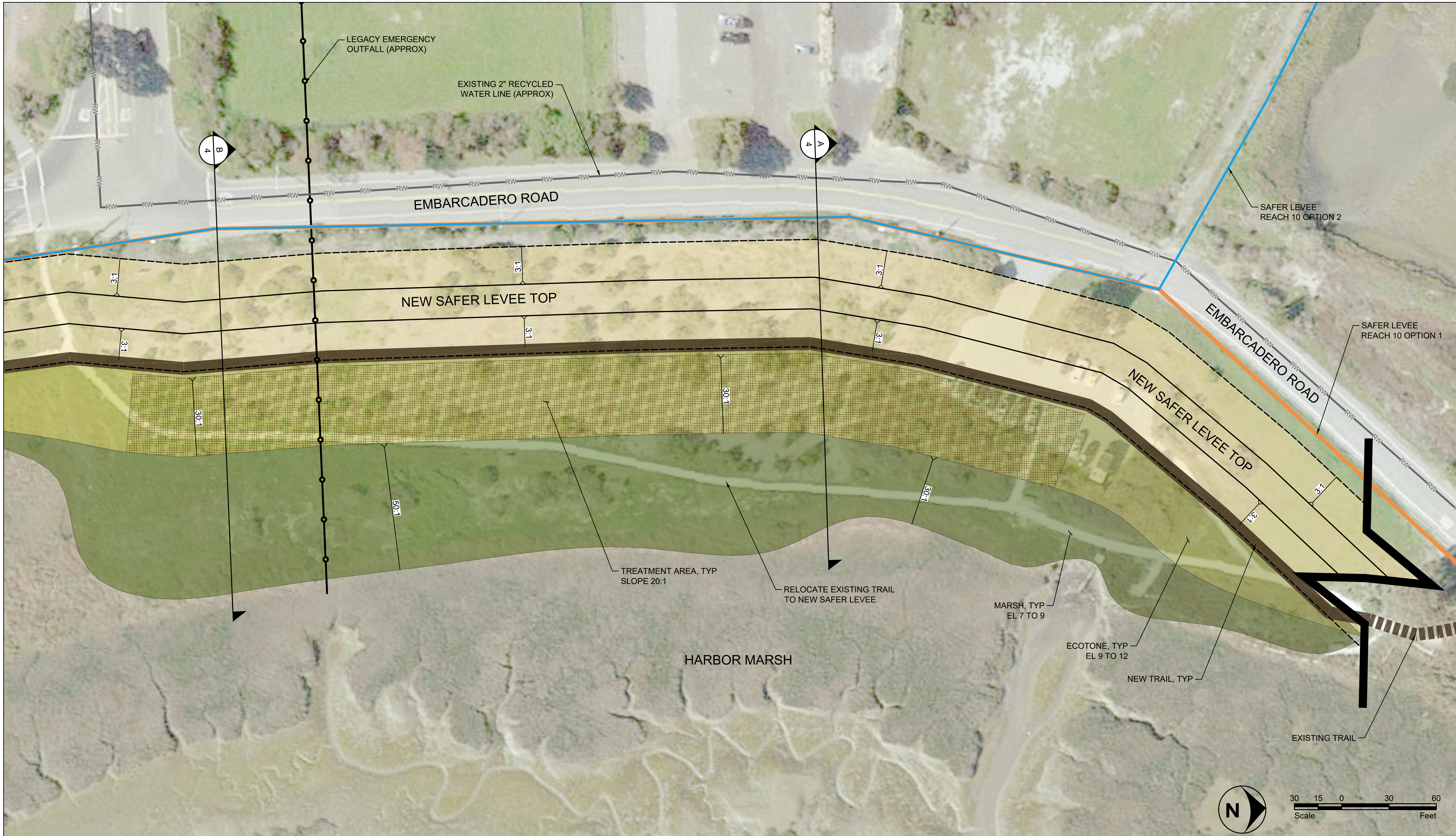
DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\EMBARCADERO.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:57:22 PM

NOTE: AERIAL ORTHOIMAGERY FROM NORTHROP GRUMMAN (2015), AS DOWNLOADED FROM USGS EARTH EXPLORER DATABASE. IMAGERY WAS COLLECTED BY NORTHROP GRUMMAN BETWEEN FEBRUARY 20 TO FEBRUARY 24, 2015.

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 2
EMBARCADERO
ROAD OVERVIEW

ESA



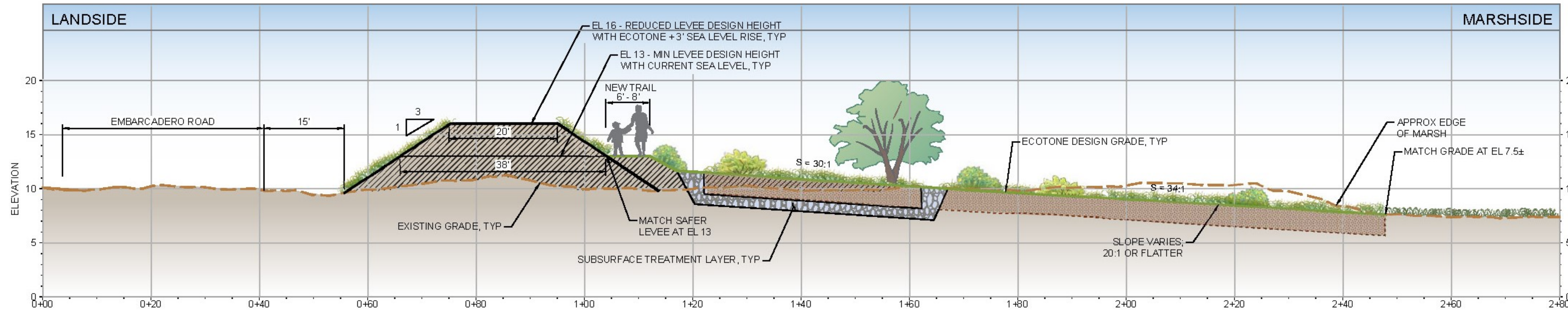
DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\EMBARCADERO DETAIL.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:57:31 PM

NOTE: AERIAL ORTHOIMAGERY FROM NORTHROP GRUMMAN (2015), AS DOWNLOADED FROM USGS EARTH EXPLORER DATABASE. IMAGERY WAS COLLECTED BY NORTHROP GRUMMAN BETWEEN FEBRUARY 20 TO FEBRUARY 24, 2015.

ORO LOMA IRWMP SUPPORT . D120042.03

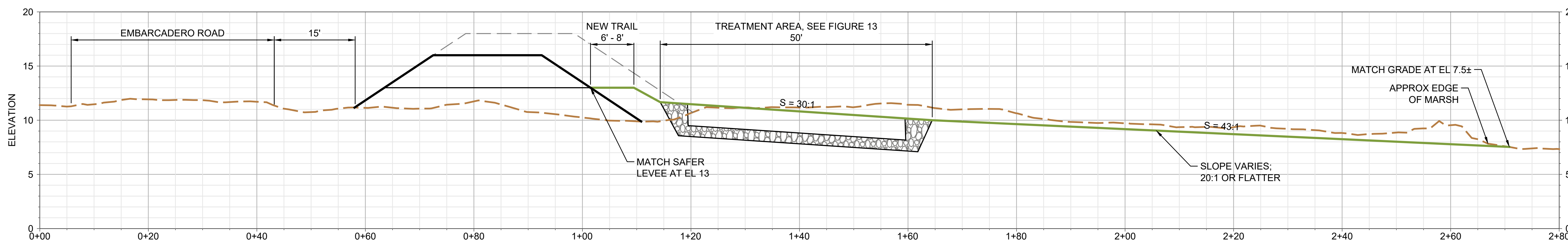
FIGURE 3
EMBARADERO ROAD
PHASE 1 PLAN VIEW

ESA



A SECTION 2.3 EMBARCADERO ROAD

VERT: 1" = 10'
HORIZ: 1" = 20'



B SECTION 2.3 EMBARCADERO ROAD

VERT: 1" = 10'
HORIZ: 1" = 20'

NOTE: EXISTING GRADE SURFACE IS APPROXIMATE AND BASED ON USGS TOPOGRAPHIC LIDAR (USGS, 2010), AS DOWNLOADED FROM THE NOAA OFFICE FOR COASTAL MANAGEMENT. ELEVATIONS ARE PRESENTED IN NORTH AMERICAN VERTICAL DATUM OF 1988.

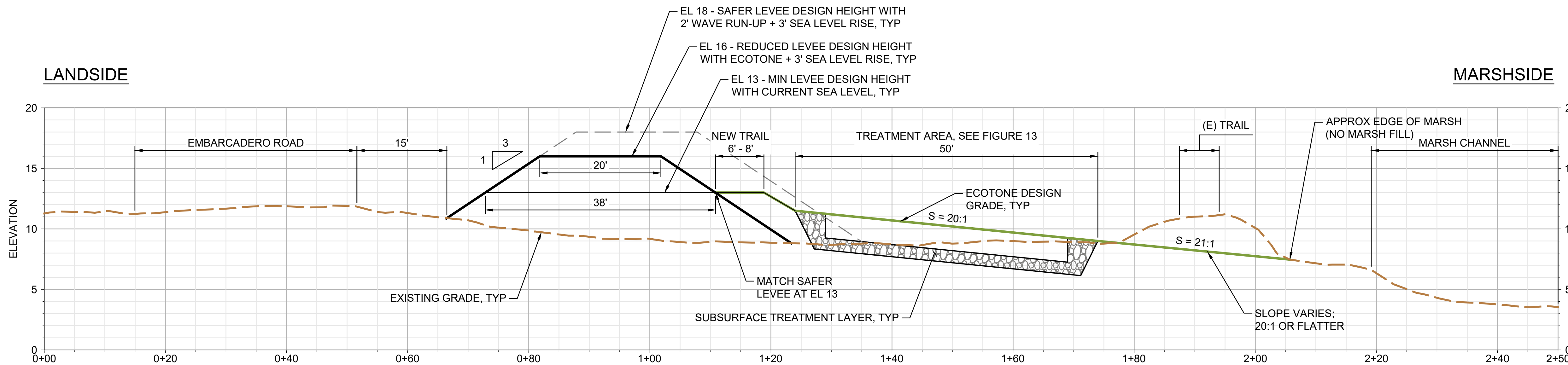
Scale 10 5 0 10 20 Feet

DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\SECTIONS.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:57:34 PM

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 4
EMBARCADERO PHASE 1
CROSS SECTIONS

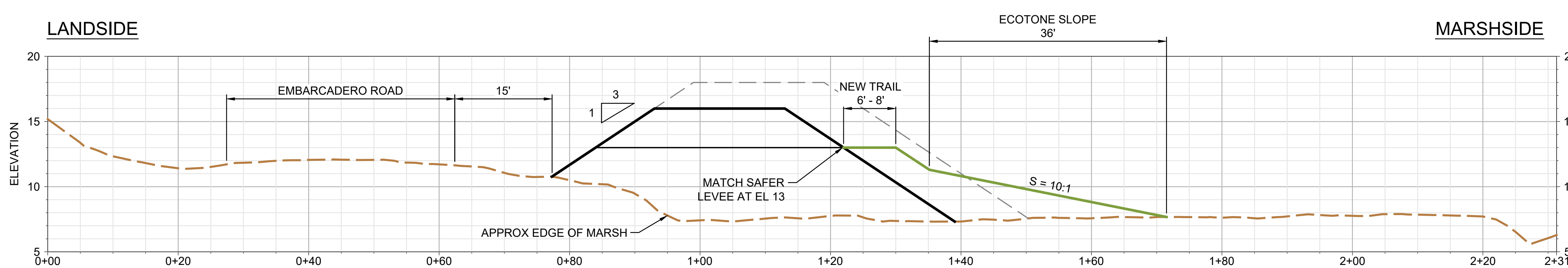
ESA



C / 2 SECTION

EMBARCADERO ROAD

VERT: 1" = 10'
HORIZ: 1" = 20'



D / 2 SECTION

EMBARCADERO ROAD

VERT: 1" = 10'
HORIZ: 1" = 20'

NOTE: EXISTING GRADE SURFACE IS APPROXIMATE AND BASED ON USGS TOPOGRAPHIC LIDAR (USGS, 2010), AS DOWNLOADED FROM THE NOAA OFFICE FOR COASTAL MANAGEMENT. ELEVATIONS ARE PRESENTED IN NORTH AMERICAN VERTICAL DATUM OF 1988.

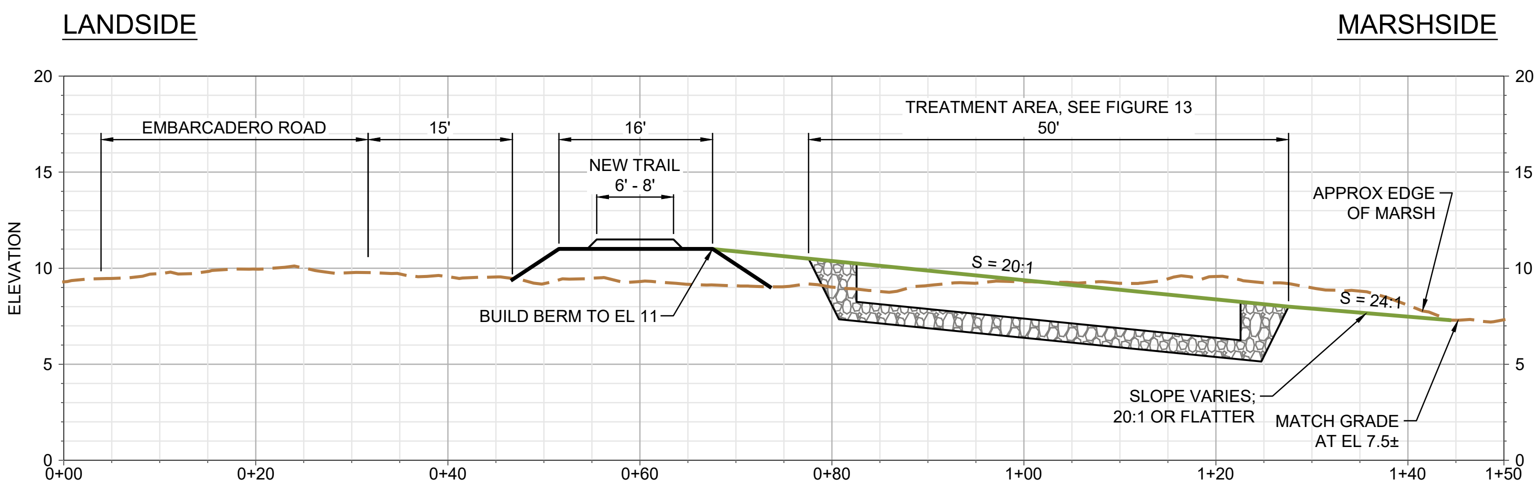
10 5 0 10 20
Scale Feet

ORO LOMA IRWMP SUPPORT . D120042.03

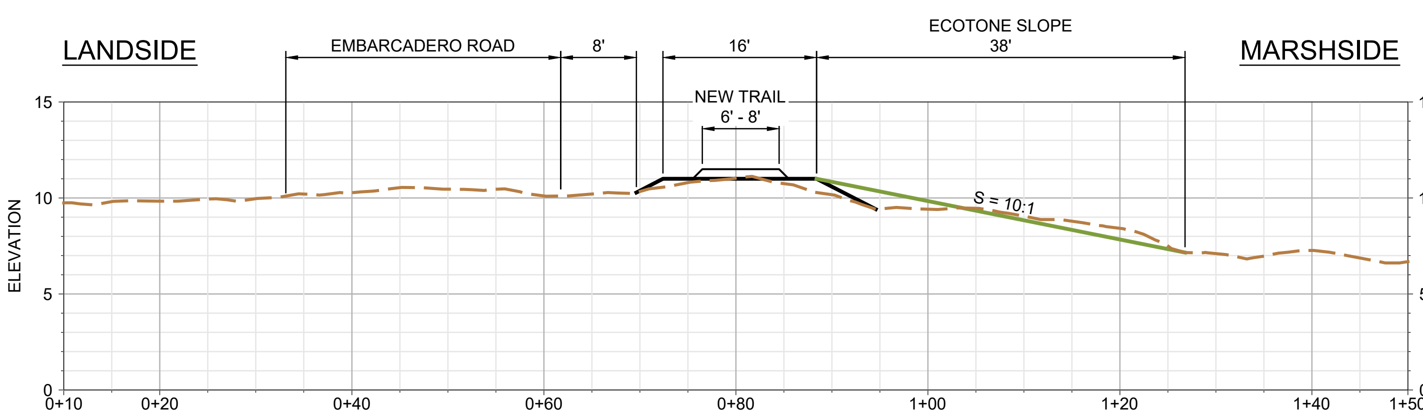
FIGURE 5

EMBARCADERO SOUTH
CROSS SECTION

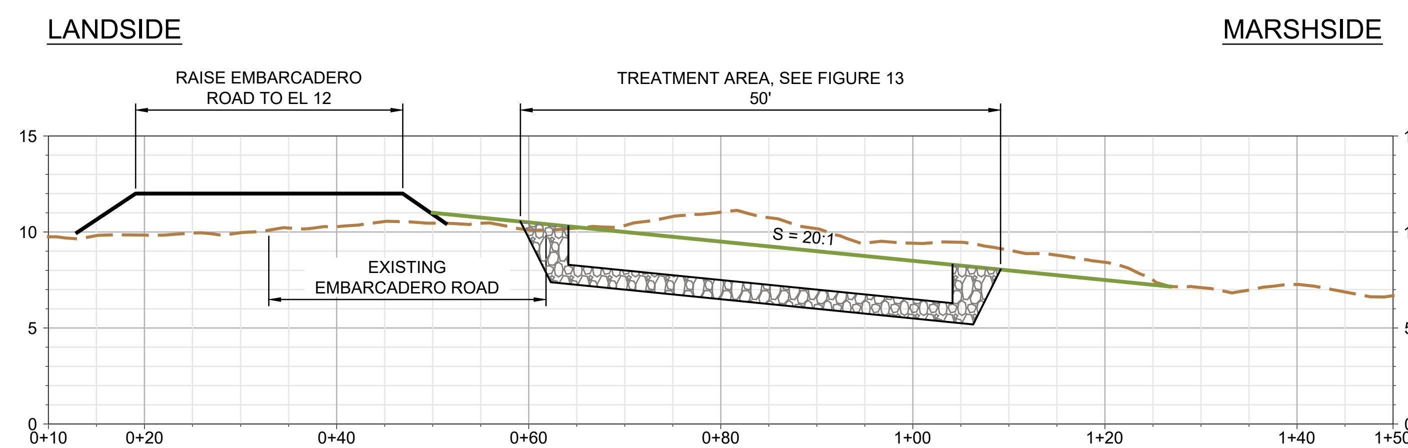
ESA



E / 2 SECTION — EMBARCADERO ROAD — VERT: 1" = 10' HORIZ: 1" = 20'



F1 / 2 SECTION (WITH BERM) — EMBARCADERO ROAD — VERT: 1" = 10' HORIZ: 1" = 20'



F2 / 2 SECTION (RAISE ROAD) — EMBARCADERO ROAD — VERT: 1" = 10' HORIZ: 1" = 20'

NOTE: EXISTING GRADE SURFACE IS APPROXIMATE AND BASED ON USGS TOPOGRAPHIC LIDAR (USGS, 2010), AS DOWNLOADED FROM THE NOAA OFFICE FOR COASTAL MANAGEMENT. ELEVATIONS ARE PRESENTED IN NORTH AMERICAN VERTICAL DATUM OF 1988.

10 5 0 10 20
Scale Feet

DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\SECTIONS.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:57:39 PM

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 6
EMBARCADERO NORTH
CROSS SECTIONS

ESA

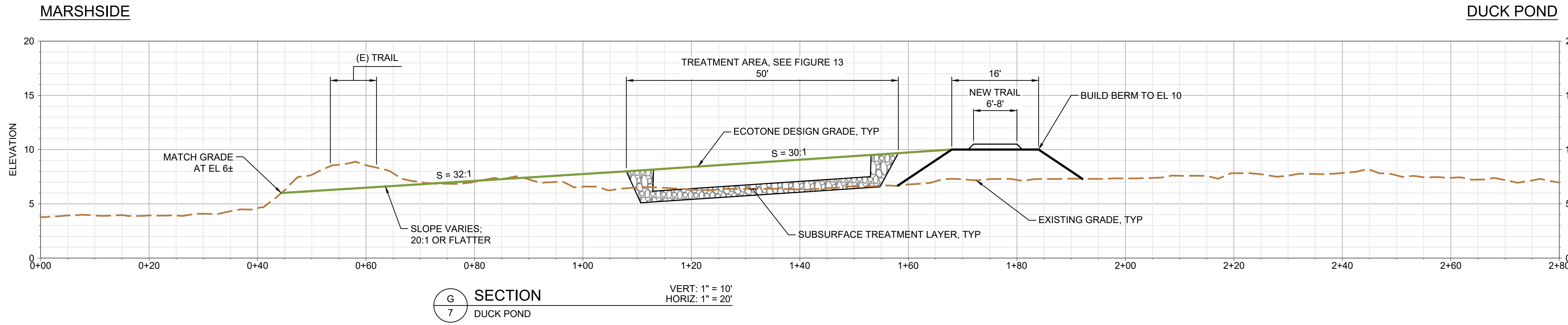
DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\DUCK POND.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:57:48 PM

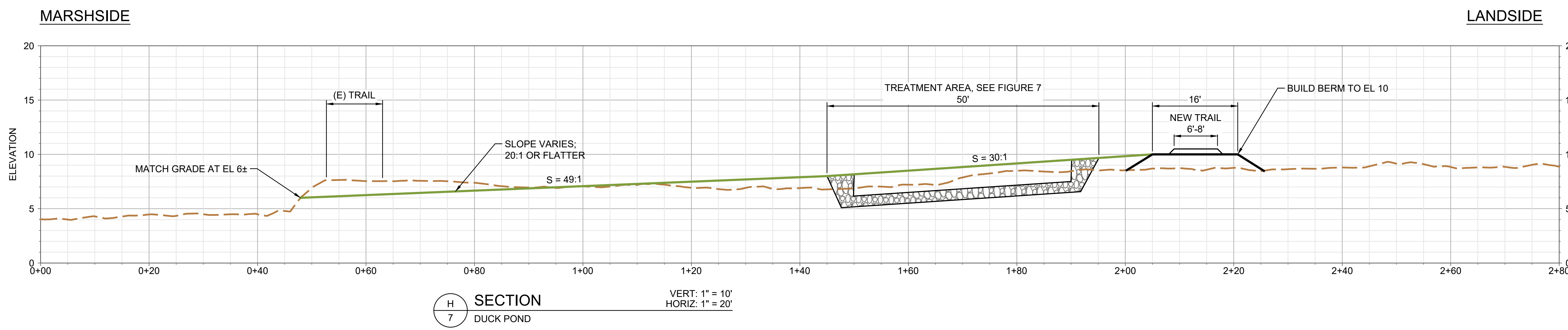
NOTE: AERIAL ORTHOIMAGERY FROM NORTHROP GRUMMAN (2015), AS DOWNLOADED FROM USGS EARTH EXPLORER DATABASE. IMAGERY WAS COLLECTED BY NORTHROP GRUMMAN BETWEEN FEBRUARY 20 TO FEBRUARY 24, 2015.

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 7
DUCK POND
PLAN VIEW

ESA





NOTE: EXISTING GRADE SURFACE IS APPROXIMATE AND BASED ON USGS TOPOGRAPHIC LIDAR (USGS, 2010), AS DOWNLOADED FROM THE NOAA OFFICE FOR COASTAL MANAGEMENT. ELEVATIONS ARE PRESENTED IN NORTH AMERICAN VERTICAL DATUM OF 1988.

10 5 0 10 20
Scale Feet

DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\SECTIONS.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:57:52 PM

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 8
DUCK POND
CROSS SECTIONS

ESA

DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\SBSP.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:57:58 PM

NOTE: AERIAL ORTHOIMAGERY FROM NORTHROP GRUMMAN (2015), AS DOWNLOADED FROM USGS EARTH EXPLORER DATABASE. IMAGERY WAS COLLECTED BY NORTHROP GRUMMAN BETWEEN FEBRUARY 20 TO FEBRUARY 24, 2015. SOUTH BAY SALT PONDS RESTORATION (60% DESIGN) BY DUCKS UNLIMITED (2017).

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 9
POND A-1 OVERVIEW

ESA

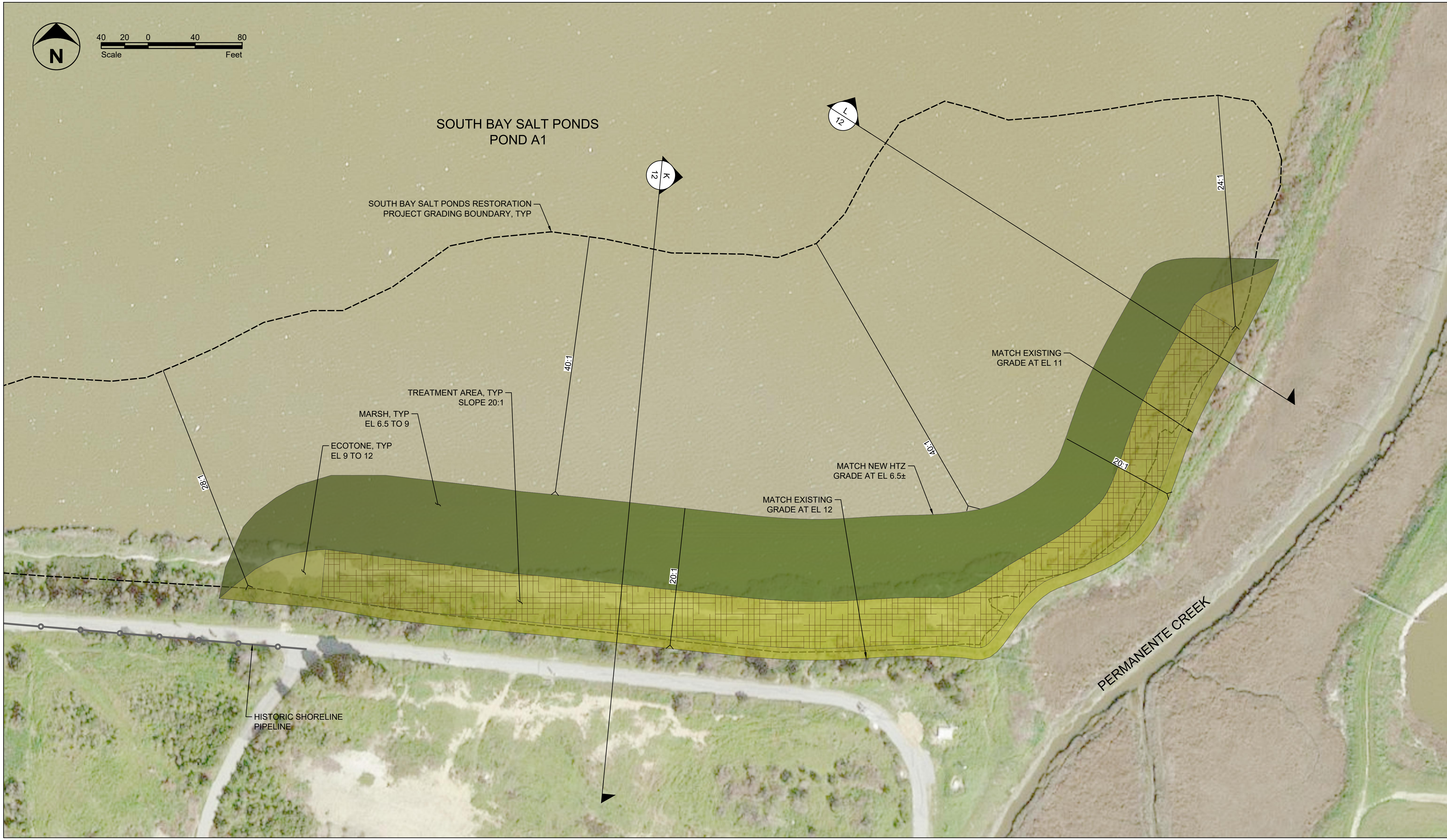
DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\SBSP DETAIL.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:58:05 PM

NOTE: AERIAL ORTHOIMAGERY FROM NORTHROP GRUMMAN (2015), AS DOWNLOADED FROM USGS EARTH EXPLORER DATABASE. IMAGERY WAS COLLECTED BY NORTHROP GRUMMAN BETWEEN FEBRUARY 20 TO FEBRUARY 24, 2015. SOUTH BAY SALT PONDS RESTORATION (60% DESIGN) BY DUCKS UNLIMITED (2017).

ESA

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 10
POND A-1 WEST
PLAN VIEW



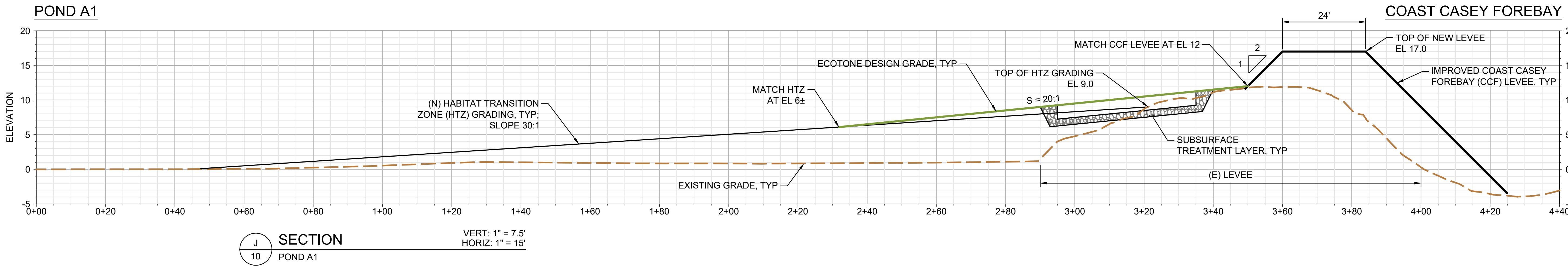
DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\SBSP DETAIL.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:58:07 PM

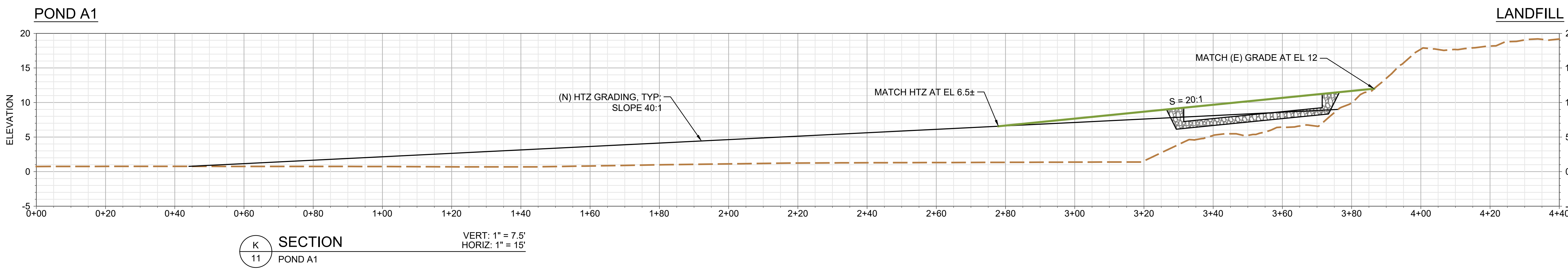
NOTE: AERIAL ORTHOIMAGERY FROM NORTHROP GRUMMAN (2015), AS DOWNLOADED FROM USGS EARTH EXPLORER DATABASE. IMAGERY WAS COLLECTED BY NORTHROP GRUMMAN BETWEEN FEBRUARY 20 TO FEBRUARY 24, 2015. SOUTH BAY SALT PONDS RESTORATION (60% DESIGN) BY DUCKS UNLIMITED (2017).

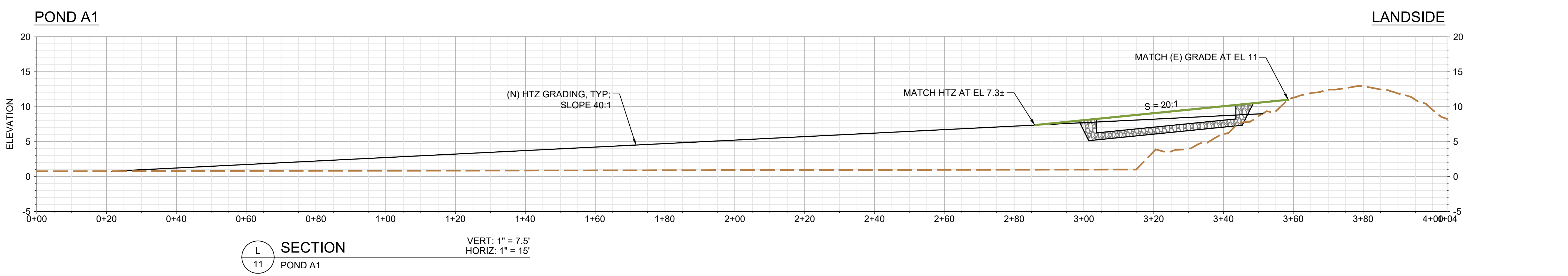
ESA

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 11
POND A-1 EAST
PLAN VIEW







NOTE: EXISTING GRADE SURFACE IS APPROXIMATE AND BASED ON DUCKS UNLIMITED (2017) 60% DESIGN FOR SOUTH BAY SALT PONDS RESTORATION PROJECT. ELEVATIONS ARE PRESENTED IN NORTH AMERICAN VERTICAL DATUM OF 1988.

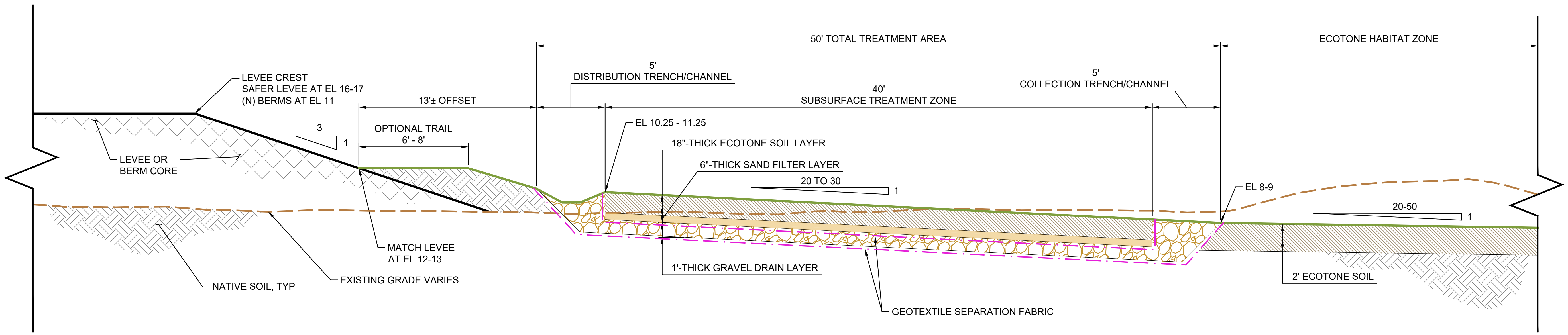
15 7.5 0 15 30
Scale Feet

DWG: K:\projects_2012\D120042.03 - Oro Loma IRWMP Support\09 CAD\Dwgs\SECTIONS.dwg USER: Marisa Landicho PLOT DATE: 8/7/2018 1:58:11 PM

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 12
POND A-1 CROSS SECTIONS

ESA



1 - TYPICAL SECTION
ECOTONE TREATMENT AREA

VERT: 1" = 8'
HORIZ: 1" = 8'

Scale: 4 2 0 4 8 Feet

ORO LOMA IRWMP SUPPORT . D120042.03

FIGURE 13
ECOTONE TREATMENT
AREA TYPICAL SECTION

ESA

Attachment C

TABLE 4
PALO ALTO
CONCEPTUAL DESIGN - OPINION OF PROBABLE COSTS

ITEM NO.	ITEM	Phase 1 Embacadero ESTIMATED QUANTITY	Embarcadero Build-Out ESTIMATED QUANTITY	South Bay Salt Ponds ESTIMATED QUANTITY	Duck Ponds ESTIMATED QUANTITY	UNIT OF MEASURE	UNIT PRICE	Phase 1 Embacadero TOTAL	Embarcadero Build-Out TOTAL	South Bay Salt Ponds TOTAL	Duck Ponds TOTAL
0	Treatment Length	590	930	1,845	820	LF	---	---	---	---	---
1	Mobilization & Demobilization (7%)	1	1	1	1	LS	10%	$ 98,700	$ 193,200	$ 217,600	$ 155,400
2	SWPPP Implementation	2.3	4.3	5.4	3.6	AC	$ 10,000	$ 23,000	$ 43,000	$ 54,000	$ 36,000
Clearing & Grubbing											
3	Disc Grading Area	2.3	4.3	5.4	3.6	AC	$ 1,000	$ 2,300	$ 4,300	$ 5,400	$ 3,600
Earthwork											
4	Remove & Stockpile Topsoil (Upper 1')	3,700	7,000	8,700	5,800	CY	$ 15	$ 55,500	$ 105,000	$ 130,500	$ 87,000
5	Excavation to Ecotone Subgrade	9,700	22,600	0	10,900	CY	$ 10	$ 97,000	$ 226,000	$ -	$ 109,000
6	Furnish & Install Geotextile Fabric	6,700	10,500	16,400	9,900	SY	$ 5	$ 33,500	$ 52,500	$ 82,000	$ 49,500
7	Import & Place Gravel	1,400	2,100	4,200	1,900	CY	$ 50	$ 70,000	$ 105,000	$ 210,000	$ 95,000
8	Import & Place Sand	440	690	1,370	610	CY	$ 50	$ 22,000	$ 34,500	$ 68,500	$ 30,500
9	Import, Mix, & Place Blended Ecotone Soil	6,800	13,000	16,000	10,800	CY	$ 30	$ 204,000	$ 390,000	$ 480,000	$ 324,000
Revegetation											
10	Drill Seeding	2.3	4.3	5.4	3.6	AC	$ 8,000	$ 18,400	$ 34,400	$ 43,200	$ 28,800
11	Plantings (per acre, assuming 2' O.C.)	2.3	4.3	5.4	3.6	AC	$ 40,000	$ 92,000	$ 172,000	$ 216,000	$ 144,000
Infrastructure											
11	WWTP Connection (pump station, turnout, controls, etc.)	1	1	1	1	LS	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 90,000
13	Pipeline Connection to WWTP or Ex Irr Line	660	660	2,850	2,210	LF	$ 175	$ 115,500	$ 115,500	$ 498,750	$ 386,750
14	Distribution Line to Treatment Area	700	2,500	1,450	670	LF	$ 150	$ 105,000	$ 375,000	$ 217,500	$ 100,500
15	Discharge (box, valves, flow meters, etc)	4	13	8	4	EA	$ 10,000	$ 40,000	$ 130,000	$ 80,000	$ 40,000
Public Access											
16	New Trail (8' Wide)	900	2,710	0	1,420	LF	$ 20	$ 18,000	$ 54,200	$ -	$ 28,400
						SUBTOTAL:		$ 1,085,000	$ 2,125,000	$ 2,393,000	$ 1,708,000
						CONTINGENCY:	35%	$ 380,000	$ 744,000	$ 838,000	$ 598,000
	TOTAL ESTIMATE OF PROBABLE CONSTRUCTION COST (2018 DOLLARS):							**$ 1,465,000**	**$ 2,869,000**	**$3,231,000**	**$2,306,000**
	ESCALATED TOTAL ESTIMATE OF PROBABLE CONSTRUCTION COST (2021 DOLLARS):						4%/yr	**$ 1,650,000**	**$ 3,230,000**	**$3,630,000**	**$2,590,000**

1 For planning purposes we have provided order of magnitude estimates to allow cost comparison of alternatives. These cost estimates are intended to provide an approximation of total projects construction costs appropriate for the conceptual level of design. These cost estimates are considered to be approximately -30% to +50% accurate and include a 35% contingency to account for project uncertainties (such as final design, permitting restrictions and bidding climate).

2 These estimates are subject to refinement and revisions as the design is developed in future stages of the project.

3 This table does not include estimated project costs for permitting, design, monitoring, or ongoing maintenance.

4 Estimated costs are developed in 2018 dollars, and escalated to 2021 dollars assuming a 4% annual escalation.

5 This opinion of probable construction cost is based on ESA's previous project experience and bid prices from similar projects.

6 This estimate does not include earthwork associated with building levees designed by others (i.e. SAFER levee or the South Bay Salt Ponds restoration). We assume excess material will be mixed within the ecotone soil, or used for levee construction. Earthwork units costs assume no off-haul.

CITY OF
PALO
ALTO

Long Range Facilities Plan

for the

Regional Water Quality Control Plant

Final Report

October 2012

carollo
Engineers...Working Wonders With Water®

City of Palo Alto

LONG RANGE FACILITIES PLAN FOR THE
REGIONAL WATER QUALITY CONTROL PLANT

FINAL

August 2012

08/20/2012

08/20/2012

2700 YGNACIO VALLEY ROAD • SUITE 200 • WALNUT CREEK, CALIFORNIA 94598 • 925.932.1710 • 925.930.0208

City of Palo Alto

LONG RANGE FACILITIES PLAN

TABLE OF CONTENTS

Page No.

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
EXECUTIVE SUMMARY

1.1 INTRODUCTION

The City of Palo Alto operates the Regional Water Quality Control Plant (RWQCP) for the benefit of the City and the surrounding communities. The City has provided wastewater treatment services for 78 years. The RWQCP is located at the end of Embarcadero Road on Embarcadero Way adjacent to the Palo Alto Airport, Byxbee Park, and the Emily Renzel Wetlands.

The RWQCP prepared a comprehensive planning document in 1966 for a regional plant to move to full secondary treatment; this is the first long range plan for RWQCP facilities since that plan. The planning horizon for this study is 50 years and is focused on RWQCP's on-site needs. The RWQCP is facing several key issues: 1) aging infrastructure, 2) increasing regulatory requirements and 3) increasing interest in finding alternatives to the existing solids incineration process. For these reasons, the City decided to embark upon a planning process to look at the long-term needs for the RWQCP facility to continue to provide reliable treatment and satisfy regulations. To do this, the LRFP must determine the future needs (flows and loads), assess the existing facilities capacity, condition and deficiencies, assess the treatment impacts of potential future regulatory scenarios, develop alternatives for both solids and liquid treatment processes, develop layouts for whole plant scenarios (leaving room for potential future facilities), and develop recommendations and a financial plan for implementation.

1.2 BACKGROUND

The City of Palo Alto has provided wastewater collection services since 1899 and completed construction of the first the Palo Alto Treatment Plant in 1934. In 1968, the Cities of Mountain View and Los Altos agreed to retire their treatment plants and partner with the City of Palo Alto to construct a regional secondary treatment plant – the Regional Water Quality Control Plant (RWQCP). The original Palo Alto Treatment Plant site was expanded from a 3-acre site to a 25-acre site. The 25-acre site is located within the Palo Alto Baylands between Highway 101 and San Francisco Bay. The 1968 agreement is good through July 1, 2035 and states Palo Alto is the owner and operator of the plant. This agreement, and agreements with East Palo Alto Sanitary District, Stanford University, and Los Altos Hills, require all six agencies to proportionately share in the costs of building and maintaining the facilities. The service area for the RWQCP is shown in Figure 1.1.

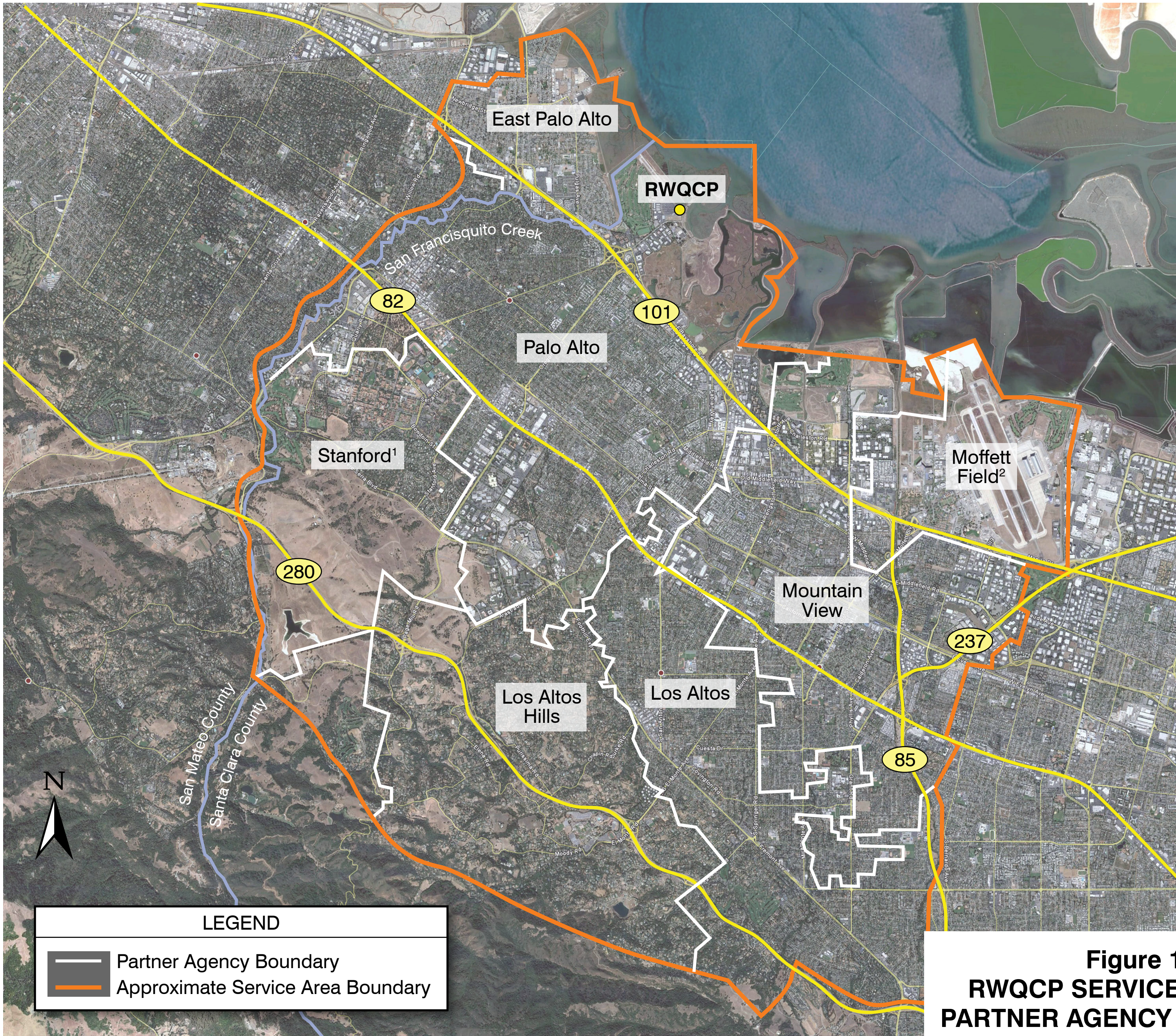


Figure 1.1
RWQCP SERVICE AREA AND PARTNER AGENCY BOUNDARIES
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

NOTE:
1. The RWQCP does not serve the entire area shown for Stanford.
2. Included in Mountain View's contribution.

pa412f23-8510.ai

The RWQCP was designed in 1969 and construction of the RWQCP was completed in 1972 providing secondary treatment to the City of Palo Alto and the partner agencies. Construction in 1980 added fixed film reactors and dual media filters. Construction in 1988 added additional secondary clarifiers. Construction in 2010 added ultraviolet light disinfection.

The RWQCP has provided recycled water for landscape irrigation since 1975. Recycled water use at Mountain View's Shoreline Golf Course (Shoreline Golf Links) began in 1980, but was suspended in 2001 due to failure of the recycled water pipeline. In 1992, the Water Reclamation Master Plan (WRMP) was prepared and the distribution line was subsequently extended to Palo Alto's Municipal Service Center (MSC) yard and a new pipeline was installed to the Palo Alto Golf Course. In 2009, a new pipeline was installed to serve recycled water to existing and new customers including Palo Alto's Greer Park, Shoreline Park (and Golf Course) in Mountain View, and other landscape irrigation customers in the North of Bayshore business area of Mountain View. An expansion to Palo Alto's Stanford Research Park area is being considered and environmentally assessed.

1.3 PARTNER AGENCY AND PUBLIC REVIEW PROCESS

The City established a public workshop process as part of this LRFP to solicit input from the stakeholders and partner agencies. Five (5) stakeholder workshops were held during the LRFP development to provide an opportunity for interested parties to provide their input and/or feedback throughout the LRFP process. The workshop topics are listed below in chronological order and were publicly advertised on the City's website a minimum of two (2) weeks prior to the scheduled meeting. Presentation materials used for each workshop and notes taken to capture public input were also posted on the City's website.

- Introduction and Goals (October 27, 2010).
- Biosolids Options (February 9, 2011).
- Decision Process and Liquid Treatment/Recycled Water (May 4, 2011).
- Biosolids Alternatives (November 16, 2011).
- Liquid Treatment Alternatives and Overall Recommendations (March 1, 2012).

In addition to the public workshops, special meetings were held with staff from the partner agencies to keep them informed and to gather input. Partner meetings were held on November 10, 2011 and April 23, 2012. At the conclusion of this LRFP project, the partner agencies were provided administrative draft reports. Comments from the partner agencies were incorporated into the Draft Report, which was also posted on the City of Palo Alto's website. The RWQCP staff also made public presentations on the LRFP at city council meetings including:

- Palo Alto City Council Study Session – May 7, 2012

- EPASD Study Session – June 7, 2012
- Los Altos City Council Study Session – June 26, 2012
- Palo Alto City Council Meeting – July 2, 2012
- Los Alto Hills presentation – July 31, 2012

The City of Mountain View did not schedule a special study session.

As the projects recommended in this LRFP move forward, there will be additional opportunities for public and partner agency review and input in future planning and design efforts, public workshops and council updates.

1.4 PLAN DEVELOPMENT

Development of a long range facilities plan requires projection of future flows and loads, evaluation of the existing facilities' condition and capacity, and consideration of regulatory changes that could require new or modified facilities. This information is then used to determine future facility needs and alternatives for meeting those needs. Recommendations are developed after a thorough comparison of alternatives. For this LRFP, a systematic process was used to identify, screen, and evaluate the LRFP project alternatives (both solids and liquids). This process consisted of five basic steps:

1. Establish "Long Term Goals."
2. Establish evaluation criteria.
3. Initial qualitative screening.
4. Detailed alternative evaluation.
5. Prioritization and presentation of recommendation to the public.

The goals were largely set by previous efforts (The Long Term Goals (LTG) study conducted in 2001) and were presented at the first public workshop. Comments received at that workshop were used to refine the goals. The goals were then used to develop evaluation criteria and minimum project alternative requirements. Minimum alternative requirements included sizing alternatives to meet projected influent flow and loads, meeting the projected capacity needs, and meeting existing regulatory requirements. Evaluation criteria were developed and categorized into four main categories, as shown in Figure 1.2. The overall decision process was presented to stakeholders during the third public workshop.

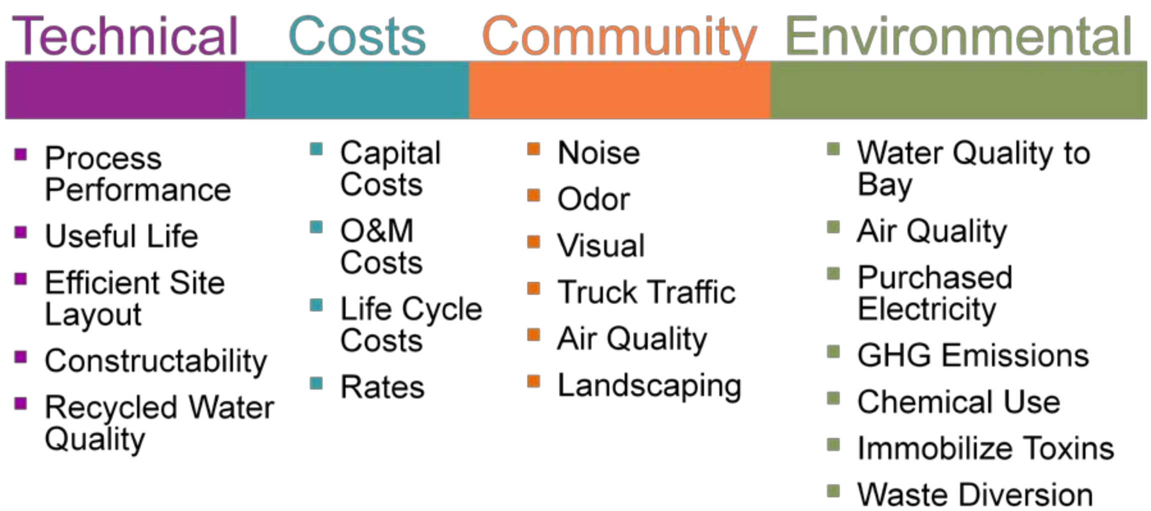


Figure 1.2 Categories and Evaluation Criteria Considered For Alternative Evaluation

1.5 PROJECTED FUTURE NEEDS

Future capacity needs of the RWQCP were developed by projecting influent flow and loads into the plant. The projections were based on historical per capita flows and loads and the projected service area population. Population estimates were based on projections by the Association of Bay Area Governments (ABAG). Two different flow projections were developed, one based on historical average per capita flows, and one based on projections provided by the partner agencies to account for planned conservation measures, as shown in Figure 1.3. While these different methods affect the projection of dry weather flows, as the population projection is unchanged, the loadings will remain the same. In addition, the peak wet weather flow projections are unchanged by conservation measures, as they are largely a result of inflow and infiltration into the collection system during wet weather events.

In addition to evaluating the need for treatment capacity to handle projected influent flows and loads, the project capacity needed to provide for recycled water demands in the service area was also evaluated. The City of Palo Alto has implemented two of the identified four phases of its recycled water system and currently serves users in both the City of Palo Alto and the City of Mountain View. Estimates for future recycled water demands were based on past planning efforts and are shown in Table 1.1. As the decision to expand the recycled water system is a policy decision, a specific timeline has not been assigned to these phases.

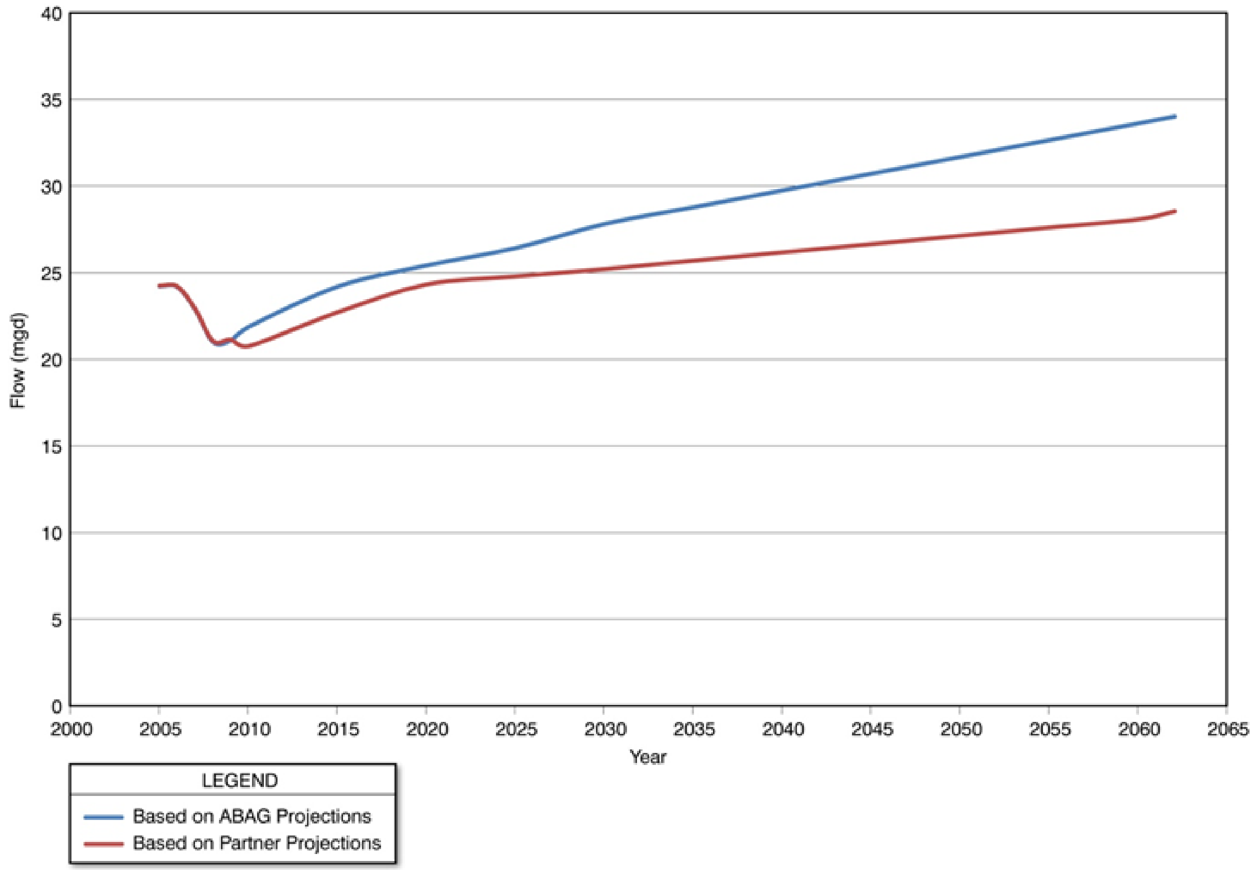


Figure 1.3 Existing and Projected Average Dry Weather Flow into RWQCP

Table 1.1 Recycled Water Demands in the Near, Intermediate and Long Term[(1)]

	Annual Average Flow Rate (mgd)	Peak Month Flow Rate (mgd)	Peak Hour Flow Rate (mgd)
Near Term: Demand for Phases 1-3	2.5	5.6	15.9
Intermediate Term: Recommended Project - 1992 WRMP	4.2	9.8	21.9
Long Term: Target Users - 1992 WRMP	5.3	12.4	27.8 [(2)]

Notes:

(1) The planning horizon of the near, intermediate, and long term recycled water demands depends on the timing of City Council decisions to implement.

(2) Estimated based on the peaking factors from the 1992 Water Reclamation Master Plan (WRMP).

1.6 EXISTING FACILITIES AND CAPACITY

The existing treatment processes at the RWQCP consist of headworks, primary sedimentation, two-stage secondary treatment with fixed film reactors and aeration basins followed by clarifiers, tertiary, disinfection, and recycled water treatment, as well as solids treatment and handling.

A process flow diagram showing the path of the liquid and solids streams through the RWQCP is shown in Figure 1.4. Figure 1.5 shows an aerial view of the existing facilities, the location of its boundaries as well as existing headworks, primary, secondary and tertiary treatment, disinfection, recycled water, and biosolids treatment facilities. The existing facilities were found to be operating within normal ranges, based on typical values used in engineering designs.

The RWQCP also has a good record for meeting its effluent discharge permit limits, for discharge to the San Francisco Bay. There were only a few permit violations over the time period analyzed (2005-2010). These violations were primarily for chlorodibromomethane, a by-product of chlorine disinfection. In 2010, the new ultraviolet light disinfection system came on-line and use of chlorine was eliminated for disinfection of effluent for Bay discharge.

Projected dry weather flows are anticipated to be between 28 and 34 mgd in the year 2062. Based on the treatment processes design criteria and historical performance, it is anticipated that the existing facilities will provide adequate capacity to meet dry weather and maximum month flows into the near future (2035) assuming the same level of treatment is required. Higher levels of treatment would require additional facilities as discussed in Section 1.9.

Capacity of peak wet weather flows appears to be limited not by the treatment facilities but in the influent sewer and the outfall. Previous estimates of peak hour wet weather flow capacity for the RWQCP were 80 mgd, but are not well documented. An evaluation of the 72-inch joint interceptor sewer (which carries a large portion of the plant's flow) as part of this LRFP indicates a sewer capacity of between 63 and 69 mgd. An evaluation of the outfall also showed a potential peak flow capacity restriction during extremely high tides and high flows. A collection system estimate for all the contributing areas into the interceptor should be developed to determine the flows during wet weather. This can then be used to determine the needed peak wet weather capacity of the influent sewer, the treatment facilities, and the outfall.

1.7 CONDITION ASSESSMENT

An assessment of the physical condition and remaining useful life of the existing mechanical equipment was performed as part of this Long Range Facilities Plan (LRFP). The assessment used a standard asset management approach as established in the International Infrastructure Management Manual (IIMM), Version 3.0, 2006, written by the Association of Local

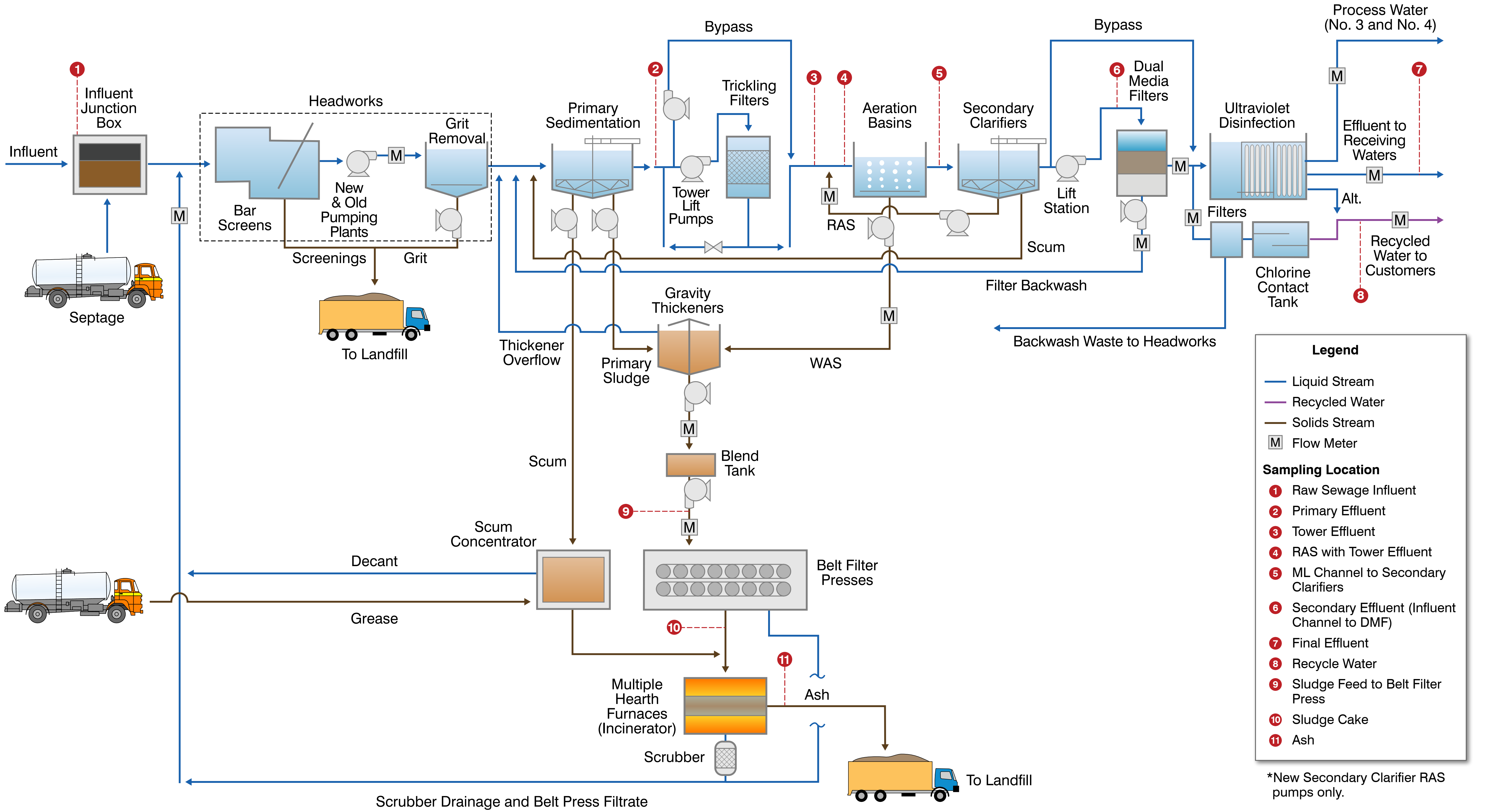


Figure 1.4
EXISTING FACILITIES LIQUID AND BIOSOLIDS PROCESS FLOW DIAGRAM
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa412f3-8510.ai

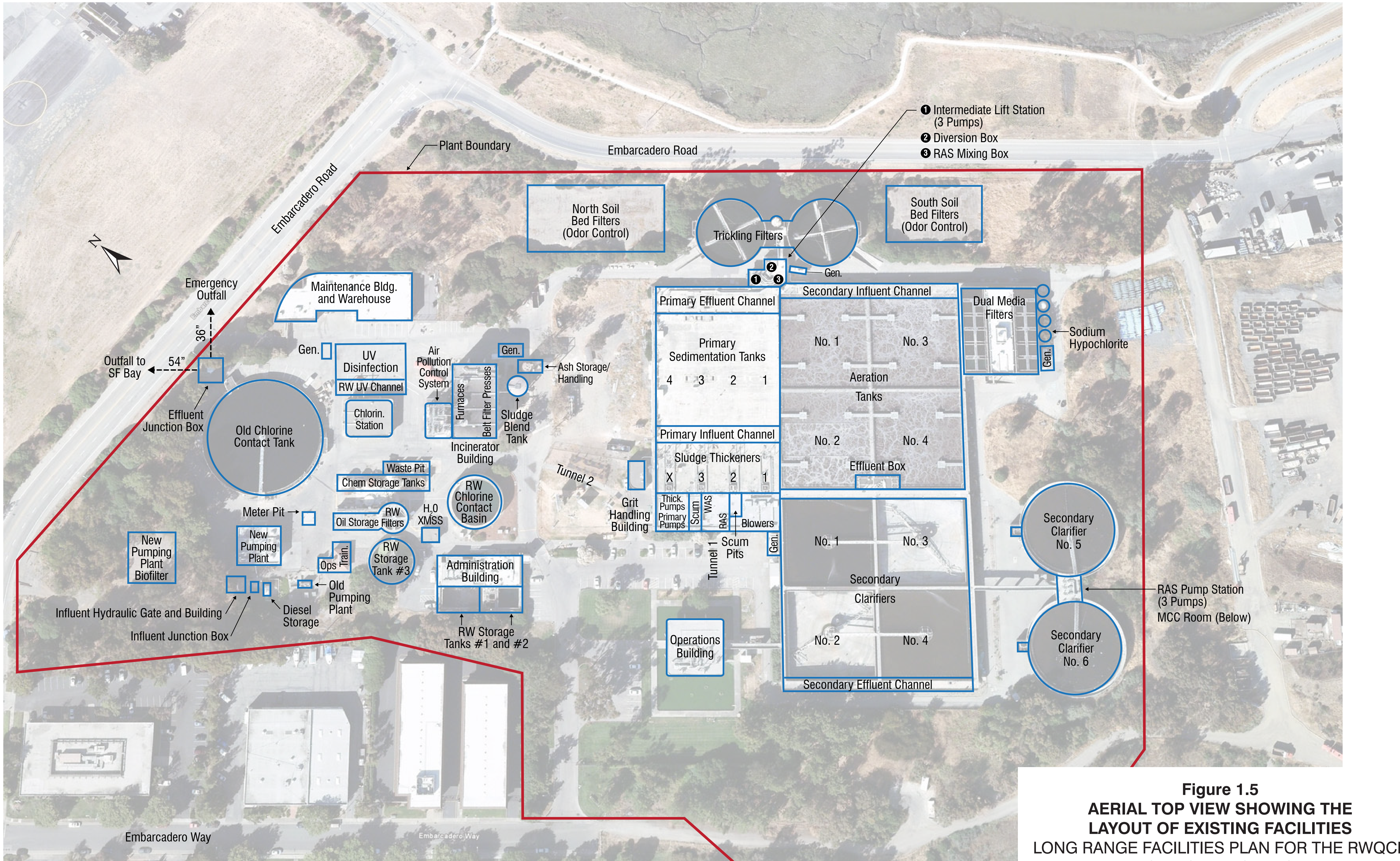


Figure 1.5
AERIAL TOP VIEW SHOWING THE LAYOUT OF EXISTING FACILITIES
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f1-8510.ai

Government Engineering New Zealand, Inc (INGENIUM) and the Institute of Public Works Engineering of Australia (IPWEA).The results of the assessment are used to estimate the cost to modify or rehabilitate existing facilities.

The structural components of the facilities were assessed in 2006 and results of that assessment were also considered as part of this LRFP in order to determine future process and equipment needs and to develop data for comparing existing facilities/equipment with alternative technologies.

The general findings of the condition assessment are that while the facilities have been well-maintained, much of the RWQCP unit processes and equipment are nearing the end of their useful life and will be considered for replacement or major rehabilitation. Repairing or replacing the aging facilities will require a significant investment in the next 15 years. A summary of the major findings and replacement needs are shown in Table 1.2.

The most significant finding affecting the RWQCP is that the existing incinerators, which are 40 years old, are at or near the end of their useful life. Units are difficult to maintain as they age; the steel structure holding the refractory bricks together is stressed and rusting from within. Existing repair efforts have focused on patching and rewelding problem areas that have stressed due to decades of thermal stress. In addition, a seismic analysis of the incinerators and the incinerator building indicate that an earthquake could render the incinerator process nonfunctional. A backup raw sludge hauling contract needs to be in place.

1.8 REGULATORY REQUIREMENTS

Through the planning horizon of 2062, the RWQCP will consider many strategies to deal with emerging regulations. At this level of planning, it is more practical to review groups of similar contaminants, rather than individual constituents, to determine ways to control their discharge. In general, the future regulations that have the greatest impact on the RWQCP long range planning and facility layout are those requiring major process changes, namely increased nutrient removal standards and incineration regulations that would drive the RWQCP to consider alternative process technologies.

Throughout the nation and California, attention is being focused on regulation for nutrients (nitrogen and phosphorus) in our natural water bodies. Excess nutrients to the San Francisco Bay could harm marine life. Research suggests that the Bay has changed over the last 20 years and although it is not currently impaired, additional research is needed. There are many sources of nutrients to the Bay including, stormwater runoff and wastewater treatment plant discharges. If regulations are implemented requiring wastewater treatment plants to reduce nutrient discharges to the Bay (most likely nitrogen), the RWQCP would need to install new tanks and equipment.

Table 1.2 Summary of Needs and Opportunities for Existing Facilities

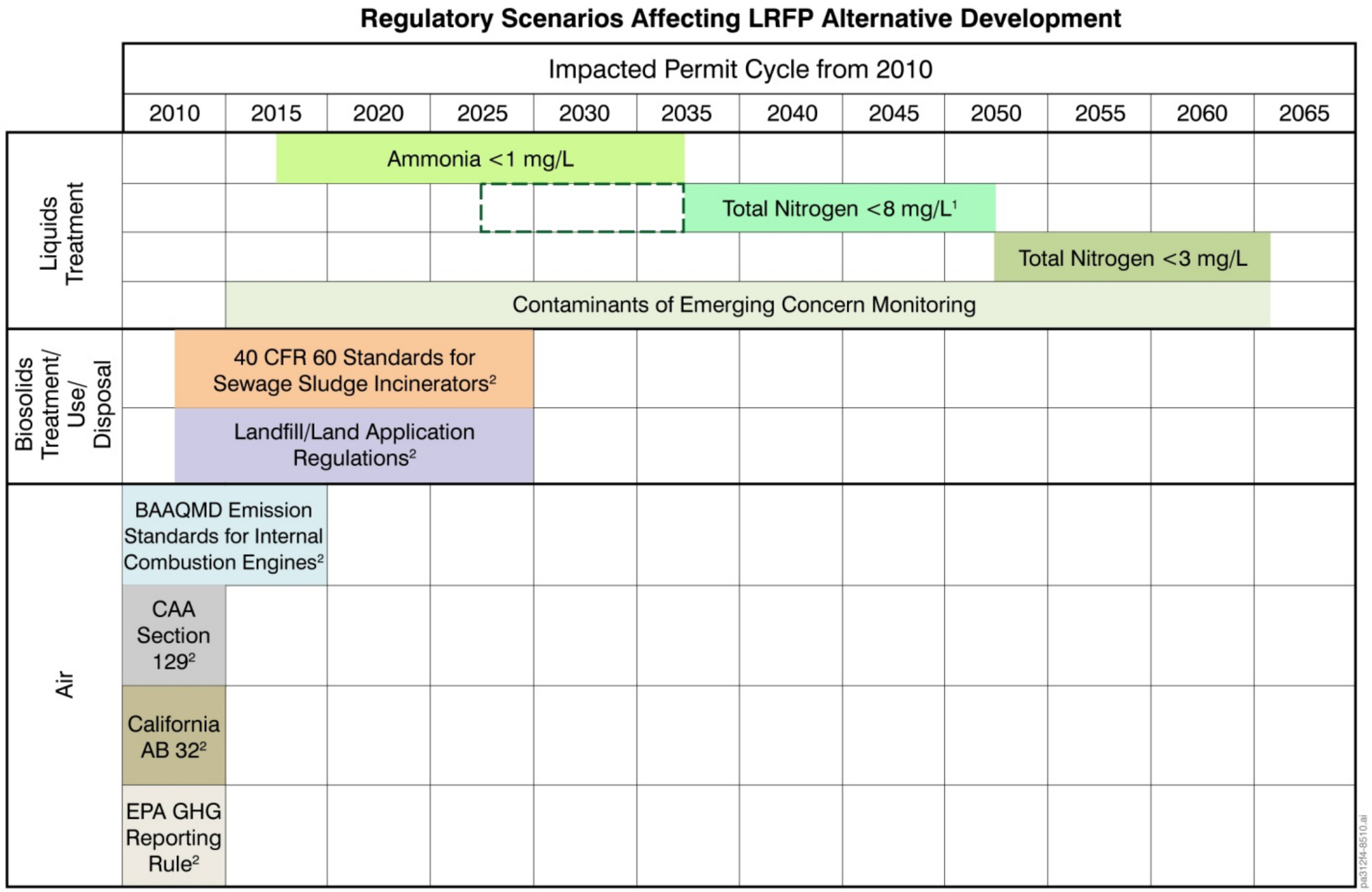
Driver	Process	Need/Opportunity	Reason
Capacity	Interceptor	Clean, CCTV, repair. Study to determine needed capacity.	Corrosion and leakage. Appears to have inadequate capacity.
	Outfall	Inspect and perform study to determine existing and future capacity needs.	Appears to have inadequate capacity and is aging.
Replacement	Headworks	New headworks	Near end of useful life.
	Solids Process	Replace incinerators	End of useful life.
	Support Facilities	New Laboratory and Environmental Services Building	Existing facilities have inadequate space. Administration building is at end of its useful life. Lab is outdated.
	Recycled Water Facilities	Need additional pumping, storage, and new RW filter and CCT	Limited capacity and aging infrastructure.
Rehabilitation	Primaries	Rehabilitate tanks/channels	Concrete cracks and exposed rebar.
	Secondary	Rehabilitate fixed film reactors, aeration basins and clarifiers	Structural and media damage to FFR. Corrosion of concrete and equipment.
	Tertiary	Dual media filters and pumps	Pumps and piping near end of useful life.
	Sludge pumps and thickeners	WAS, sludge and scum pumps. Thickener #4	End of useful life. Need new equipment.
	Piping	In plant piping	End of useful life.
	Misc. buildings, power/electrical	Generators, MCCs, tunnels, storage buildings	End of useful life.
	Support Facilities	Remodel Operations Building and Maintenance Building and expand Warehouse	Existing facilities are inadequate and have inefficient use of space. Need additional space for staff and equipment storage.
	Recycled Water	Pumping, storage	Limited capacity and aging infrastructure

New regulations affecting incineration facilities were implemented in March 2011 by the U.S. Environmental Protection Agency (EPA), which require stricter air emissions for incineration. Per these regulations, if in the future a significant investment is made to repair or upgrade the City's existing incinerators, then the strictest air limits are triggered and the current furnaces would need to be replaced. The final regulations also included stricter air emissions for existing incineration facilities to match the top 12 percent of air pollution control performance of existing U.S. multiple hearth furnaces; Palo Alto can currently meet these standards due to the 1999 incinerator rehabilitation of the air pollution control system. The final regulations were appealed by both Sierra Club and NACWA (National Association of Clean Water Agencies). The Sierra Club / NACWA litigation is still working through the judicial process in the DC courts; a ruling on both suits is expected in early 2013. It is unknown at this time what the results of these appeals and potential litigation will be. In developing the initial rule, EPA indicated the regulations will be reevaluated every five years. It is considered likely that these regulations will continue to get more stringent in the future.

Figure 1.6 summarizes the primary regulatory scenarios that will affect the LRFP alternative development. Ranges of permit cycles during which future regulations are likely to be implemented are shown for each regulatory scenario. Actual implementation dates for future regulations are projected and not certain. Table 1.3 summarizes solutions that can be implemented at the RWQCP to comply with current and future potential regulatory issues.

1.9 SOLIDS TREATMENT ALTERNATIVES

The existing solids process of thickening, dewatering and incineration (with a multiple hearth furnace) has served the RWQCP for 40 years, but is nearing the end of its useful life. Recent regulations by the EPA have further restricted the air emissions from incineration processes, although the plant can currently meet these requirements. The existing incineration process produces ash that is classified as a hazardous waste, requiring special disposal. In addition, the public has expressed concern over use of an incineration process. Therefore, the recommendation of this LRFP is to retire the existing incineration process as soon as a new solids process can be selected and implemented. As such, solids treatment options that could be implemented at the RWQCP in the near term have been comprehensively evaluated. A range of potential solids treatment and disposal options was considered and screened down to the most viable alternatives.



Notes:

(1) San Jose/Santa Clara WPCP's latest Plant Master Plan assumed that TN<8 mg/L requirements would begin by 2025.
(2) Already in effect.

Figure 1.6 Regulatory Scenarios for RWQCP Long Range Facilities Plan

Table 1.3 Summary of Potential Regulatory Issues and Solutions

Topic	Issue	Potential Solution
Nutrient Removal	Federal and State consideration of nutrient removal regulations. Data collection and studies are ongoing to evaluate eutrophication of the Bay that may result in effluent limits.	Add processes and/or capacity to remove nutrients and maximize source control.
Microconstituents and Bioaccumulative Constituents	There is a trend of increasing regulation and it is anticipated that new effluent limits will be added to permits in the distant future.	Maximize removal through increased source control and pollution prevention programs. Consider advanced oxidation.
Recycled Water	State of California goal to increase water reuse to offset potable use.	Expand use of recycled water.
Biosolids	Landfilling of ash and land application of biosolids is becoming increasingly restricted and fewer landfills are accepting biosolids.	Consider diversifying biosolids management alternatives.
Incineration	EPA's new regulations impose strict requirements for new and modified incineration units. Based on this permitting cycle, these will only become more stringent.	Begin to diversify incrementally as opportunities arise and phase out the use of the current incinerators.
Air Emissions	New sewage sludge incineration (SSI) standards require RWQCP to apply for a Title V permit. Air emissions regulations increasing for standby engines.	Plan for increasingly stringent emissions requirements and need for emissions control equipment for stationary combustion facilities/engines.
Greenhouse Gases (GHG)	POTWs are not directly required to report GHG emissions but may need to report general stationary combustion emissions.	Monitor GHG emissions regulations and comply. Implement energy efficiency and green energy projects.

The viable solids alternatives that were considered in more detail include the following and are shown in Figures 1.7 to 1.9:

1. Thermal processes: fluidized bed incineration or gasification.
2. Anaerobic Digestion (Wet) with biosolids reuse/disposal.
3. Regional opportunities to haul dewatered solids to San Jose/Santa Clara Water Pollution Control Plant (SJ/SC WPCP) for digestion or to the Bay Area Biosolids to Energy (BAB2E) project for treatment/disposal (process undecided but it is likely to be gasification).

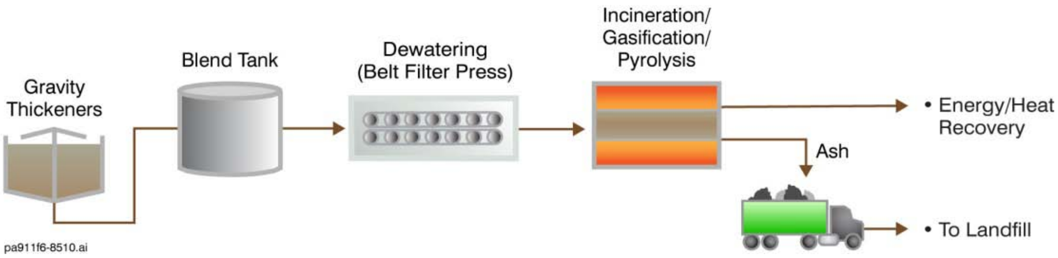


Figure 1.7 Thermal Solids Process

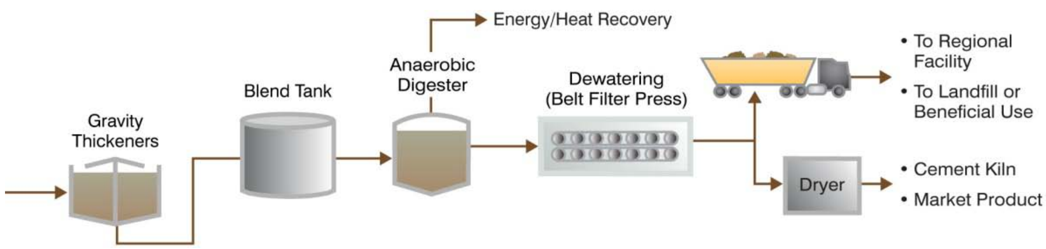


Figure 1.8 Digestion Solids Process

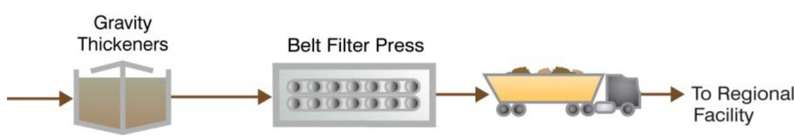


Figure 1.9 Regional Opportunities Solids Process

A summary of the solids alternatives evaluation is shown in Table 1.4. The net present values for the solids alternatives are shown in Figure 1.10 (detailed breakdown of the net present values are provided in Table A.1 at the end of this section). A summary of the GHG emission estimates are shown in Figure 1.11 (further breakdown of GHG emissions sources can be found in Figure A.1 and Table A.2 at the end of this section). The annual energy usage/production comparison is shown in Figure 1.12 (detailed breakdown of the energy usage/production values are provided in Table A.3 at the end of this section).v

The solids treatment alternatives are compared in Table 1.4. It is clear that the regional options represent the lowest capital cost and net present value costs. Of the two regional options, delivery to the SJ/SC WPCP has the lowest net present value and GHG emissions. However, the decision to send solids to an off-site treatment facility needs to be a policy decision by the City and its Partners. Therefore, the recommendation for solids treatment is to continue operating and maintaining the existing incineration processes and initiate a Solids Facility Plan that will include discussions with Partner Agencies and potential regional partners (i.e. SJ/SC WPCP and the potential regional BAB2E facility). The RWQCP staff should also continue to track future regulations and potential new technologies, such as gasification, that may be considered more viable in the future. The RWQCP should also consider participating in regional and local pilots of processes, such as the gasification pilot planned at SJ/SC WPCP, which would provide information on how well the process handles undigested solids (which would be required for design of the process) and what are requirements and costs for operation and maintenance of the process. If the preference is to keep treatment of the solids at the facility then a preliminary design should be initiated to evaluate this option in more detail.

Table 1.4 Biosolids Treatment and Disposition Alternatives Comparison(1)

Treatment Alternative(2)	Annual O&M Costs ($MM/yr)	Capital Costs ($MM)	Net Present Value(3) ($MM)	Total GHG emissions(4), mt CO_2e/yr	Site Layout, acres
Fluidized Bed Incineration	5.0	130.5	240.3	31,516	0.4
Gasification	4.5	49.8	138.5(5)	20,385	0.7
Anaerobic Digestion	4.4	89.0	182.0	10,755	1.5
Delivery to SJ/SC WPCP (regional digestion)	4.0	39.5	115.4	10,821	0.2
BAB2E (regional gasification)	6.1	12.8	124.2	20,565	0.2

Notes:
(1) Alternative costs and impacts include treatment and disposition for the year 2045.
(2) Costs presented in 2015 dollars
(3) Present value cost represents the value of the total cash flow occurring over 30 years with a 5 percent interest.
(4) Greenhouse gas emissions in 2045, including biogenic carbon dioxide emissions.
(5) Based on a similar project it was determined that the capital portion of the O&M fee was approximately 85 percent. To be consistent with our capital cost estimates, a 30 percent contingency was applied to the capital cost portion of the annual contract for gasification.

Another solids disposal option that is being considered independent of the LFRP is dry anaerobic digestion. The City hired consultants Alternative Resources, Inc. (ARI), to complete a dry anaerobic digestion study for solids generated by the RWQCP and for handling green and food wastes collected in the City. ARI concluded that a dry anaerobic digester could indeed be cheaper than the exporting options for green and food wastes, but only if such factors as carbon adders, state and federal grants and contingency costs for exports are added into the mix. A public vote in November 2011 passed Measure E, which undedicated ten (10) acres of Byxbee Park for the exclusive purpose of considering dry digestion processing. City staff and Alternative Resources, Inc. (ARI) are developing an Action Plan to layout the process and timeline for considering the facility.

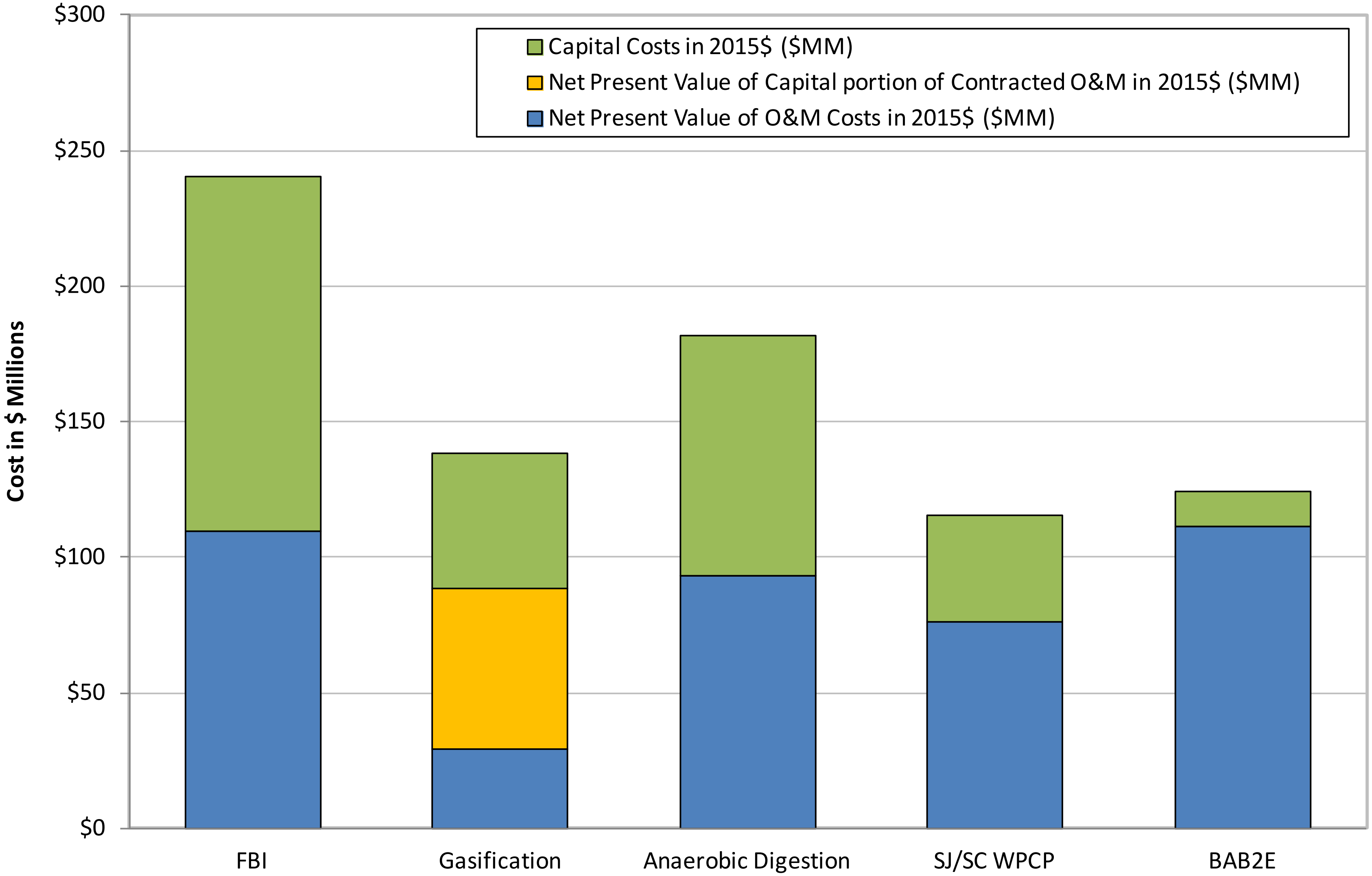


Figure 1.10 Net Present Value for Solids Alternatives in 2015 Dollars

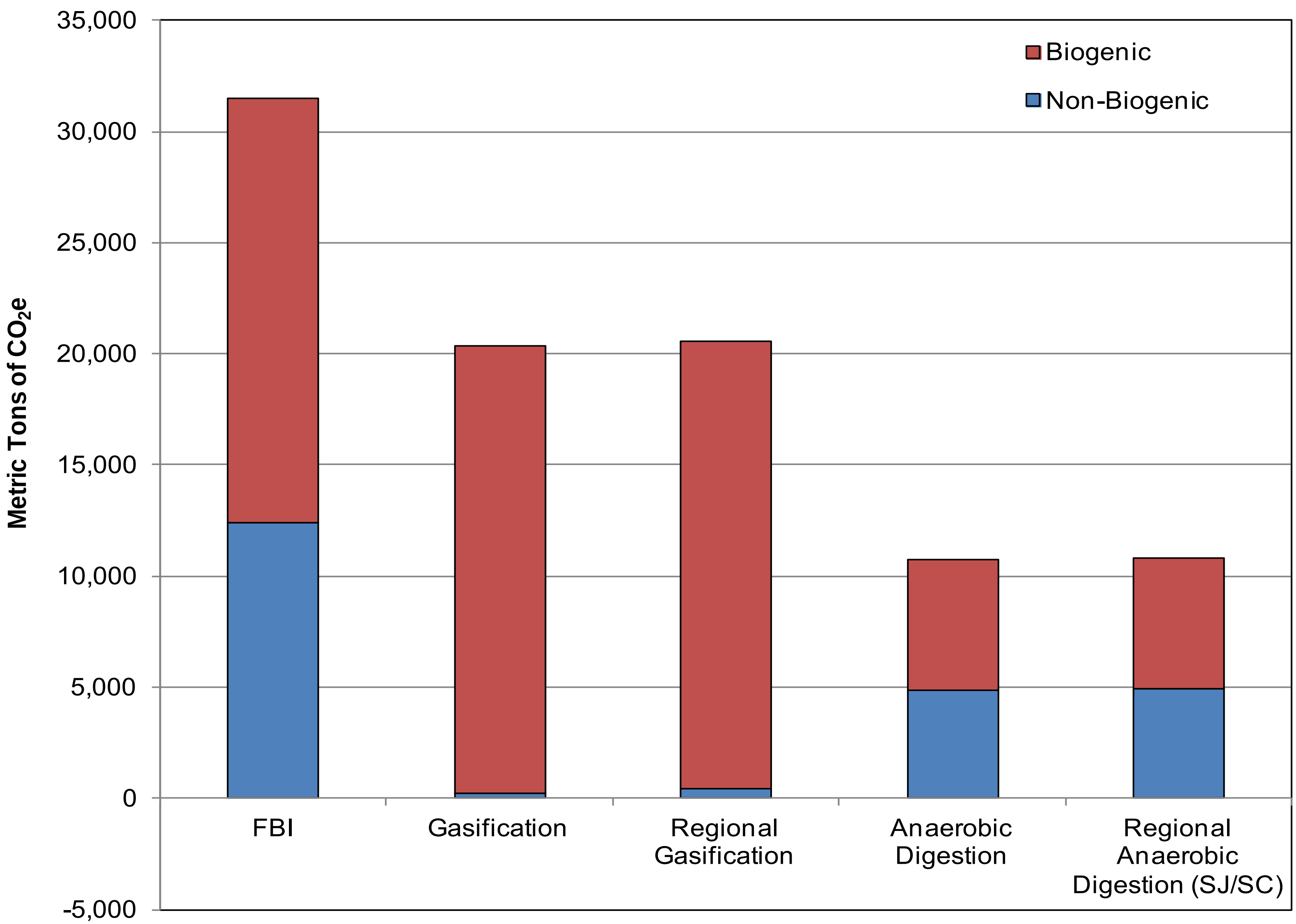


Figure 1.11 Greenhouse Gas Emission Estimates for Solids Alternatives in 2045

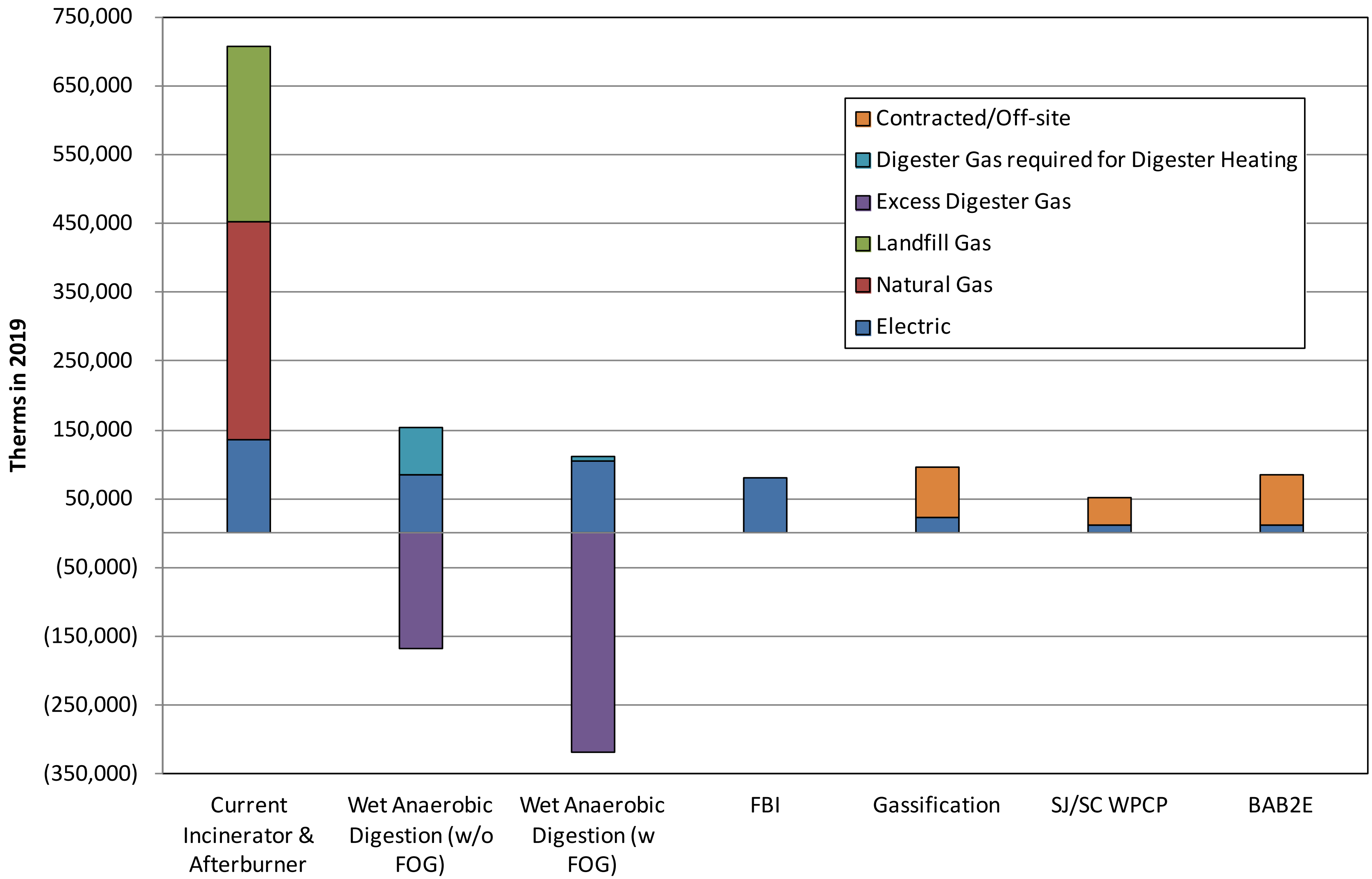


Figure 1.12 Annual Energy Usage/Production for Solids Alternatives in 2019

1.10 LIQUID TREATMENT ALTERNATIVES

The existing liquid treatment processes are performing well and meeting current regulatory requirements. As part of this LRFP, the needed facilities to meet potential future regulations have been identified. The most pressing future regulation for liquid treatment is nutrient (nitrogen) removal as it has the potential to require significant expense to construct new facilities. A range of potential liquid treatment alternatives to meet low total nitrogen limits was considered and screened down to the most viable alternatives. The viable liquid alternatives that were considered in more detail include the following and are shown in Figures 1.13 to 1.15, respectively:

1. Membrane Bioreactors

2. Trickling Filters/Activated Sludge/Denitrification Filters

3. Integrated Fixed Film Activated Sludge (IFAS) Reactors

A summary of the liquid treatment alternatives evaluation is shown in Table 1.5.

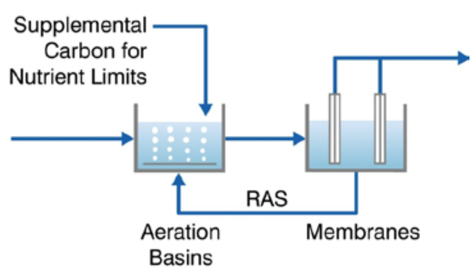


Figure 1.13 Membrane Bioreactor Process

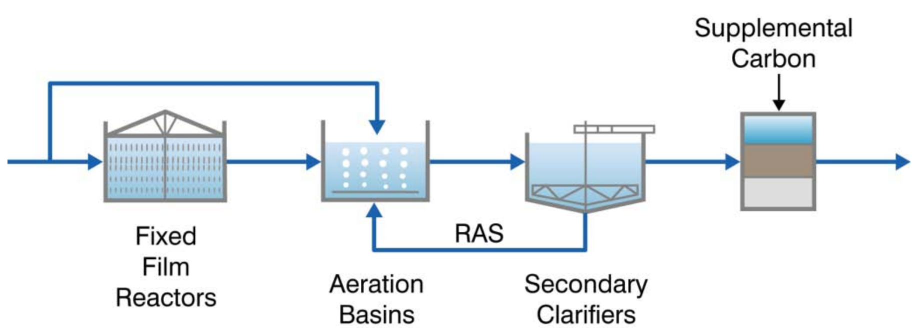


Figure 1.14 Trickling Filters/Activated Sludge/Denitrification Filters Process

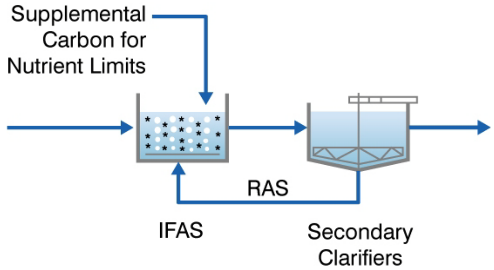


Figure 1.15 Integrated Fixed-Film Activated Sludge Process

The liquid treatment alternatives for meeting future regulations for total nitrogen control are compared in Table.1.5. All of the alternatives for nitrogen reduction have a significant capital cost and require a large increase in energy consumption and chemical use. It is clear that continued investment in the existing processes of tricking filters followed by activated sludge and filtration is appropriate in that denitrification processes (denitrification filters) can be added on as the lowest capital cost alternative. Therefore, the recommendation for liquid treatment is to continue operating and maintaining the existing processes while continuing to track future regulations and potential new technologies that may be considered in the future.

Table 1.5 Liquid Treatment Alternatives Comparison

Treatment Alternative	Capital Cost, $ millions	Annual O&M Cost, $ millions	GHG Emissions, CO_2e mt/yr	Site Layout, acres
Membrane Bioreactor	$135.9	$10.4	3,085	2.5
TF/AS/Denitrification Filter	$68.5	$8.3	6,600	1.0
Integrated Fixed Film Activated Sludge	$114.5	$9.9	3,106	1.0

Notes:
(1) Costs presented in 2015 dollars
(2) O&M costs and GHG emissions shown for liquid treatment alternative operations for year 2035, assuming a requirement of total nitrogen < 8 mg/l.

In addition to considering facilities needed for future total nitrogen removal, facilities needed to remove emerging contaminants from the effluent and salinity from recycled water were considered and costs and site needs developed for advanced oxidation with ozone and for reverse osmosis facilities.

1.11 RECOMMENDATIONS

In general, the RWQCP is able to treat the existing wastewater flows to meet current effluent discharge limits and provide recycled water to users. With the exception of the interceptor and outfall during peak wet weather events, the plant capacity is adequate to meet the anticipated growth in the service area over the next 50 years. Alternatives have been developed for solids and liquid treatment facilities in response to changing regulatory requirements for incineration and for complying with more restrictive effluent discharge limits such as total nitrogen limits and the potential removal of emerging contaminants.

Findings from treatment evaluations show that while continued investment in the incineration process is not warranted due to its age, condition, and lack of regulatory flexibility; continued investment in the existing liquid treatment processes is appropriate in the light of changing regulatory requirements. Therefore, the major recommendation is to rehabilitate and replace existing facilities that are nearing the end of their useful life, and not switch the current liquid treatment processes for the foreseeable future. However, since a significant portion of the plant was built in 1972 (e.g., the Main Structure), many facilities are aging and are in need of significant investment in rehabilitation and replacement.

The recommendations for the RWQCP are as follows:

Model Influent Sewer Flows

- **Determine peak wet weather flow:** Work with RWQCP partner agencies to understand sewer flows. Develop a sewer system estimate of the key components of the wastewater collection system to determine the peak wet weather flows that will reach the RWQCP. Knowing peak flows will inform sewer rehabilitation options, inform plant capital improvement sizing for wet weather flows (note: not pollutant loads), and inform effluent outfall capacity evaluation. Understanding peak flows will also inform infiltration and inflow management needs, if necessary, to reduce capital sizing.

- **Inspect and Clean Influent Sewer:** Following the development of the sewer system flow estimate to determine needed capacity, clean and inspect the 72-inch diameter interceptor sewer to decide the best option for rehabilitation.

- **Outfall:** Following the development of the collection system flow estimate, the capacity of the outfall should be reviewed. Additionally the outfall should be inspected to determine rehabilitation needs for the near future.

Continue Source Control and Flow Reduction Efforts

- Continue to evaluate options for source control and flow reduction measures for cost-effective options to reduce costs at the RWQCP for treatment of flow and loads.
- Continue traditional source control efforts; source control is more cost effective at removing some pollutants than traditional wastewater treatment technology (e.g., toxic heavy metals) and will reduce the potential need for more expensive capital facilities.
- Source control for emerging contaminants should be considered before advanced treatment.
- Continue support of water conservation efforts as well as infiltration and inflow reduction efforts, which reduce operating costs, preserve surplus wet-weather capacity, reduce energy consumption, and reduce the wear and tear on existing capital investments, thereby extending their life.
- Consider alternative source control methods to reduce pollutant loads, as necessary, to reduce the sizing of potentially necessary capital facilities. Commercial garbage disposals are already banned in Palo Alto and Mountain View to reduce sanitary sewer overflows. If the food waste collection system is expanded, the program would include outreach and education for residents and businesses.
- Continue strategic analysis of salinity infiltration to reline and rehabilitate sewers with highly saline groundwater infiltration.
- Consider banning or working with others on regional/state-wide solutions related to specific household products that pass through the treatment plant and have ecological impacts on the Bay to reduce the need for large capital improvements to reduce pollutants better reduced through source control.

Rehabilitate and Replace Critical Infrastructure

- **Solids Treatment:** Continue using the existing Multiple Hearth Furnace for the immediate future, but initiate a detailed Solids Facility Plan immediately. In light of the many regulatory and cost uncertainties, this plan should develop a portfolio of management options.
- **Preliminary Treatment:** Replace the headworks (screenings, pumping and grit).
- **Primary Treatment:** Rehabilitate existing primary clarifiers.

- **Secondary/Tertiary Treatment:** Continue operating and maintaining existing processes. Rehabilitate existing fixed film reactors, aeration basins, secondary clarifiers, and dual media filters.
- **Recycled Water:** Replace recycled water filters and chlorine contact tank.
- **Support Facilities:** Replace the administration building with a new Laboratory and Environmental Services Building to house a new laboratory and staff office space. This new building can be onsite or off-site at a neighboring commercial property. The City should look into the availability of any neighboring properties that can be used for siting this new building. Remodel the operations building and maintenance building and expand the maintenance building to include additional warehouse space.

Prepare for Regulatory Action

- **Nutrient (nitrogen) Removal:** RWQCP and Partner agencies to participate in ongoing studies of the Bay and continue to track regulations and emerging technologies that would reduce nitrogen with lower energy and chemical requirements. If total nitrogen removal is required, construct denitrification filters.
- **Incineration:** Move expeditiously on incinerator retirement as new regulations potentially force more difficult environmental compliance; 5-year regulatory reviews and/or lawsuits on US EPA regulations may force an accelerated and costly capital compliance schedule.
- **Emerging Contaminants:** Leave space for ozonation facilities if a higher quality effluent for emerging contaminants is required.

Respond Strategically

- **Emerging Technologies:** Continue to track emerging technologies that may have potential for meeting new regulations or for providing an opportunity to save energy and costs.
- **Recycled Water:** If recycled water demands increase, provide additional storage and pumping to be able to meet peak-hour demands for future recycled water users. Reserve space on the site for reverse osmosis should source control measures on sewer infiltration prove ineffective. Alternatively, an inter-connection with other recycled water systems may also be more effective than reverse osmosis.

The recommended layout to reserve space for new facilities is shown in Figure 1.16.

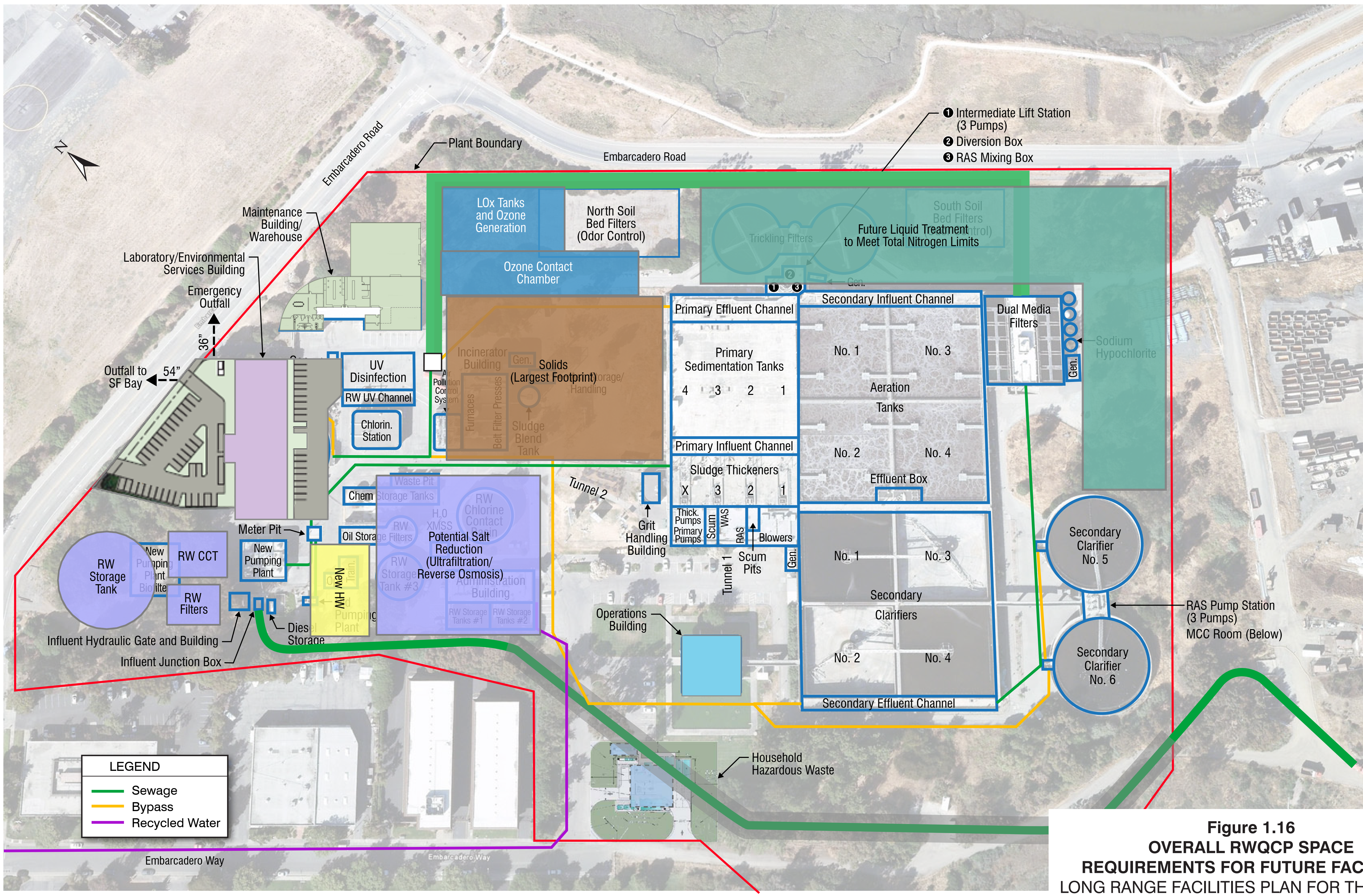


Figure 1.16
OVERALL RWQCP SPACE REQUIREMENTS FOR FUTURE FACILITIES
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f4-8510.ai

1.12 IMPLEMENTATION PLAN FOR RECOMMENDED PROJECTS

The recommendations of this LRFP result in a significant investment in projects at the RWQCP over the next 50 years. However, many projects, such as reverse osmosis to remove salts from recycled water or ozonation to meet emerging contaminants regulations, may not need to be implemented in the future unless by regulation or City policy. Improvements to the liquid treatment to remove nitrogen have been identified, but the recommendation is to continue participating in data collection and investigation of the Bay and not to move forward immediately with a nitrogen reduction project. In addition, a final decision has not been made on which solids handling process should be implemented, which has a large impact on the overall capital improvement project (CIP) program cost estimates, as shown in Table 1.6 and Figure 1.17. Figure 1.18 shows the overall cash flow for all projects identified in the CIP program, which is based on the proposed implementation schedule.

Table 1.6 Summary of Recommended Projects and Estimated Costs(1)

Project Category	Project Costs in 2015, millions
Solids Handling Projects	$13 to 89
Replacement Projects	$54
Rehabilitation Projects	$78
Support Facilities Project	$25
Future Regulatory Requirement Projects	$69
Future Recycled Water Projects	$77
Total	**$315 - 392**

(1) Cost sharing allocations and cost control measures will be evaluated for each individual project.

Of the total identified potential project CIP of $315 to $392 million, future projects that may or may not be implemented amount to $146 million. To represent how the RWQCP intends to implement the projects, they have been divided into three (3) main categories: Major CIP (larger capital cost projects that require debt financing), Minor CIP (smaller capital cost projects that can be done under the existing plant annual CIP budget) and Future Major CIP (may be required in the future based on some potential regulatory requirement). Figure 1.19 shows the contribution of each CIP category to the overall CIP program, assuming costs for the anaerobic digestion option for the solids project (see Table A.4 at the end of this section for the detailed breakdown of values).

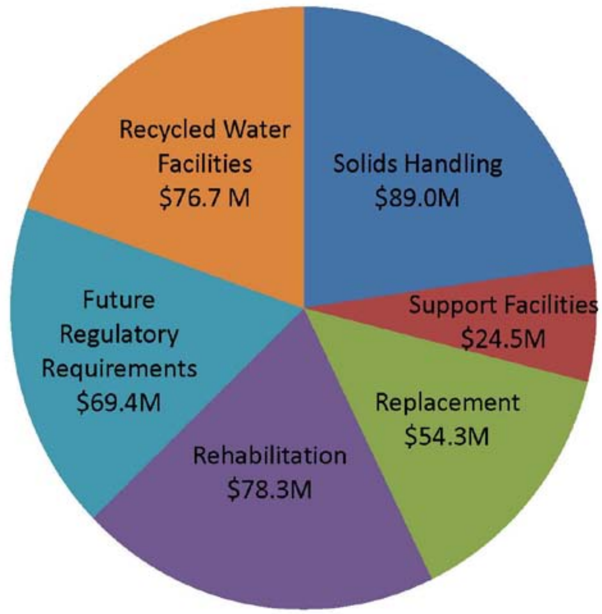


Figure 1.17 Contributions and Cost of Project Categories to Overall CIP Program

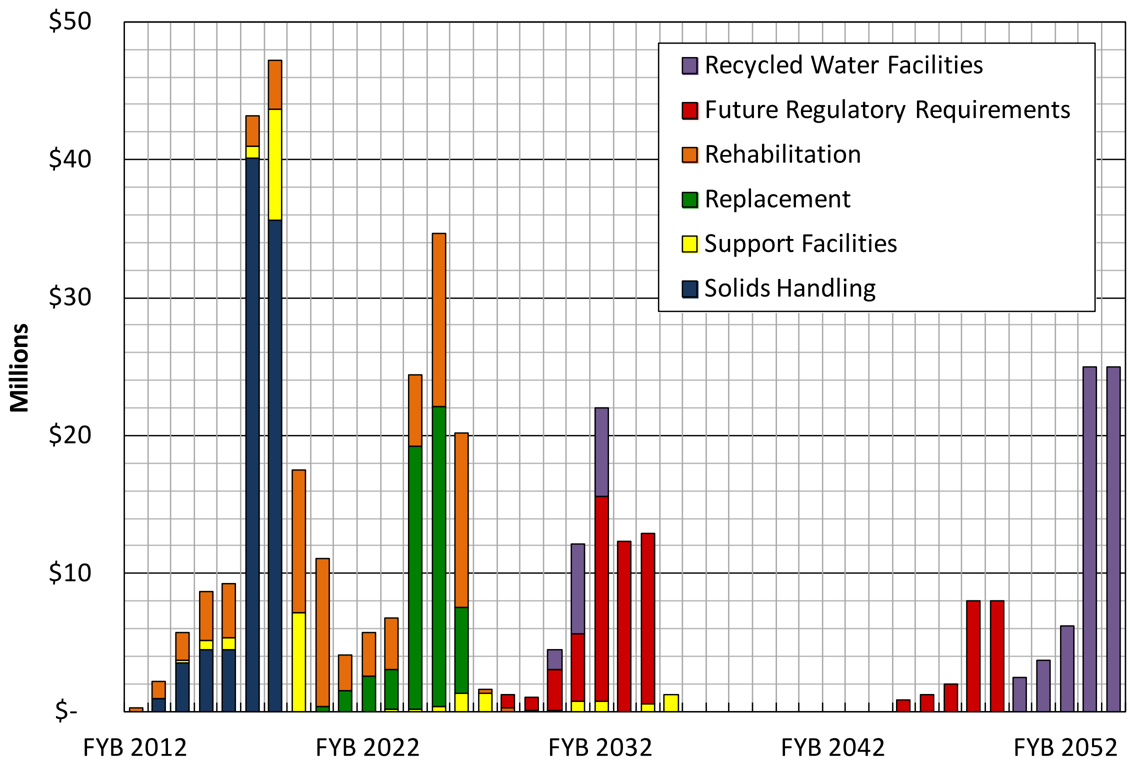


Figure 1.18 Cash Flow for the Major Project Categories of CIP Program

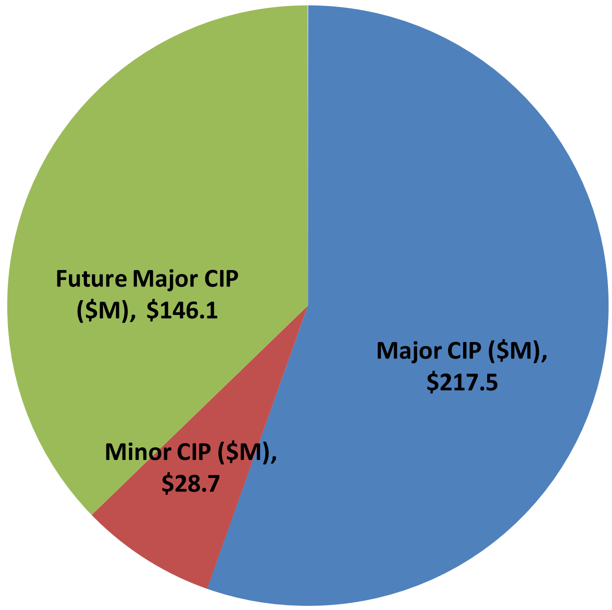


Figure 1.19 Distribution of Major Project Categories and Costs to Overall CIP Program

1.12.1 Financing

As discussed above, the Minor CIP projects are smaller rehabilitation projects that will be funded through the existing RWQCP ongoing CIP budget that is currently funded by the partner agencies' contributions of $2.6 million/year (2011), adjusted annually to an inflation index. The Major CIP projects will require funding through other mechanisms such as a low interest State Revolving Fund (SRF) loans or water revenue bonds. The financing options and the resulting debt service for the Major CIP projects are discussed in Chapter 9 of the report. Financing for Future CIP projects is not being considered now because of the tentative nature of the projects. A separate financing plan will be developed to consider how best to finance the recommended improvements from this LRFP. Preparation of the financing plan will require coordination and input by the all the partner agencies.

1.12.2 Partner Agencies Shares

Major capital improvement project costs are shared by all the partner agencies that contribute to the RWQCP. A preliminary allocation has been made as to each partner's share of the Major CIP project costs based on the current capacity allocations, as shown in Table 1.7. However, the final cost allocation will need to be re-evaluated for each major project as a different cost share approach may be warranted. For example, the solids project is dependent on solids loading and a cost allocation will need to be worked out between partner agencies. Additional details on the cost of financing for each partner is included in Chapter 9 and will be evaluated in more detail in the Financing Plan. Costs for projects are planning level estimates and do not consider potential measures for cost control. As each project moves forward, a more detailed analysis will be performed and cost saving measures will be explored. For example, the first major project will be the solids project, which will be evaluated in more detail during preparation of the Solids Facility Plan (to be prepared in 2013) and in subsequent predesign and design efforts. Partner agencies will be encouraged to participate and provide input into these efforts.

Table 1.7 Summary of Preliminary Partner Cost Allocation for Major CIP Projects(1)

Partner Shares	Palo Alto	Mountain View	Los Altos	East Palo Alto	Stanford	Los Altos Hills
	Percent Cost Share Based on Capacity					
Sewer	18.24%	62.50%	15.00%	0.00%	0.00%	4.26%
Wastewater Treatment	38.16%	37.89%	9.47%	7.64%	5.26%	1.58%
Project	**Cost Allocation in Millions**					
Solids Project (cost shown for Anaerobic Digestion)	$33.98	$33.74	$8.43	$6.80	$4.68	$1.41
Laboratory and Environmental Services Building	$7.81	$6.19	$1.55	$1.25	$0.86	$0.26
Headworks Facility (including Grit Removal System)	$14.83	$14.72	$3.68	$2.97	$2.04	$0.61
Recycled Water Filters and Chlorine Contact Tank	$5.42	$5.38	$1.35	$1.09	$0.75	$0.22
Primary Sedimentation Tanks Structure	$2.79	$2.77	$0.69	$0.56	$0.38	$0.12
Fixed Film Reactors Structure and Equipment	$7.41	$7.36	$1.84	$1.48	$1.02	$0.31
Joint Interceptor Sewer	$5.62	$19.25	$4.62	$ -	$ -	$1.31
Total	**$77.85**	**$89.41**	**$22.16**	**$14.15**	**$9.74**	**$4.24**

(1) Preliminary allocation. Cost sharing allocations and cost control measures will be evaluated in more detail for each individual project.

ATTACHMENTS

Table A.1 Net Present Value for Solids Alternatives in 2015 Dollars			
	Net Present Value of O&M Costs in ($MM)[1]	**Net Present Value of Capital portion of Contracted O&M in ($MM)**	**Capital Costs in ($MM)**
FBI	109.8	-	130.5
Gasification	29.1	59.6	49.8
Anaerobic Digestion	92.9	-	89.0
SJ/SC WPCP	75.9	-	39.5
BAB2E	111.4	-	12.8

Note:

(1) The O&M costs provided for the on-site gasification alternative included a capital cost portion. This capital cost portion was estimated to be about 85 percent of the O&M cost provided. For all other options, the O&M and capital costs estimates were determined separately.

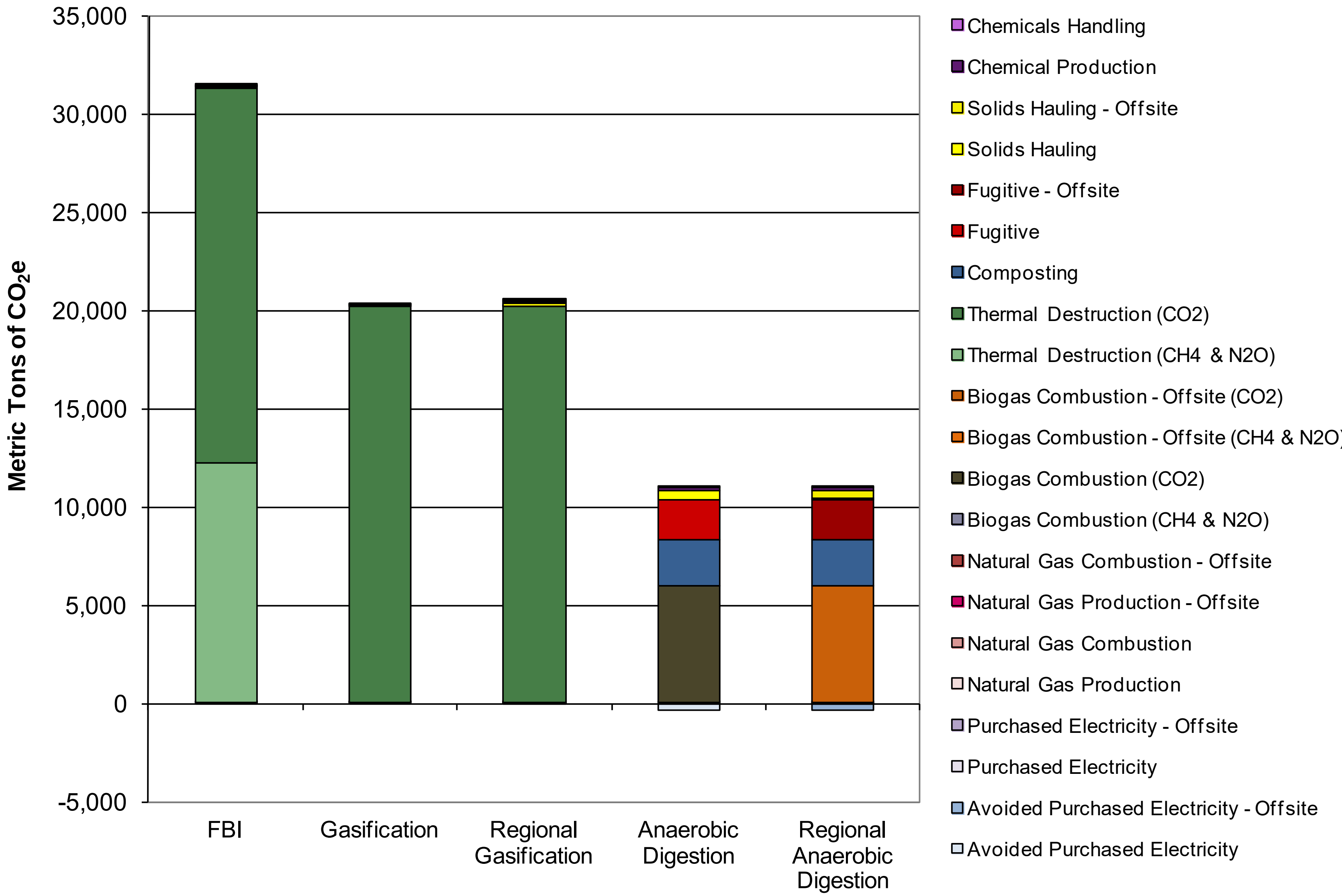


Figure A.1 Breakdown of Greenhouse Gas Emissions for Biosolids Alternatives in 2045

Table A.2	**Breakdown of GHG Emissions for Biosolids Alternatives for 2045**									
	Avoided Purchased Electricity	**Purchased Electricity**	**Natural Gas Production & Combustion**	**Biogas Combustion**	**Thermal Destruction**	**Composting**	**Fugitive**	**Solids Hauling**	**Chemical Production**	**Chemical Hauling**
FBI	0	132	7	0.0	31,266	0	2	54	53	2
Gasification	0	101	10	0.0	20,163	0	2	54	53	2
Regional Gasification	0	84	10	0.0	20,163	0	2	251	53	2
Anaerobic Digestion	-268	137	0	5,916	0	2,341	2,049	469	107	4
Regional Anaerobic Digestion	-268	139	0	5,916	0	2,341	2,049	480	160	5

Table A.3	**Annual Energy Usage/Production for Solids Alternatives Expressed in Therms for 2019**						
	Current Incinerator & Afterburner	**Wet Anaerobic Digestion (without FOG)**	**Wet Anaerobic Digestion (with FOG)**	**FBI**	**Gasification**	**SJ/SC WPCP**	**BAB2E**
Electric	135,491	84,289	104,175	80,380	21,938	11,400	11,237
Natural Gas	317,509	-	-	-	-	-	-
Landfill Gas	255,135	-	-	-	-	-	-
Excess Digester Gas	-	(168,565)	(319,249)	-	-	-	-
Digester Gas required for Digester Heating	-	68,644	7,531	-	-	-	-
Contracted/Off-site	-	-	-	-	72,903	40,665	72,903

Table A.4 Cash Flow for the Major Project Categories of the Capital Improvement Program in 2015 Dollars(1)

	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Solids Handling		$890,388	$3,561,550	$4,451,938	$4,451,938	$40,067,441	$35,615,503	
Support Facilities			$179,038	$716,151	$895,188	$895,188	$8,056,694	$7,161,505
Rehabilitation	$284,100	$1,278,450	$2,030,903	$3,522,363	$3,881,696	$2,235,474	$3,503,432	$10,326,254

	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027
Support Facilities				$132,697	$199,045	$331,742	$1,326,970	$1,326,970
Replacement	$388,566	$1,554,265	$2,561,913	$2,871,454	$19,033,186	$21,733,468	$6,190,818	
Rehabilitation	$10,665,207	$2,575,315	$3,158,765	$3,817,071	$5,133,683	$12,616,142	$12,700,754	$296,142

	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032	FY 2033	FY 2034	FY 2035
Support Facilities		$65,316	$97,975	$734,809	$734,809		$512,651	$1,196,186
Rehabilitation	$274,989							
Future Regulatory Requirements	$988,371	$988,371	$2,965,114	$4,941,856	$14,825,568	$12,354,640	$12,354,640	
Recycled Water Facilities			$1,433,572	$6,451,072	$6,451,072			

	FY 2045	FY 2046	FY 2047	FY 2048	FY 2049	FY 2050	FY 2051	FY 2052
Future Regulatory Requirements	$798,116	$1,197,173	$1,995,289	$7,981,157	$7,981,157			
Recycled Water Facilities						$2,497,613	$3,746,419	$6,244,032

	FY 2053	FY 2054
Recycled Water Facilities	$24,976,126	$24,976,126

Note:
(1) The table only shows years for which there are costs.

Chapter 2
INTRODUCTION/BACKGROUND

The City of Palo Alto operates the Regional Water Quality Control Plant (RWQCP) for the benefit of the City and the surrounding communities. The City has provided wastewater treatment services for 78 years. The RWQCP is located at the end of Embarcadero Road on Embarcadero Way adjacent to the Palo Alto Airport, Byxbee Park, and the Emily Renzel Wetlands.

This chapter of the LRFP introduces the history of the RWQCP, its location and the service area. The environmental and biological setting of the RWQCP is also presented. This chapter also explains the overall LRFP planning and decision processes as well as the public stakeholder and technical advisory group processes.

2.1 PLANT HISTORY AND LOCATION

2.1.1 Early History (1894-1934)

Palo Alto was incorporated in 1894. Palo Altans started public sewage improvements in 1898 by approving $28,000 in bond money to fund construction of the City's first sewer network, which was completed in 1899. Private cesspools and privies were banned, and the City health officer had residents connected to the sewer system within a few years. The sewer system served approximately 3,000 people and discharged raw sewage from a 12-inch diameter outfall pipe into the Mayfield Slough at the edge of South San Francisco Bay.

While public health in the town of Palo Alto was improved, public heath in the Baylands was not. During the 1920s the Baylands park and yacht harbor were being planned, but City leaders feared health contamination to boaters and park enthusiasts. In addition, tide-induced sewage backflows on City streets prevented population growth in Palo Alto. As a result, the State Board of Public Health decided to require a primary treatment plant with a new outfall discharging further from shore into the bay.

2.1.2 Palo Alto Treatment Plant (1934-1972)

The Palo Alto Treatment Plant began operating July 1, 1934, and was the first wastewater treatment plant in South San Francisco Bay. At a cost of $63,324, the plant could treat 3 million gallons of wastewater per day (mgd), serving a cannery and approximately 20,500 residents of Palo Alto and Stanford University. The plant discharged primary effluent 700 feet offshore, and the raw sludge was digested in an anaerobic digester, placed in sludge drying beds that were located in place of the current landfill, then used as a soil amendment in parks of Palo Alto.

In 1946, immediately after World War II, $299,000 was spent to increase treatment capacity to 5 mgd in order to handle the seasonal Sutter Packing Company cannery wastes. To keep up with the post-war boom in population, the plant increased capacity again to treat up to 10 mgd with some secondary treatment at a cost of $528,000 in 1957.

Meanwhile, the neighboring City of Mountain View had constructed a primary treatment plant (in 1951) that was upgraded to provide enhanced primary treatment in 1961. The City of Los Altos also constructed a primary treatment plant in 1957.

2.1.3 Regional Water Quality Control Plant (1968 - present)

Over the years, residents observed increased signs of pollution and stress on the environment of South San Francisco Bay. In December 1962, the Palo Alto plant received its first discharge permit from the California Regional Water Pollution Control Board. In response, the plant built a new outfall in 1964 to prevent periodic discharges near the (now defunct) Yacht Harbor. A 1966 long range plan recommended adoption of secondary treatment in anticipation of state regulations requiring disinfection of effluent and higher oxygen levels in receiving waters. The study also recommended possible consolidation with neighboring communities.

In October 1968, the Cities of Mountain View and Los Altos agreed to retire their treatment plants and partner with the City of Palo Alto to construct a cost-effective regional secondary treatment plant – the Regional Water Quality Control Plant (RWQCP). The original Palo Alto Treatment Plant site was expanded from a 3-acre site to a 25-acre site. The 25-acre site is located within the Palo Alto Baylands between Highway 101 and San Francisco Bay, as shown in Figure 2.1. The 1968 agreement is good through July 1, 2035 and states Palo Alto is the owner and operator of the plant. This agreement, and the agreements with East Palo Alto Sanitary District, Stanford University, and Los Altos Hills, require all six agencies to proportionately share in the costs of building and maintaining the facilities.

During the mid-1960s, heavy metals from the electronics industries were causing digester upsets at the former Palo Alto plant. The digester upsets caused problematic odors. Incineration was not subject to these shock load upsets and odors. It was deemed that incinerator air pollution control technologies had evolved sufficiently to remove ash from the exhaust gases (i.e., wet scrubbers). Incineration had a small footprint on the Baylands. Furthermore, incinerator ash was much more easily disposed of than anaerobically digested sludge due to the large volume reduction caused by thermal destruction. Consequently, sludge dewatering followed by sewage sludge incineration was selected as the biosolids treatment technology.

The RWQCP was designed in 1969 and construction of the RWQCP was completed in October 1972 for a cost of $11 million. Since then the plant has provided complete secondary treatment of wastewater and incineration of sewage sludge. Disinfected effluent has been discharged to an

Figure 2.1
RWQCP NEIGHBORS AND LAND USE
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa412f2-8510.ai

unnamed slough near the Palo Alto Airport, which flows into San Francisco Bay, approximately 1,500 feet distant from the point of discharge.

To further protect the Bay, in October of 1980 the RWQCP was upgraded to an advanced (tertiary) wastewater treatment facility to improve ammonia removal. This was accomplished through the addition of two fixed film reactor towers and dual media filters at a cost of $8.8 million. When there is a need for essential maintenance or to handle wet weather flows exceeding 40 mgd, provisions were made to bypass the advanced wastewater treatment processes.

In August 1988, another capacity expansion project was completed to assure that the RWQCP effluent standards could be met during periods of heavy rainfall. As part of this project, two round secondary clarifiers were added to the RWQCP. In 2010, construction of the advanced ultraviolet disinfection system was complete.

2.1.4 Recycled Water Plant (1975 – present)

In 1975, the Santa Clara Valley Water District (SCVWD) constructed an advanced reclamation facility. Recycled water use at Mountain View's Shoreline Golf Course (Shoreline Golf Links) began in 1980 (but was suspended in 2001 due to failure of the recycled water pipeline). In 1986, SCVWD transferred operations to the RWQCP. Palo Alto continued to operate the facilities for landscape irrigation in Mountain View. In 1990, recycled water distribution was extended to Greer Park from the existing line. In 1992, the Water Reclamation Master Plan (WRMP) was prepared. In 1993, a distribution line was extended to Palo Alto's Municipal Service Center (MSC) yard and a new pipeline was installed to the Palo Alto Golf Course. Then, in 2008 the recycled water pump station was upgraded and a distribution system was built to supply new customers in Mountain View. The goal of the new pump station and pipeline was to deliver 1,503 acre-feet per year (or 489 million gallons per year). As of February 2012, the recycled water system was delivering 39 percent of this goal.

In 2009, a new pipeline was installed to serve recycled water to Greer Park, Shoreline Park (and Golf Course) in Mountain View, and other landscape irrigation customers in the North of Bayshore business area of Mountain View. In 2010, construction of the advanced ultraviolet disinfection system was complete, which increased potential recycled water treatment capacity by 6 mgd. An Environmental Impact Report (EIR) is currently being developed for Palo Alto's Stanford Research Park area as part of Phase 3 of the recycled water program identified in the 2008 Recycled Water Facility Plan (RWFP) for the Palo Alto RWQCP.

2.2 PARTNERS AND SERVICE AREA

The RWQCP partner agencies (Partners) include the Cities of Palo Alto, Mountain View (including some flow from Moffet Field) and Los Altos, the Town of Los Altos Hills, East Palo Alto Sanitary District (EPASD), and Stanford University. Flow capacity rights for the RWQCP and 72-inch joint intercepting sewer have been allocated to each of the partner agencies based on an agreement signed in 1968. In Table 2.1, the flow capacity rights assigned to each partner agency are shown – average annual flow for the RWQCP and peak wet weather flow for the 72-inch joint intercepting sewer.

Table 2.1 Average Partner Flow into the RWQCP and 72-inch Joint Intercepting Sewer Wet Weather Flow Capacity Rights

City	RWQCP Average Annual Flow Capacity Rights (mgd)	72-inch Sewer Peak Wet Weather Flow Capacity Rights (mgd)
Mountain View	15.1	50
Los Altos	3.8	12
Palo Alto [(1)]	15.3	14.59
East Palo Alto [(2)]	3.06	0
Los Altos Hills	0.63	3.41
Stanford University [(2)]	2.11	0
Total	40.0	80

Notes:

(1) A portion of Palo Alto sewage discharges to the 72-inch diameter interceptor sewer.

(2) EPASD and Stanford University discharge into the final manholes of the 72-inch diameter joint intercepting sewer, but they did not contribute to the original construction cost of the trunk-line sewer. A small proportionate cost of any rehabilitation may be required by EPASD and Stanford University.

The RWQCP service area including the boundaries of each of the partner agencies is shown in Figure 2.2.

2.3 ENVIRONMENTAL SETTING AND LAND USES

This section provides a brief description of the environmental setting of and land uses adjacent to the Palo Alto RWQCP. It is important to consider the setting surrounding the RWQCP as any improvements recommended by this Plan could result in construction activity at the RWQCP. Therefore, it is important to consider what are the potential beneficial uses of the area that could

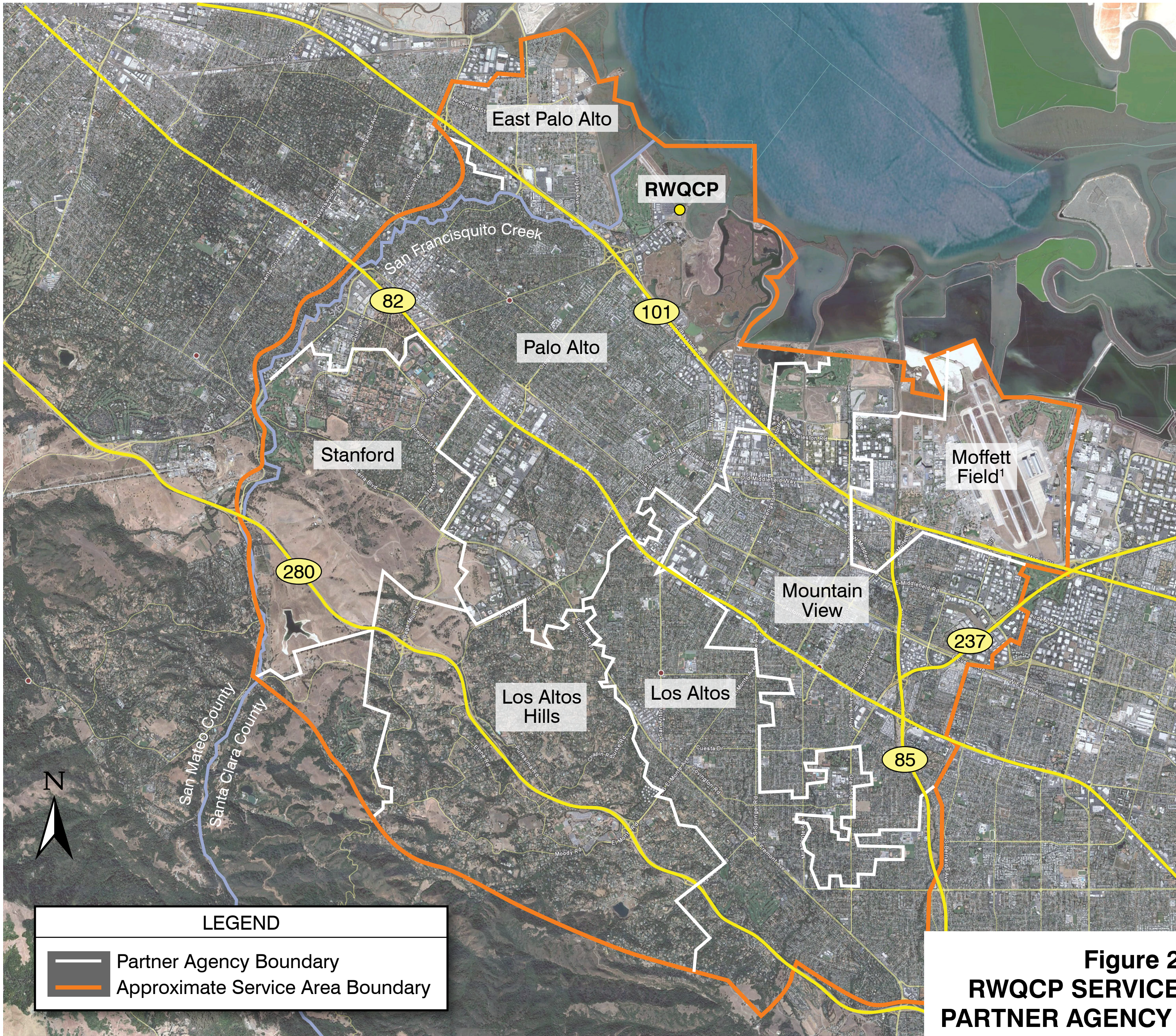


Figure 2.2
RWQCP SERVICE AREA AND PARTNER AGENCY BOUNDARIES
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

NOTE:
1. Included in Mountain View's contribution.

pa412f16-8510.ai

be impacted by a construction project or on-going operation of the RWQCP. A more detailed discussion of the environmental setting and land uses, including biology of the Palo Alto Baylands is included in Appendix A.

2.3.1 Palo Alto Baylands Setting

The *Baylands* is one of the largest expanses of tidal salt marsh currently remaining in San Francisco Bay. Historically the Baylands were a small part of a vast contiguous marshland that stretched from what is now San Mateo to Hayward. This once contiguous habitat has been fragmented by conversion to salt ponds and development, leaving only “islands” of tidal marsh. The loss of 85 to 90 percent of the original marshlands around the Bay increases the importance of the Palo Alto Baylands.

The Palo Alto Baylands provide a very diverse setting for the RWQCP as shown in Figure 2.3. Embarcadero Road, a four-lane boulevard that passes through a small commercial area and research office park before paralleling the southern edge of the municipal golf course, approaches the RWQCP from Highway 101. At Embarcadero Way, the entrance to the golf course and regional airport are on the left and the RWQCP entrance is to the right. Embarcadero Road continues along the north side of the RWQCP to an intersection with Harbor Road. Harbor Road defines the eastern edge of the RWQCP and the airport, and is the extent of current landward development in the Baylands. Historically, the harbor was across Harbor Road from the RWQCP, but it was closed in 1986 due to the high cost of dredging. Much of the Baylands area surrounding the RWQCP is salt marsh in varying degrees of naturalization.

South of the RWQCP is Byxbee Park and former landfill area, the former ITT Property with the Emily Renzel Marsh, backed up by the Flood Basin of the Natural Unit shown in Figure 2.4. A lease access is maintained to the ITT Property from East Bayshore Road. Both the ITT Property and the former landfill area are part of Byxbee Park. In 2010, Palo Alto began accelerating conversion of phase IIc of the landfill so this part of Byxbee Park could be opened. On July 28, 2011, the landfill closed permanently. Final capping, restoration planting, and trail construction will take an additional year to complete the conversion from landfill to parkland. The entire area south of the plant is Byxbee Park with the exception of 10 acres that were undedicated in a public election process in November of 2011 to be able to consider the siting of an energy/compost facility on the 10 acres. A new 36-acre section of the Byxbee Park was opened in July of 2011 for recreation, as well as another 10 acres in December 2011, and by 2013 an additional 51 acres will be opened (City of Palo Alto, 2011).

Figure 2.3
PALO ALTO BAYLANDS MAP
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa412f22-8510.ai

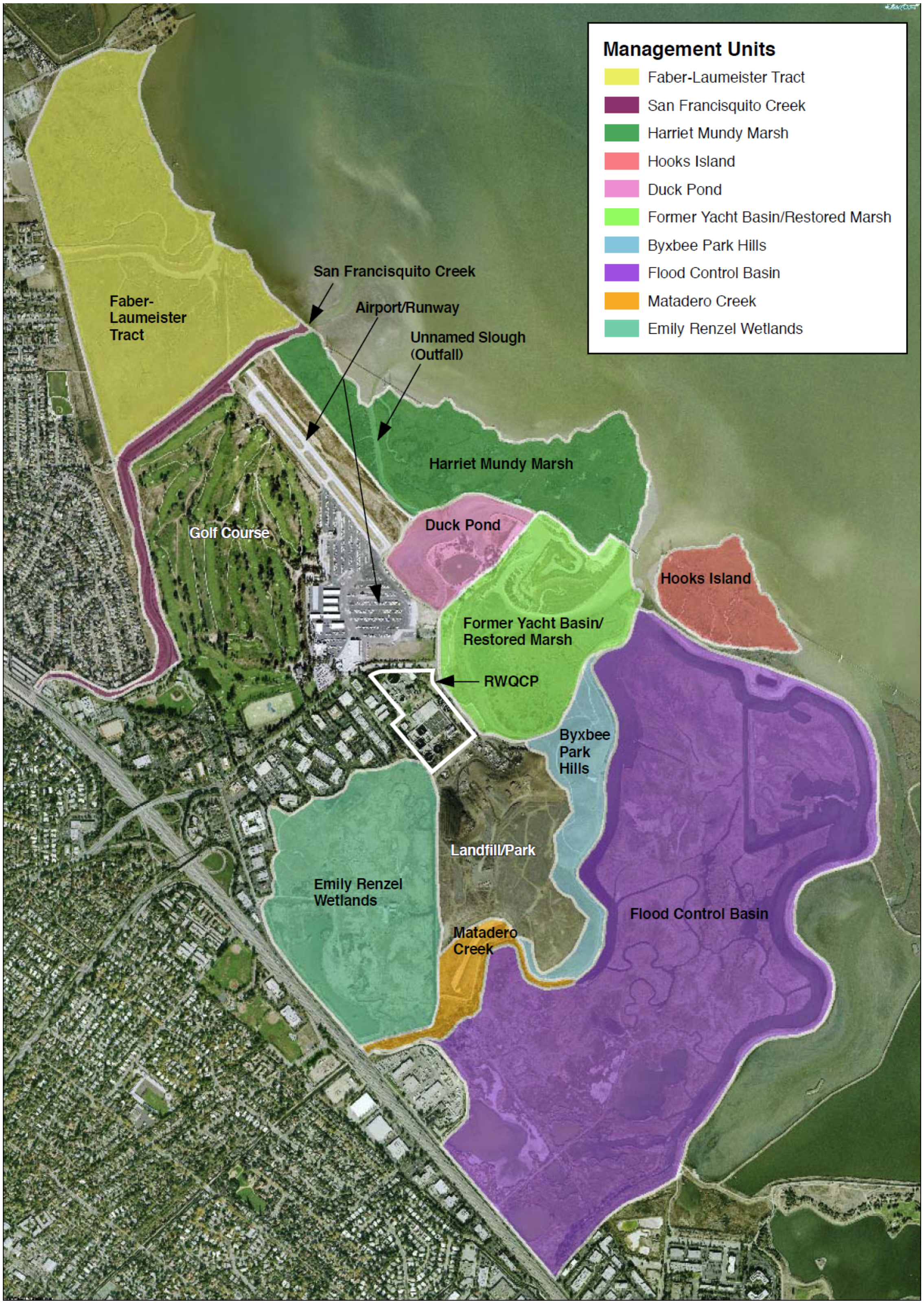


Figure 2.4
PALO ALTO BAYLANDS MANAGEMENT UNITS
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

2.3.1 Biological and Regulatory Setting

The RWQCP site does not currently support any natural plant communities, though landscaping with native plant materials and a wildlife corridor on the southern perimeter (near Byxbee Park) are currently being developed. The salt marshes to the east of the RWQCP (across Harbor Road) are abundant in wildlife diversity. The Palo Alto Baylands contain some of the most productive and densely populated marshlands in the Bay Area for the endangered California clapper rails and the mudflats along the Bay margin provide important feeding and resting habitat for shorebirds. Stream and riparian habitat benefit anadromous fishes, amphibians, small mammals, and birds. The marshes may also provide habitat for the endangered salt marsh harvest mouse. Migratory waterfowl and shorebirds, raptors, and a diversity of songbirds are also common in these marshes.

A total of 44 special-status plant species are known to occur within the project vicinity. Of these species, eight species have the potential to occur within the project area and 36 species are not likely to be on the project site due to lack of habitat, elevation requirements, and/or the site is geographically removed from the species range.

There are ten special-status wildlife species observed near the project area including: Monarch butterfly, Pallid bat, Hoary bat, Yuma myotis bat, Burrowing owl, Cooper's hawk, Northern harrier, White-tailed kite, Black-crowned night heron, and Great blue heron. Special-status species and other species of concern are protected under several statutes. The Federal Endangered Species Act (FESA) requires consideration of whether a project would potentially have significant impacts on any federally listed species or their critical habitat. Species listed as threatened or endangered under California Endangered Species Act (CESA) must also be evaluated for potentially significant impacts.

Trees within the project area are subject to regulation under Title 8 of the City of Palo Alto Municipal Code, which protects specific trees on public or private property from removal or disfigurement. The City's *Tree Technical Manual: Standards and Specifications* (City of Palo Alto, 2001) establishes procedures and standards for the purpose of encouraging the preservation of trees.

2.4 OVERVIEW OF THE LRFP PROCESS

The RWQCP prepared a Long Range Plan in 1966. The RWQCP has not prepared a comprehensive planning document for its facilities since the time of the 1966 Long Range Plan. The LRFP is the plant's first formal planning effort since that plan; the planning horizon is 50 years (through 2062). The RWQCP is facing several key issues: 1) aging infrastructure, 2) increasing regulatory requirements, and 3) increasing public interest in finding alternatives to the existing solids incineration process. For these reasons, the City decided to embark upon a planning process to look at the long-term needs for the RWQCP facility to continue to provide reliable treatment and satisfy regulations. To do this, the LRFP must determine the future needs (flows and loads), assess the existing facilities capacity, condition and deficiencies, estimate future regulatory scenarios that require additional treatment, develop alternatives for both solids and liquid treatment processes, develop layouts for whole plant scenarios (leaving room for potential future facilities), and develop recommendations and a financial plan for implementation.

The main scope elements for the LRFP and associated chapters of this report are as follows:

- Historical and Projected Flows and Loads – Chapter 3
- Existing Facilities and Capacity Evaluation – Chapter 4
- Existing Plant Assessment – Chapter 5
- Regulatory Requirements (Existing and Future) – Chapter 6
- Solids Treatment Alternatives Development & Screening – Chapter 7
- Liquid Treatment Alternatives Development & Screening – Chapter 8
- Recommendations and Implementation Plan – Chapter 9

2.5 DECISION PROCESS AND EVALUATION CRITERIA

The purpose of this section is to describe the systematic process by which the preliminary LRFP project alternatives (both solids and liquids) were developed, evaluated, and eventually combined to create viable treatment scenarios for the LRFP. This process consisted of five basic steps described in this section, and is illustrated in Figure 2.5.

1. Establish "Long Term Goals"
2. Establish evaluation criteria
3. Initial qualitative screening
4. Detailed alternative evaluation
5. Prioritization and presentation of recommendation to the public

Each step of the process is described in the following sections. The goals were largely set by previous efforts and presented at the first public workshop. The LRFP project team created a preliminary list of minimum project alternative requirements and evaluation criteria during three meetings and presented these and the overall decision process to stakeholders during the third public workshop.

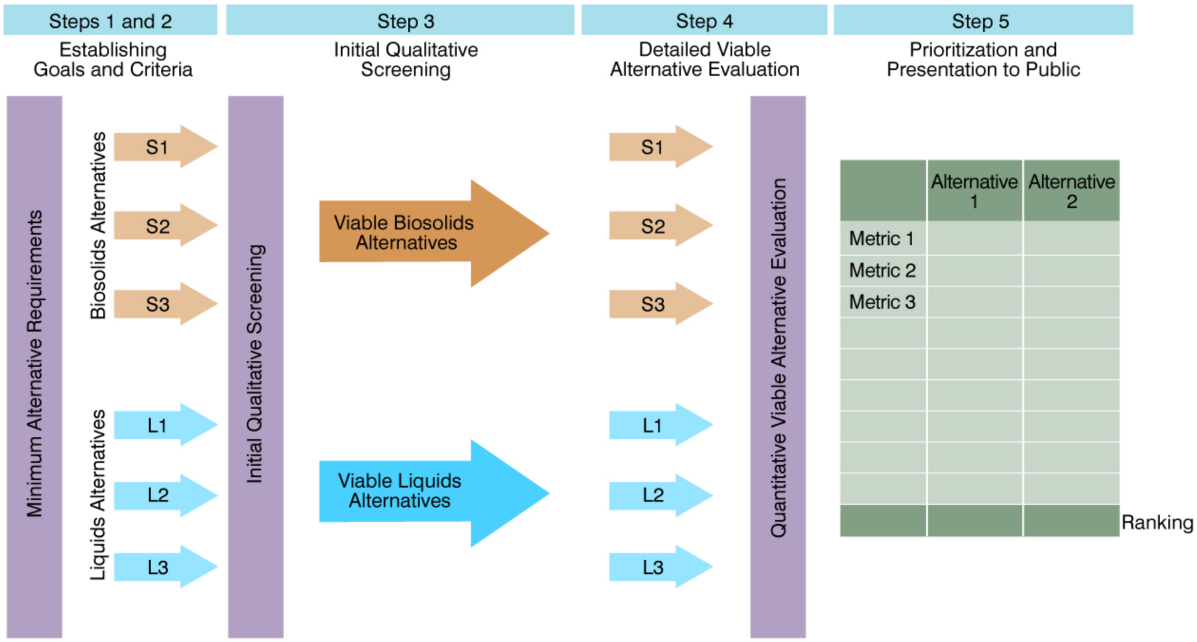


Figure 2.5 Project Alternatives Evaluation and Prioritization Process

2.5.1 "Long Term Goals"

A Long Term Goals (LTG) study was conducted in 2001 with extensive input from the community and other stakeholders. That effort identified 14 LTGs to guide future RWQCP planning efforts. The RWQCP staff proposed four additional LTGs and the LRFP project team proposed two additional LTGs. The complete list of LTGs used in the LRFP process was presented at the first stakeholder workshop held in December 2010. The LTGs are as follows:

1. Meet Future Capacity Needs
2. Meet or Exceed Regulatory Requirements
3. Minimize or Eliminate Toxins in the Influent (e.g. dioxin)
4. Minimize Energy Consumption and Maximize Energy Life Cycle Efficiency
5. Minimize or Eliminate Potentially Hazardous Chemical Usage
6. Minimize or Eliminate Total Release of Toxins to the Environment
7. Minimize Impact on Ecosystem
8. Minimize Impacts on Community, Including Neighboring Communities
9. Minimize or Justify Financial Impacts on Ratepayer

10. Involve Stakeholders in the Decision Making Process
11. Immobilize or Beneficially Reuse Persistent Toxins
12. Take Leadership Role in Promoting Beneficial Reuse and Environmental Enhancement
13. Maximize Worker Safety
14. Maximize Recycled Water as a Supplemental Water Source
15. Minimize the Plant's Life Cycle Greenhouse Gas Emissions
16. Address Climate Change and Sea Level Rise
17. Minimize Recycled Water Salinity
18. Treat Biosolids with Other Organic Waste Streams, Where Practical
19. Provide Reliable, Safe Treatment Now and in Future
20. Maintain and Improve an Efficient Municipal Infrastructure

The development and selection of evaluation criteria used throughout the evaluation process stems from and is in support of the LTGs.

2.5.2 Evaluation Criteria and Minimum Alternative Requirements

The LRFP project team created a preliminary list of minimum project alternative requirements and evaluation criteria during three meetings and presented it to stakeholders during the third public workshop held in May 2011. As shown in Figure 2.5 there is a stepwise process for evaluating alternatives. The complete list of criteria is provided in Table 2.2.

While the evaluation criteria were being developed and selected, the solids and liquids alternatives were also developed. The Minimum Alternative Requirements subset of evaluation criteria were used in the early development of solids and liquids alternatives. These criteria must be satisfied by any solids and liquids alternative in order to be considered in the next stage of evaluation.

The list of minimum alternative requirements is as follows:

- Meet projected influent flow
- Address sea level rise
- Meet projected discharge flow/outfall capacity
- Meeting existing regulatory requirements

Table 2.2	Evaluation Criteria Used to Evaluate Alternatives	
	Evaluation Criteria	**Units of Measure (Metrics)**
Costs	Life cycle costs (Capital and O&M)	• $
	Residential sewer rate	• $ • % increase
	RW users cost recovery	• $
	Eligible funding/grants opportunities	• $ • # eligible
Treatment	Process performance/ efficiency	• relative stability to flow/load variations (qualitative)
	Extend useful life	• # years or qualitative
	Efficient site layout	• acres or qualitative
	Constructability (complexity)	• ability to phase the project & maintain operations (qualitative)
	RW quality	• mg/L of TDS, Na, & TN
Community/ Neighbors (Local)	Noise	• ability/$ to mitigate, qualitative
	Odor	• ability/$ to mitigate, qualitative
	Visual	• height of structures, qualitative
	Truck traffic	• # of truck trips
	Air quality	• compared to local air permit limits
	Landscaping	• number of trees removed
Environment	Overall water quality discharged to the Bay	• mg/L • technology-based removal (qualitative)
	Air quality	• compared to local air permit limits
	Purchased or generated electricity	• kWh • Btu
	GHG emissions	• metric tons CO_2e
	Onsite chemical use	• lbs/year by chemical
	Immobilize toxins	• yes/no (qualitative)
	Waste diversion	• dry tons/yr solids landfilled

2.5.3 Initial Qualitative Screening

An initial qualitative screening step was completed to help narrow down the list of alternatives to those that are viable. A subset of the evaluation criteria were used to screen (eliminate) any solids and liquids alternative that is not viable for the RWQCP operations and site footprint. The criteria for this step are organized into four categories – treatment, community/neighbors, environment, and cost. The result of the evaluation is a shorter list of viable solids and liquids treatment alternatives that can be combined to form viable solids/liquids treatment scenarios for a more detailed evaluation.

The initial qualitative screening of the solids and liquids treatment alternatives was done using the matrices shown in Figures 2.6 and 2.7, respectively. The matrices show the criteria organized into the four categories with the alternatives listed in the left-most column. The LRFP project team (i.e., RWQCP staff and Carollo) held a meeting to qualitatively screen the solids and liquids treatment alternatives based on these criteria. The project team reviewed the list of alternatives and filled in the matrices by providing the reasoning for whether each did or did not satisfy each screening criteria. Then a summary matrix (example shown in Figure 2.8) was created showing how well each alternative satisfied the overall categories. The resulting matrices for the initial comparison of solids and liquids treatment alternatives are provided in Chapters 7 and 8, respectively.

2.5.4 Viable Alternative Evaluation

The viable alternative evaluation is a more detailed evaluation than the initial qualitative screening since there are additional criteria in each of the four categories (shown in Table 2.2) and the evaluation is a mix of qualitative and quantitative analyses. The units of measure (metrics) for each criterion are listed in Table 2.2. It is noted when the evaluation of a unit of measure is qualitative. The criteria are used to evaluate how well each viable treatment scenario satisfies the LTGs.

Results of the detailed evaluations were presented at the fourth and fifth stakeholder workshops for solids and liquids alternatives, respectfully. The slides used in these workshops that presented the results of the evaluation are included in Appendix B. As some of the initial list of criteria summarized in Table 2.2 were not actually differentiators for the alternatives considered, not all the criteria were used in the presentation of the comparison of alternatives.

2.5.1 Prioritization and Presentation to the Public

The result of the alternatives evaluation is a comparison and prioritization of projects and alternatives based on their overall scores. The prioritization and overall recommendations were presented to the public for their opinion and feedback at the fifth stakeholder workshop.

Alternative	***Treatment***			***Environment***		***Community/ Neighbors***		***Cost***	
	Footprint	**Flexibility (for future regs)**	**Proven Technology**	**Energy**	**Air Quality**	**Visual**	**Odors**	**Capital**	**Life Cycle**
Alternative 1									
Alternative 2									
Alternative 3									
Alternative 4									

Figure 2.6 Initial Qualitative Screening Matrix and Criteria for Solids Alternatives

Alternative	***Treatment***			***Environment***		***Community/ Neighbors***		***Cost***	
	Footprint (to meet TN<3)	**Flexibility (for future regs)**	**Proven Technology**	**Energy**	**Chemicals**	**Visual**	**Odors**	**Capital**	**Life Cycle**
Alternative 1									
Alternative 2									
Alternative 3									
Alternative 4									

Figure 2.7 Initial Qualitative Screening Matrix and Criteria for Liquids Alternatives

Alternative	Treatment	Environment	Community/ Neighbors	Cost
Alternative 1	●	○	●	◒
Alternative 2	◒	◒	●	○
Alternative 3	◒	○	◒	○
Alternative 4	○	○	●	○

Figure 2.8 Example Resulting Matrix from the Initial Qualitative Screening Process

2.6 STAKEHOLDER PROCESS

The City established a public workshop process as part of this LRFP to solicit input from the stakeholders and partner agencies. Five (5) stakeholder workshops were held during the LRFP development to provide an opportunity for interested parties to provide their input and/or feedback throughout the LRFP process. The workshop topics are listed below in chronological order and were publicly advertised on the City's website a minimum of two weeks prior to the scheduled meeting.

- Introduction and Goals (October 27, 2010)
- Biosolids Options (February 9, 2011)
- Decision Process and Criteria/Liquid Treatment/ Recycled Water (May 4, 2011)
- Biosolids Alternatives (November 16, 2011)
- Liquid Treatment Alternatives and Overall Recommendations (March 1, 2012)

Presentation materials used for each workshop and notes taken to capture public input were also posted on the City's website and are included in Appendix B. Appendix B also contains presentation materials used during a Palo Alto City Council Study Session held May 7, 2012 on the results of this LRFP.

2.7 TECHNICAL ADVISORY GROUP REVIEW

The City arranged for a Technical Advisory Group (TAG) to meet with the LRFP project team to offer their knowledge and opinions related to new or prospective technologies that might be of use to the RWQCP. The TAG was comprised of two local professors – Craig Criddle and Perry

McCarty of Stanford University. Professors Criddle and McCarty made public presentations to the City at Stanford University on April 25, 2011. The ideas presented were included in the considerations for alternatives for liquid and solids treatment, presented in Chapters 7 and 8, respectively.

2.8 MEETING WITH THE PARTNERS

The City met with the partner agencies on November 10, 2011 to discuss the preliminary findings of the LRFP and in particular the remaining useful life and capacity of the incinerators. A second meeting was held on April 23, 2012. This meeting reviewed the overall LFRP recommendations, the impact to the rates, and cost sharing allocations of the recommended CIP to the partners.

Chapter 3

HISTORICAL AND PROJECTED FLOWS AND LOADS

The purpose of this chapter is to project the wastewater flows and loads that are expected at the Palo Alto Regional Water Quality Control Plant (RWQCP). Historical population and wastewater flows and loads are summarized and used to project future flows and loads through 2062. This chapter also presents projections of recycled water flows based on anticipated demands. These projections allow the City to identify and plan for new wastewater treatment plant infrastructure needed in the future.

3.1 BACKGROUND

The Palo Alto RWQCP treats domestic, commercial, and industrial wastewater from the cities of Mountain View, Palo Alto and Los Altos, the Town of Los Altos Hills, East Palo Alto Sanitary District and Stanford University (the partners). The service area covers approximately 37,800 acres and includes a residential population of approximately 217,000 people. The community served by the Plant is composed primarily of low-density residential housing. In addition, there are several industrial areas and commercial districts within the service area. Figure 3.1 shows the service area. Note that not all the area within the boundary shown for Stanford University sends flow to the RWQCP – this is accounted for in the flows and loads data. For the most part, the service area has been fully developed and major increases in population or industrial flows are not anticipated at this time. Recent decades have seen a trend towards high-density infill and the conversion of under-utilized light industrial and commercial properties into residential and mixed commercial residential. There has also been a shift from manufacturing to office space, software, and research and development facilities. In the last few years, several larger industrial facilities have left the service area including a centralized hazardous waste treatment facility, Romic Environmental Technologies Inc., as well as metal finishing facilities including Sanmina, Meta Technologies, and Technitron (City of Palo Alto, 2010).

3.2 HISTORICAL POPULATION, FLOWS, AND LOADS

Approximately six years of data from the RWQCP (January 1, 2005 - August 31, 2010) was analyzed to evaluate historical influent flows and loadings. Average Dry Weather Flow (ADWF), representing the lowest consecutive three-month average during the months of June through October, was analyzed to evaluate the per capita ADWF. Per capita flow and load values are used to project future flows and loads as discussed in Section 3.4. Table 3.1 summarizes the historical flows and loads.

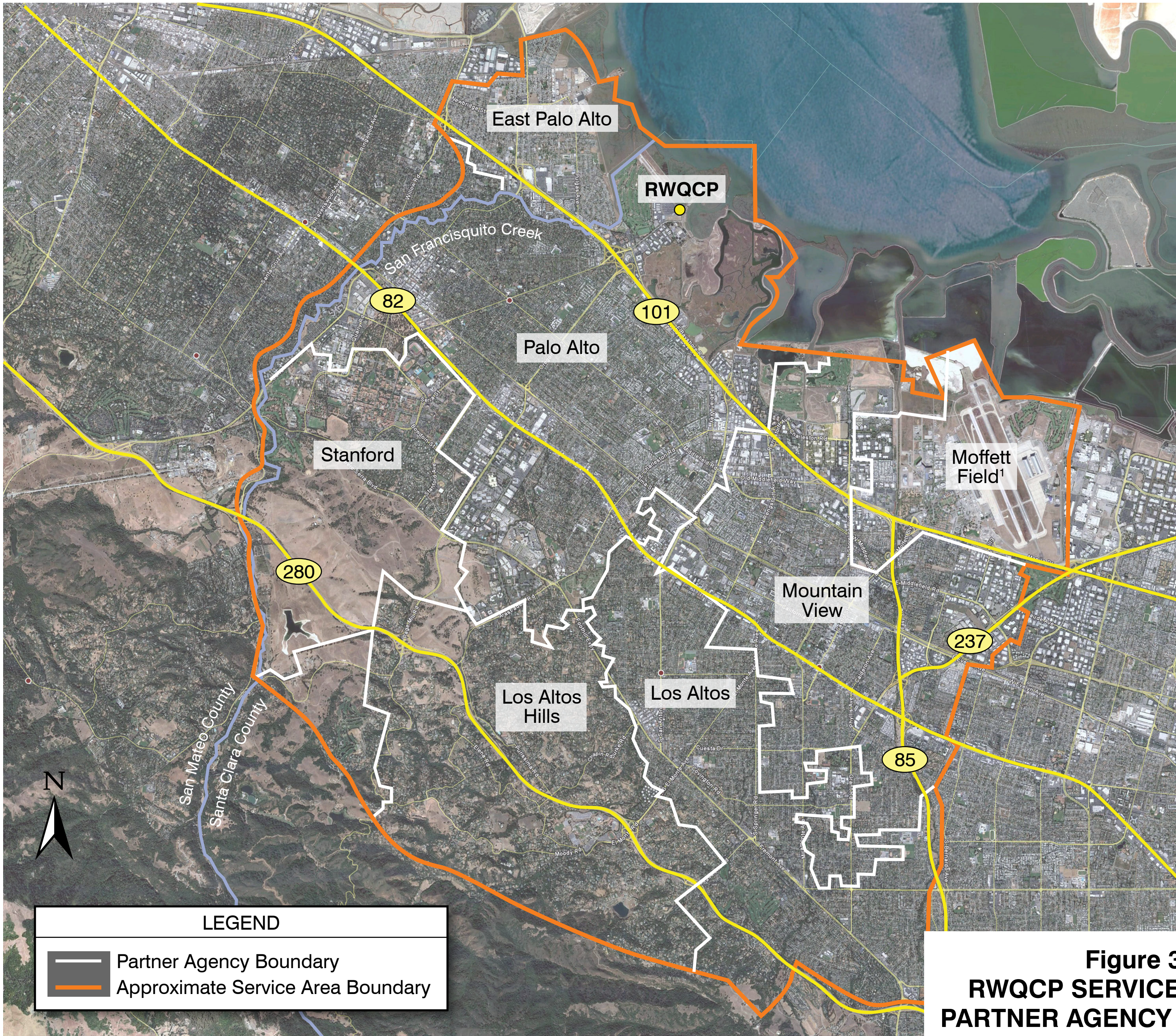


Figure 3.1
RWQCP SERVICE AREA AND PARTNER AGENCY BOUNDARIES
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

NOTE:
1. Included in Mountain View's contribution.

pa412f17-8510.ai

Table 3.1	**Historical Average Dry Weather Influent Flows, Loads, and Concentrations[1]**						
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**Average**
ADWF (mgd)	24.2	24.2	22.9	21.0	21.1	21.9	22.5
BOD[2] loading (ppd)	47,208	43,506	48,541	45,266	44,449	45,622	45,765
BOD[2] concentration (mg/L)	233	216	254	258	252	250	243
TSS[3] loading (ppd)	43,846	42,268	39,590	42,687	38,904	41,044	41,390
TSS[3] concentration (mg/L)	217	209	207	243	221	225	220
Ammonia loading (ppd)	4,751	4,895	5,638	4,993	5,178	5,721	5,196
Ammonia concentration (mg/L)	23	24	30	28	29	31	28

Notes:
(1) Average dry weather influent flow and load includes residential and commercial contributions from Palo Alto and its partners over the lowest three consecutive months from June to October.
(2) BOD: biochemical oxygen demand.
(3) TSS: total suspended solids.

Figures 3.2 and 3.3 illustrate the historical influent flow and loading trends. The historical flow trend, Figure 3.2, shows that the ADWF has been continuously decreasing over the period 2005 to 2009. This could be due to a reduction and shift in commercial activity in the service area, stemming from the current economic recession as well as recent conservation efforts by the City and its Partners. In Figure 3.3, the BOD, TSS, and ammonia loading trends show that the loadings have steadily increased over the period. This coupled with the reducing flows would indicate that the water conservation efforts implemented by the City and its Partners have been successful.

Per capita values of ADWF and loads were calculated using estimated historical populations and historical influent flow and load values from RWQCP data. For each partner agency population estimates from the California Department of Finance (DOF) were compared to estimates from the Association of Bay Area Governments (ABAG) and the U.S. Census (shown in Table 3.2). The 2010 U.S. Census shows a lower total population (217,331) for the service area than the DOF (223,616), and is more in line with the ABAG estimates. Therefore, the historical population estimates used to determine per capita values are based on the 2009 ABAG projections and the 2010 U.S. Census estimates (interpolating the years in between). The average of per capita values over the last six years was subsequently used for dry weather projections into the future. Table 3.3 shows the dry weather flow and load per capita values.

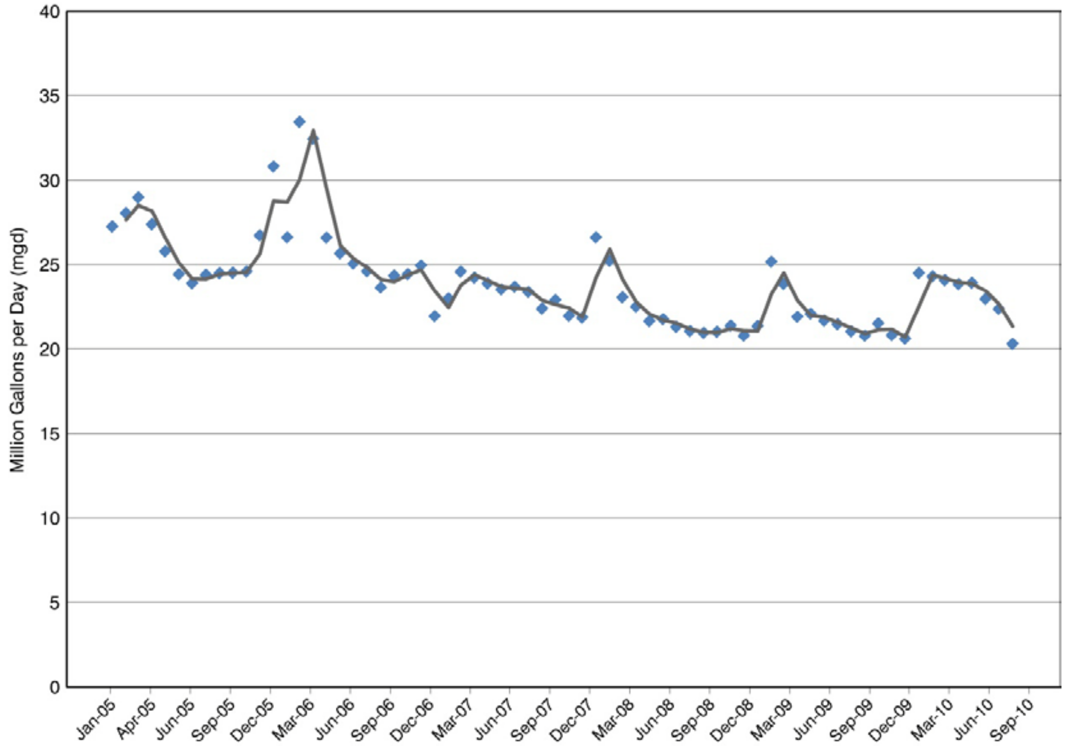


Figure 3.2 Historical Average Monthly Influent Flows

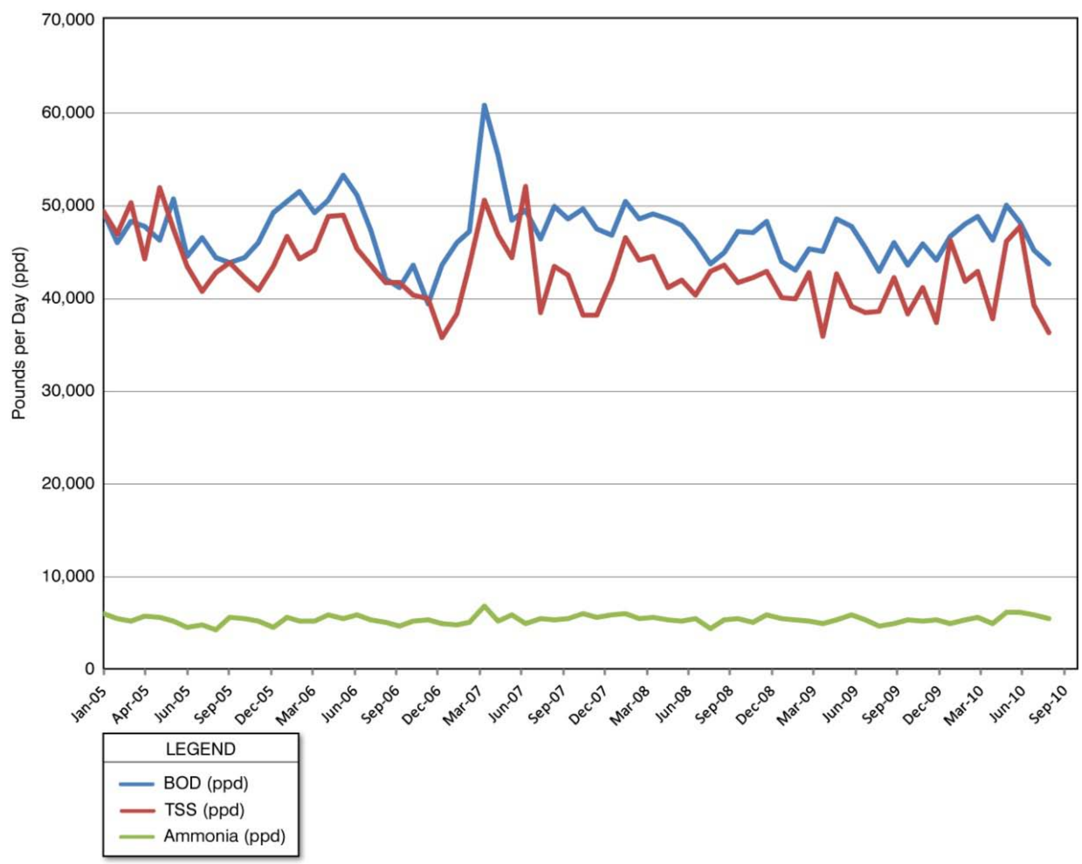


Figure 3.3 Historical Average Monthly Influent BOD, TSS, and Ammonia Loads

Table 3.2 Historical Populations Per Partner Agency

	2005	2006	2007	2008	2009	2010
California Department of Finance Estimates						
East Palo Alto	32,080	32,034	32,386	32,779	33,164	33,524
Los Altos	27,513	27,584	27,941	28,165	28,457	28,863
Los Altos Hills	8,420	8,475	8,556	8,799	8,890	9,042
Mountain View	71,770	71,934	72,829	73,598	74,758	75,787
Palo Alto (with Stanford) (1)	75,500	76,756	77,517	78,963	80,975	76,400
TOTAL	**215,283**	**216,783**	**219,229**	**222,304**	**226,244**	**223,616**
Association of Bay Area Governments and U.S. Census						
East Palo Alto	32,200(2)					28,155(4)
Los Altos	30,200(2)					28,976(4)
Los Altos Hills	10,100(2)					7,922(4)
Mountain View	71,900(2)					74,066(4)
Palo Alto (with Stanford) (1)	75,500(2)					78,212(4)
TOTAL	**219,900**(2)	**219,386**(3)	**218,872**(3)	**218,359**(3)	**217,845**(3)	**217,331**(4)

Notes:
(1) Stanford University's residential student population is included in this estimate; however, the transient student population was not included as historical data were not available.
(2) Based on 2009 ABAG Projections.
(3) Interpolated value between the 2005 and 2010 total service populations.
(4) Based on 2010 U.S. Census.

Table 3.3 Historical Average Dry Weather Per Capita Flows and Loads(1)

	2005	2006	2007	2008	2009	2010	Average
ADWF (gpcd(2))	110	110	105	96	97	101	103
BOD loading (ppcd(3))	0.21	0.20	0.22	0.20	0.20	0.20	0.21
TSS loading (ppcd(3))	0.20	0.19	0.18	0.20	0.18	0.19	0.19
Ammonia loading (ppcd(3))	0.022	0.022	0.026	0.023	0.024	0.026	0.024

Notes:
(1) Average dry weather influent flow and load includes residential and commercial contributions from Palo Alto and its partners over the three lowest consecutive months from June through October.
(2) gpcd: gallons per capita per day.
(3) ppcd: pounds per capita per day.

Average Annual, Maximum Month, Maximum Day, and Peak Hour Wet Weather conditions were also analyzed for the same 2005 to 2010 period. Table 3.4 presents the historical flow peaking factors for the 2005 to 2010 period. The average ratio of average annual flow (AAF) to ADWF is 1.06 and is used for projecting the AAF in future years. Similarly, peaking factors for maximum month flow and loads are used to project future influent flows and loads. Hourly data from the two wettest years (2006 and 2009) were analyzed for peak hour wet weather flow (PHWWF). The PHWWF during each event (67.6 and 64.3 mgd, respectively) did not exceed the rated wet weather design capacity of 80 mgd.

Table 3.4 Historical Flow Peaking Factors

	2005	2006	2007	2008	2009	2010	Average
ADWF[(1)] (mgd)	24.2	24.2	22.9	21.0	21.1	21.9	22.5
AAF[(2)] (mgd)	25.9	26.9	23.1	22.3	21.9	23.3	23.9
AAF/ADWF	1.07	1.11	1.01	1.06	1.03	1.06	1.06
ADMMF[(3)] (mgd)	29.0	33.4	24.6	26.6	25.2	24.5	27.2
ADMMF/ADWF	1.20	1.38	1.07	1.27	1.19	1.12	1.20
PHWWF[(4)] (mgd)	N/A	67.6	N/A	N/A	64.3	N/A	66.0
PHWWF/ADWF	N/A	2.7	N/A	N/A	3.0	N/A	2.9

Notes:
(1) ADWF: average dry weather flow
(2) AAF: average annual flow
(3) ADMMF: average day maximum month flow
(4) PHWWF: peak hour wet weather flow

Table 3.5 presents the historical peaking factors for both flow and loads for the ADMMF condition. Also presented in Table 3.5 is the maximum peaking factor that has occurred since 2005, which is used to project the future maximum month flows and loadings.

Table 3.5 Historical Maximum Month to Average Dry Weather Peaking Factors

	2005	2006	2007	2008	2009	2010	Maximum
Total Influent Flow	1.20	1.38	1.07	1.27	1.19	1.12	1.38
BOD loading	1.07	1.22	1.25	1.11	1.09	1.10	1.25
TSS loading	1.18	1.16	1.31	1.09	1.10	1.16	1.31
Ammonia loading	1.23	1.19	1.18	1.17	1.11	1.06	1.23

3.3 PROJECTED POPULATION

The service area is a mix of residential, institutional, industrial, and commercial uses consisting of 217,331 residents and approximately 168,620 jobs in 2010. As mentioned previously, new growth in the service area is anticipated to be primarily infill development. The historic population served in Los Altos, Mountain View, and Palo Alto, the Town of Los Altos Hills, the East Palo Alto Sanitary District, and Stanford University was estimated using ABAG data for 2009 and U.S. Census data for 2010. Future population for each City was determined using ABAG projections.

Table 3.6 presents the current population estimates and projected populations for the RWQCP service area.

Table 3.6 Historic and Projected Populations Served by the RWQCP

	2010(2)	2020(3)	2040(4)	2060(4)	2062(4)
East Palo Alto	28,155	37,100	45,200	52,800	53,560
Los Altos	28,976	31,600	32,800	33,600	33,680
Los Altos Hills	7,922	10,400	10,800	11,200	11,240
Mountain View	74,066	81,400	95,200	108,400	109,720
Palo Alto (with Stanford)(1)	78,212	86,100	104,600	120,200	121,760
Total Population Served	**217,331**	**246,600**	**288,600**	**326,200**	**329,960**

Notes:
(1) Stanford University's transient student population was not included in this population estimate since historic data were not available.
(2) U.S. Census 2010 estimates.
(3) Based on 2009 ABAG projections.
(4) Extrapolated assuming an additional 9,400 people every 5 years.

3.4 PROJECTED FLOWS AND LOADS

This section establishes the projections for flow and loads for both dry weather and wet weather conditions to build-out in 2062.

3.4.1 Projections Based on Per Capita Flows and Loads

Using the historical flow and load data and the population projections presented in Section 3.3, projections for flows and loads were made into the future through 2062. A moderate rate of residential and commercial growth is predicted by the partner Cities' General Plans and based on ABAG projections. The projected increases in ADWFs are shown in Table 3.7 along with the projected loads and concentrations for the RWQCP. These projections were calculated by multiplying ABAG population projections by the historical average per capita flows and loads and using the historical peaking factors for maximum month and annual average projections.

Table 3.7 Projected Service Area Flows, Loads, and Concentrations (based on Per capita Values and ABAG projections)

	Current (2005-2010 Average)	2020	2040	2060	2062
Flows					
Per capita ADWF (gpcd)	103	103	103	103	103
ADWF (mgd)	22.5	25.4	29.8	33.6	34.0
AAF (mgd)(1)	23.9	27.0	31.6	35.7	36.1
ADMMF (mgd)(1)	27.2	30.7	35.9	40.6	41.1
Loadings(2)					
Average Dry Weather BOD (ppd)	45,765	51,624	60,416	68,287	69,074
Average Dry Weather TSS (ppd)	41,390	46,688	54,640	61,759	62,470
Maximum Month BOD (ppd)	52,256	58,945	68,984	77,972	78,870
Maximum Month TSS (ppd)	48,282	54,463	63,739	72,043	72,874
Concentrations(3)					
Average Dry Weather BOD (mg/L)	243	243	243	243	243
Average Dry Weather TSS (mg/L)	220	220	220	220	220
Maximum Month BOD (mg/L)	230	230	230	230	230
Maximum Month TSS (mg/L)	213	213	213	213	213

Notes:

(1) Calculated based on the AAF/ADWF ratio of 1.06, and ADMMF/ADWF ratio of 1.21.

(2) Based on the population projections multiplied by the historical average per capita flow and loads.

(3) Calculated based on projected flows and loads.

3.4.2 Partner Agency Projections

Recognizing that individual partners may have planned projects that could affect future wastewater flows (such as planned water conservation measures), each partner agency was contacted by RWQCP staff to get an update of their wastewater flow projections. Based on the planned expansion of the campus and the associated drinking water projections for the Stanford University community, they are estimating they may exceed their 2.11 mgd AAF wastewater treatment capacity limit as soon as 2022. The wastewater projections provided by Stanford University through the year 2035 are shown in Table 3.8.

The City of Mountain View provided projections of wastewater flows based on their 2010 Urban Water Management Plan (UWMP) and their 2010 Sewer System Master Plan (SSMP) through the year 2035. These projections from Mountain View included anticipated flow reductions resulting from planned conservation measures and are assumed to also reflect changes in their service area affecting water demands and wastewater flows.

Table 3.8	Projected Partner Agency Wastewater Flows in Million Gallons per Day					
	Current (2010)	**2015**	**2020**	**2025**	**2030**	**2035**
Stanford University[2]						
AAF	1.3	1.8	2.0	2.2	2.4	2.6
ADWF[1]	1.2	1.7	1.9	2.1	2.2	2.4
ADMMF[1]	1.4	2.1	2.3	2.5	2.7	2.9
Mountain View[3]						
AAF	7.9	9.3	10.8	11.0	11.1	11.3
ADWF[1]	7.5	8.8	10.2	10.4	10.5	10.7
ADMMF[1]	9.1	10.6	12.3	12.6	12.7	12.9
Palo Alto[4]						
AAF[1]	6.9	6.7	6.5	6.5	6.5	N/A
ADWF	6.5	6.3	6.1	6.1	6.1	N/A
ADMMF[1]	7.9	7.6	7.4	7.4	7.4	N/A
East Palo Alto Sanitary District[5]						
AAF	1.1	1.5	1.6	1.7	1.8	1.9
ADWF[1]	1.0	1.4	1.5	1.6	1.7	1.8
Los Altos/Los Altos Hills[6]						
AAF[1]	3.0	N/A	3.4	N/A	N/A	N/A
ADWF	2.9 [7]	N/A	3.2 [8]	N/A	N/A	N/A
ADMMF[1]	3.5	N/A	3.9	N/A	N/A	N/A

Notes:
(1) Calculated based on AAF/ADWF ratio of 1.06, and ADMMF/ADWF ratio of 1.21.
(2) Per communication with Stanford University.
(3) City of Mountain View 2010 Urban Water Management Plan and 2010 Sewer System Master Plan.
(4) City of Palo Alto 2011 Urban Water Management Plan.
(5) City of East Palo Alto 2010 Urban Water Management Plan.
(6) City of Los Altos 2005 Sanitary Sewer Master Plan.
(7) Estimate for 2002 from the 2005 SSMP not including flow from Mountain View.
(8) Estimate for build-out from the 2005 SSMP not including flow from Mountain View.

The City of Palo Alto Utilities (CPAU) department provided alternate influent wastewater flow projections through 2030 based on their 2011 UWMP as shown in Table 3.8. These flow projections reflect planned conservation efforts and code changes for plumbing associated with new construction.

While East Palo Alto Sanitary District's (EPASD) Sewer Master Plan was unavailable during the analysis, the 2010 UWMP provided wastewater flows for 2010 through 2035 as shown in Table 3.8. The City of Los Altos and Town of Los Altos Hills provided wastewater flows in their 2005 SSMP for 2002 and build-out in 2020, which are shown in Table 3.8.

Based on these flow projections provided by the partner agencies and CPAU, an alternative flow projection was developed for the RWQCP. It is assumed that the lower flow projections are due to conservation and the ADWF loadings will remain the same. Therefore, the concentrations are revised. Table 3.9 shows the alternate flow and loads projection for the RWQCP. Figure 3.4 shows both flow projections and represents the range of future flow scenarios that the RWQCP will need to plan for as part of the LRFP.

Table 3.9 Alternate Projections of Service Area Flows, Loads, and Concentrations (based on Partner projections, including planned conservation measures)

	Current (2005-2010 Average)	2020	2040(1)	2060(1)	2062(1)
Flows					
Per capita ADWF (gpcd)	103	99	91	86	87
ADWF (mgd)(2)	22.5	24.3	26.3	28.3	28.8
AAF (mgd)	23.9	25.8	27.9	30.0	30.5
ADMMF (mgd)(2)	27.2	29.4	31.8	34.3	34.8
Loadings(3)					
Average Dry Weather BOD (ppd)	45,765	51,624	60,416	68,287	69,074
Average Dry Weather TSS (ppd)	41,390	46,688	54,640	61,759	62,470
Maximum Month BOD (ppd)	52,256	58,945	68,984	77,972	78,870
Maximum Month TSS (ppd)	48,282	54,463	63,739	72,043	72,874
Concentrations(4)					
Average Dry Weather BOD (mg/L)	243	255	276	291	289
Average Dry Weather TSS (mg/L)	220	230	250	263	262
Maximum Month BOD (mg/L)	230	240	262	275	273
Maximum Month TSS (mg/L)	213	222	241	254	252

Notes:
(1) Projected based on trend of flows estimated for Palo Alto, Mountain View, Los Altos, and Stanford University from 2010 through 2035.
(2) Calculated based on the AAF/ADWF ratio of 1.06, and ADMMF/ADWF ratio of 1.21.
(3) Based on the population projections multiplied by the historical average per capita loads.
(4) Calculated based on projected flows and loads.

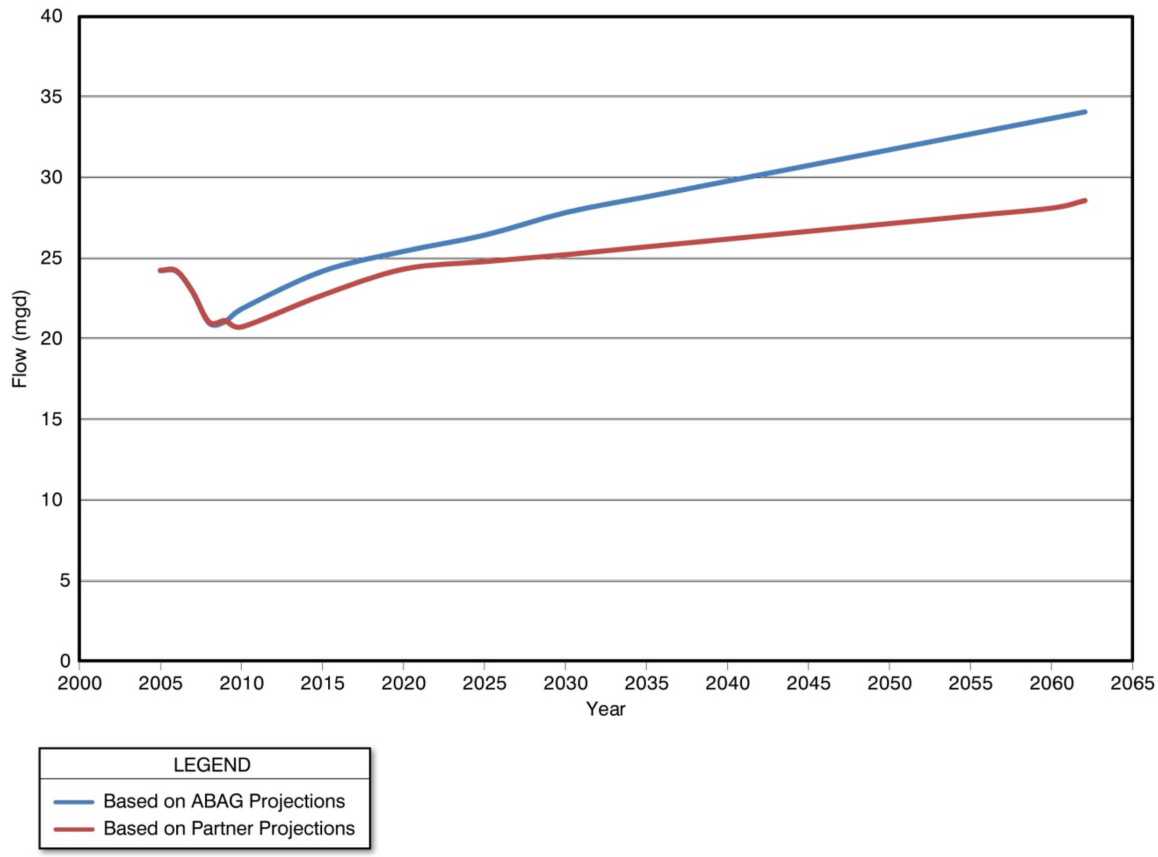


Figure 3.4 Existing and Projected Average Dry Weather Flow into RWQCP

3.4.3 Wet Weather Flow Projections

Wet weather flows are influenced by precipitation in the form of infiltration and inflow (I/I). The RWQCP has experienced several extreme wet weather events in the past 15 years. One extreme flooding event in February 1998 led to permitted bypasses and upstream flooding. The following sections describe the influences on I/I, which directly affect the RWQCP wet weather flows.

3.4.3.1 Collection System

The RWQCP service area consists of six partner agencies. Wet weather flows to the RWQCP can be substantial, and they result from an increase in I/I occurring in the collection systems of the service area during storm events. The City commissioned a few studies starting in the 1980s to assess the capacity and condition of the collection system in an attempt to identify existing and future deficiencies in the collection system and to develop improvement projects to alleviate these deficiencies. These studies included:

1. Infiltration/Inflow (I/I) Study, conducted in phases from 1980 to 1987.
2. City of Palo Alto Wastewater Collection System Master Plan (CSMP) in 1988.
3. City of Palo Alto Wastewater Collection System Master Plan (CSMP) Update in 2004.

Two additional studies not commissioned by the City were performed and considered as part of this LRFP:

1. City of Los Altos Sewer System Master Plan (SSMP) in 2005.
2. City of Mountain View Sewer System Master Plan (SSMP) in 2010.

The I/I Study identified that over 40 percent of the City's annual flow came from extraneous groundwater and storm infiltration through direct surface drainage or damaged collection pipelines. As a result, an extensive sewer rehabilitation program was recommended.

The 1988 master plan identified and recommended a number of capacity improvements totaling $32 million in 1988 dollars. The City embarked on implementing these improvements and completed about 40 percent of the recommended projects before commissioning the 2004 master plan update.

A new hydraulic model of the collection system was developed for the 2004 CSMP Update. The model used a design storm based on a 5-year event with a 6-hour duration, which is consistent with prior City assumptions. The 5-year storm event was based on intensity-duration-frequency statistics for a 6-hour nested storm event in Palo Alto. The CSMP also developed 10-year and 20-year design storm events. As a result of the sewer rehabilitation program undertaken by the City prior to the 2004 CSMP, the 5-year storm event was used to identify capacity deficiencies, while the 20-year storm event was used to size proposed relief facilities.

Based on recommendations from the 2004 CSMP, $21 million dollars (2003 dollars) of improvements originally recommended in the 1988 CSMP were eliminated. However, the City is continuing their sewer rehabilitation program to replace older collection system pipe to continue to reduce I/I, as well as saltwater intrusion into the wastewater collection system.

The City of Los Altos' 2005 SSMP was based on assessments of the hydraulics, physical condition, and maintenance of the collection system and provided recommendations for improvements to provide adequate hydraulic capacity and improve the reliability of the collection system. A capital improvement program (CIP) was developed to mitigate hydraulic and structural deficiencies over the next 20 years. The City's collection system required a number of improvements including modifications to pump stations, correcting structural problems, remediating sulfide-related corrosion, and relieving hydraulic restrictions. The total cost for all projects was approximately $47,439,000 in 2005 dollars. The SSMP is currently being updated and is going to the City Council for adoption in the summer of 2012.

The City of Mountain View's 2010 SSMP updates the 1991 SSMP with revised growth assumptions, design criteria, and hydraulic modeling data. The SSMP provided recommendations for hydraulic improvements in order to maintain service for existing and future development. It also provided infrastructure replacement recommendations to establish monitoring and replacement priorities. The result of the SSMP was an approximately $19,900,000 CIP to serve as a roadmap through 2030 for the City to invest in the sewer system for recommended pipe hydraulic improvements, pipe replacements, and lift station repairs.

East Palo Alto Sanitary District's Sewer Master Plan was unavailable during the analysis. However, EPASD is finalizing an I&I Study and their Sewer Master Plan will be updated in late 2012.

3.4.3.2 Climate Change – Precipitation Patterns

The purpose of this section is to summarize the potential effects of future climate change, specifically changes in precipitation patterns, on peak wet weather flows at the RWQCP. Climate change has been predicted to result in increased extreme precipitation events in some areas, which could result in increased I/I to the RWQCP.

Current Trends in Annual Precipitation and "Extreme" Events

The key climate variable that could impact wet weather flows is precipitation. The long-term average precipitation in Palo Alto is 15.3 inches per year, while the U.S. average is 37 inches.

From 1910 to 1996 precipitation increased by about 10 percent across the contiguous United States. Over half of this increase in precipitation is due to an increase in the extreme daily (i.e., 24-hour) precipitation events – that is, daily precipitation events exceeding two inches (Karl and Knight, 1998).

The Environment California Research and Policy Center (ECRPC) published a study in December 2007 evaluating trends in the frequency of extreme precipitation events across the contiguous U.S. The analysis considered daily precipitation records from 1948 through 2006 for more than 3,000 weather stations in 48 states. Patterns in the timing of heavy precipitation relative to the local climate at each weather station were examined (Madsen and Figdor, 2007). The study focused on extreme daily precipitation totals with an average recurrence interval of 1 year or more. Records show a 26 percent average increase in frequency of these events across California since 1948.

Detection of statistically significant trends becomes more difficult at the metropolitan level. While the study did not show the results for areas in northern California, a review of extreme precipitation for areas in southern California was provided for Bakersfield, Los Angeles, Santa Barbara, and San Diego. Extreme precipitation events there increased in frequency by 51 to 93 percent since 1948 (Madsen and Figdor, 2007).

Future Projections and Recommendations

While projected temperature changes due to climate change are broadly consistent across most climate modeling efforts, projected changes in total annual precipitation across the U.S. have varied widely across models and emissions scenarios (Kiparsky and Gleick, 2003; Madsen and Figdor, 2007). In addition, as models are run at smaller scales (e.g., regional or metropolitan level) the accuracy decreases.

Most model results for projected changes in the region are highly uncertain, but have shown a small range of changes for Northern California (Dettinger, 2005). Therefore, it is recommended that long-term planning be based on current trends of total annual precipitation.

Although projected changes in total annual precipitation are mostly small and uncertain, the intensity of precipitation is likely to increase around the world, with the most significant increases occurring in the middle to high latitudes (Meehl et al, 2005). Kharin and Zwiers show the projected frequency of daily precipitation events considered to be extreme (i.e., exceeding 2 inches) will occur twice as often by the period of 2046 to 2065 and three times as often by the end of the 21st century relative to those that occurred during the period of 1981 to 2000. This means that 24-hour precipitation events with current return periods of 1, 5, 10, 20, 50, and 100 years will occur 2 or more times as often by the year 2100 due to climate change (Kharin and Zwiers, 2005; Kharin et al, 2007). It is recommended that long-term planning include updates to intensity-duration-frequency curves to track the recent changes in extreme events and the potential impacts to the design and operation of the RWQCP.

In summary, it is important to consider the potential impact global climate change may have on precipitation events (i.e., total annual average and extreme events) in order to anticipate necessary modifications to RWQCP design and operations management for flood prevention. Prudent planning for the RWQCP should consider the projected changes in extreme events due to global climate change, which includes considering longer duration and increased frequencies of precipitation events.

3.4.3.3 Projection of Wet Weather Flows

As a result of the repair and rehabilitation work that has been done on the collection system to reduce I/I to the RWQCP, and the ongoing sewer rehabilitation programs, peak wet weather events are not projected to increase beyond past wet weather events within the planning period of the LRFP. The collection/sewer system master plans developed for partner agencies were reviewed to estimate the total peak wet weather influent flows received by the RWQCP. Projected peak wet weather flows estimated for each partner agency were not based on the same storm events as shown in Table 3.10.

Table 3.10 Projected Peak Wet Weather Flows in Million Gallons per Day(1)				
	Baseline	**2010**	**2020**	**2030**
Palo Alto (includes Stanford University and Los Altos Hills)				
ADWF	12.0(2)	N/A	N/A	15.0
5-year PWWF(3)	36.8 2)	N/A	N/A	44.4
20-year PWWF(4)	41.5(2)	N/A	N/A	50.0
Mountain View				
ADWF	7.9(5)	7.9	10.8	11.1
10-year PWWF(6)	14.2	14.2	19.0	19.4
Los Altos/Los Altos Hills				
ADWF	2.86(7)	N/A	3.22	3.22
5-year PWWF(8)	5.77	N/A	6.50	6.50
10-year PWWF(9)	6.25	N/A	7.05	7.05

Notes:

(1) East Palo Alto Sanitary District's Sewer Master Plan was not available during this analysis.
(2) Based on monitoring data during 2002.
(3) 5-year PWWF: peak wet weather flow due to a storm event with a 5-year return period and 6-hour duration.
(4) 20-year PWWF: peak wet weather flow due to a storm event with a 20-year return period and 6-hour duration.
(5) Based on data provided in the 2010 UWMP.
(6) 10-year PWWF: peak wet weather flow due to a storm event with a 10-year return period and 4-hour duration. Estimates based on 2011 UWMP.
(7) Based on monitoring data during 2002, not including Mountain View flow.
(8) 5-year PWWF: peak wet weather flow due to a storm event with a 5-year return period and 24-hour duration.
(9) 10-year PWWF: peak wet weather flow due to a storm event with a 10-year return period and 24-hour duration.

Previous design criteria indicate that the RWQCP was designed for a PHWWF of 80 mgd. The total of the worst-case projected flows from the collection system master plans (from Table 3.10) for each agency does not exceed 80 mgd. While recent peak hour flows have not reached 80 mgd, there was an event in February 1998 where plant influent reached 80 mgd. This was estimated to be a storm event with a return period ranging between 50 to 75 years. Although this was an extreme event that resulted in street flooding which aggravated inflow to the collection system, for the purposes of this LRFP we will use a PHWWF projection of 80 mgd.

A better understanding is needed of the peak flow potential for the RWQCP service area. The existing collection system models do not interact with each other or reflect the timing of flows that would occur in the system. It is recommended that a comprehensive collection system model for the entire service area be developed and calibrated with flow data collected in the system during wet weather events. This information would also be helpful to identify areas in the system with high I/I, which may need to be rehabilitated.

3.5 UPSTREAM INTERVENTION

This section looks at the impacts that any significant future upstream diversion programs would have on the future flows and loads to the RWQCP.

3.5.1 Diversions

Discussions with City staff and the partners indicated that there are two possible areas for diversion of future inflows to the RWQCP. These are:

1. Implementation of Graywater Systems. Although the use of legal graywater systems is encouraged and implemented in other cities, for the purposes of this LRFP, we are not assuming a significant pollutant or flow reduction at the plant from graywater systems. Palo Alto and Mountain View currently have five permitted graywater systems each. Gray water systems are welcomed in the service area; however, they have an insignificant impact on the long range flow projections.

2. Infiltration and Inflow Reduction. For the Palo Alto sewer collection system, no further reduction in I/I is being assumed. Based on a review of the 2004 CSMP, sewer rehabilitation programs have been implemented and resulted in a significant reduction in I/I. We will assume that I/I levels will remain unchanged for the purposes of the LRFP and in the absence of any developed modeling of the sewer system for design level storms (e.g., 10-year storm). Efforts to implement best management practices (BMPs) for stormwater management may also lead to reduced I&I in the future.

Therefore, no significant reductions due to diversions are being incorporated into the LRFP.

3.5.2 Distributed Treatment

Influent flows and some organic loading to the RWQCP could be reduced in the future as a result of upstream treatment and recycling. Recycled water can be produced at upstream satellite plants (i.e. scalping plants). These satellite plants would provide liquid treatment but be required to send solids back to the sewer to be treated at the RWQCP. The recycled water would be consumed by users close to the satellite plant and would result in a reduction on the hydraulic load at the RWQCP when in use (primarily summertime), while the solids loading would remain unchanged. Operation of a satellite plant for recycled water use requires state certified operators and an NPDES permit. Although some of the Stanford University professors have expressed an interest in satellite (distributed) treatment and the Stanford campus has the greatest potential based on demand for landscape irrigation, East Palo Alto Sanitary District is the only other partner agency considering implementation of a satellite treatment system as stated in their 2010 Urban Water Management Plan. However implementation of a satellite facility for EPASD is only estimated to offset approximately 100,000 gallons wastewater per day. Therefore, no additional diversions are incorporated into the LRFP flow projections.

3.6 RECYCLED WATER DEMAND SCENARIOS

This section identifies the historical recycled water demands and projections for the future recycled water demands. Historical recycled water demands are based on data for the period January 2005 through August 2010.

3.6.1 Background

The City of Palo Alto has been producing and supplying recycled water since the 1980s. Phase 1 of the RWQCP's recycled water program, in operation since the 1980s, supplies recycled water to the Palo Alto Golf Course, Greer Park, the Emily Renzel Marsh, and the RWQCP. Mountain View began using recycled water at the City golf course in 1980. Phase 2 of the City's recycled water program has been in operation since the spring of 2009 and supplies recycled water to the Mountain View Recycled Water Project. The next phase of the recycled water program to be implemented as identified in the Recycled Water Facilities Plan (RWFP) for the RWQCP in 2008 (RMC, 2008) is Phase 3 or the Palo Alto Recycled Water Project. An environmental impact report (EIR) is being developed for the Phase 3 project in 2012.

All the phases of the recycled water program were first identified in the Water Reclamation Master Plan (WRMP) for the RWQCP in 1992 (Brown and Caldwell, 1992). In 2006, the City of Palo Alto completed a Recycled Water Market Survey Report (Market Survey) (RMC, 2006). The 2006 Market Survey was a preliminary effort to determine the revised potential locations of recycled water use within the City. This revised list of potential recycled water users was then used in the RWFP as the basis for the recommended Phase 3 project. The proposed Phase 4 includes serving Stanford University and Medical Center Area and has not been fully developed yet. According the Stanford University the WRMP overestimates the potential demands for recycled water for Stanford.

3.6.2 Historical Demands

Based on the data from the plant for the period January 2005 to August 2010, Table 3.11 shows the historical recycled water supply over the period.

Table 3.11 Historical Recycled Water Supply Flows							
	2005	**2006**	**2007**	**2008**	**2009(1)(2)**	**2010**	**Average**
AAF (mgd)	0.26	0.28	0.28	0.35	0.35	0.57	0.35

Notes:
(1) Mountain View Recycled Water Project on-line with limited availability in Fall 2009. Formal start of operations was January 1, 2010.
(2) Data available through December 2010.

Note that for Phase 2, although the main pipeline has been installed, not all the connections to users have been completed. As of February 29, 2012, annual recycled water use is 39 percent of the estimated 489 million gallons per year of projected use. Additional connections continue to be made over time to bring on identified users.

3.6.3 Projected Demands

The phasing for the recycled water program was initially identified in the 1992 WRMP and later refined in the 2008 RWFP. The implementation of recycled water is greatly affected by political processes. While there is commitment to continue use of recycled water, there is no adopted schedule for its expansion, therefore, for the purposes of this 50-year planning horizon for the LRFP, the recycled water demand was categorized into near, intermediate and long-term demands as shown in Table 3.12.

Table 3.12 Recycled Water Demands in the Near, Intermediate and Long Term(1)			
	Annual Average Flow Rate (mgd)	**Peak Month Flow Rate (mgd)**	**Peak Hour Flow Rate (mgd)**
Near Term: Demand for Phases 1-3	2.5	5.6	15.9
Intermediate Term: Recommended Project - 1992 WRMP	4.2	9.8	21.9
Long Term: Target Users - 1992 WRMP	5.3	12.4	27.8 (1)

Notes:
(1) The planning horizon of the near, intermediate, and long term recycled water demands depends on the timing of City Council decisions to implement.
(2) Estimated based on the peaking factors from the 1992 WRMP.

The near term demand includes the existing demand through Phase 3. The demand estimates are derived from the 2008 RWFP. The intermediate demand represents the recommended project from the 1992 WRMP. This includes Phase 4 and the connection to Moffett Field, both of which were identified in the 2008 RWFP. The long-term demand is a build-out from the recommended project and represents the target users from the 1992 WRMP, which is a sub-set of the total identified users, but represents the fraction of potential users that are more likely to be implemented due to size/demand and location.

These projected recycled water demands will be used for identifying and sizing recycled water treatment facilities needed at the RWQCP and for identifying storage needs both on and offsite.

Chapter 4

EXISTING FACILITIES AND CAPACITY EVALUATION

4.1 HISTORY OF THE RWQCP FACILITIES

The Regional Water Quality Control Plant (RWQCP) was originally constructed in 1934 with a hydraulic capacity of 3 million gallons per day (mgd) and consisted of primary clarification, digestion, and sludge drying beds. In 1948, the RWQCP was expanded to handle the seasonal cannery waste load and a total hydraulic capacity of 5 mgd. In 1956, the RWQCP was expanded to handle a hydraulic capacity of 10 mgd. In 1964, the new effluent outfall (54-inch diameter) pipeline was added and discharged to an unnamed slough located directly to the north of the airport runway. In 1972, the RWQCP was upgraded to a secondary treatment facility and expanded to accept wastewater from the cities of Mountain View and Los Altos. This expansion increased the average dry weather flow capacity to 35 mgd and the peak hour wet weather capacity to 80 mgd.

In 1981, construction was completed for an upgrade to provide nitrification and tertiary treatment. In case there is a need for essential maintenance or to handle wet weather flows exceeding 40 mgd, provisions were made so the nitrification and tertiary treatment processes can be bypassed. The tertiary facilities were designed to treat an average dry weather flow of 30.6 mgd; therefore, the RWQCP was derated from 35 mgd to 30.6 mgd. In 1988, a capacity expansion project increased the overall permitted average dry weather flow capacity to 39 mgd.

4.2 EXISTING FACILITIES DESCRIPTION

The existing treatment processes at the RWQCP consist of headworks, primary, two-stage secondary, tertiary, disinfection, and recycled water treatment, as well as solids treatment and handling.

A process flow diagram showing the path of the liquid and solids streams through the RWQCP is shown in Figure 4.1. Figure 4.2 shows an aerial view of the existing facilities, the location of its boundaries as well as existing headworks, primary, secondary and tertiary treatment, disinfection, recycled water, and biosolids treatment facilities. The details of each unit process are summarized in Table 4.1 and each is briefly described in the following sections of this chapter.

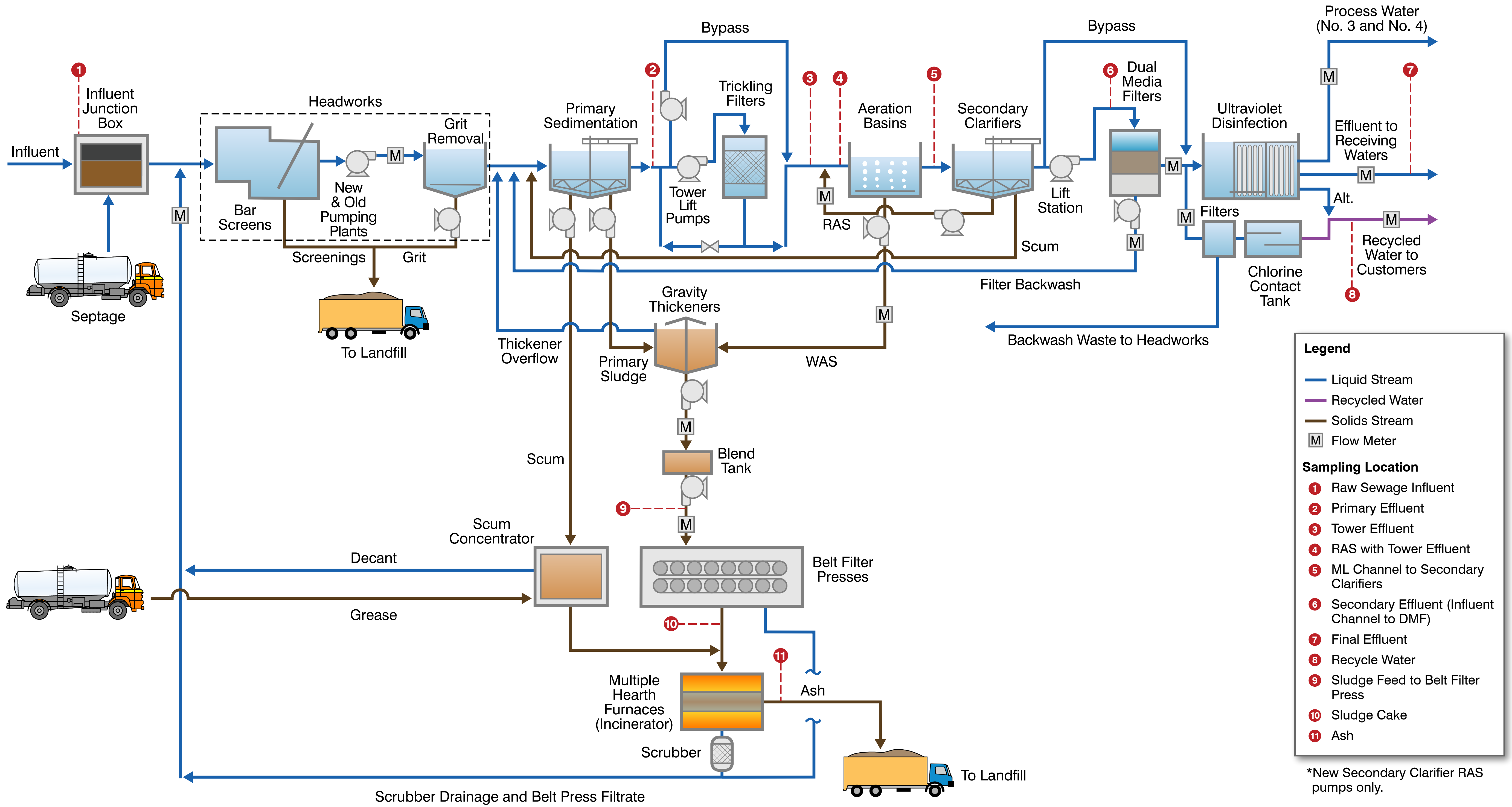


Figure 4.1
EXISTING FACILITIES LIQUID AND BIOSOLIDS PROCESS FLOW DIAGRAM
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa412f4-8510.ai

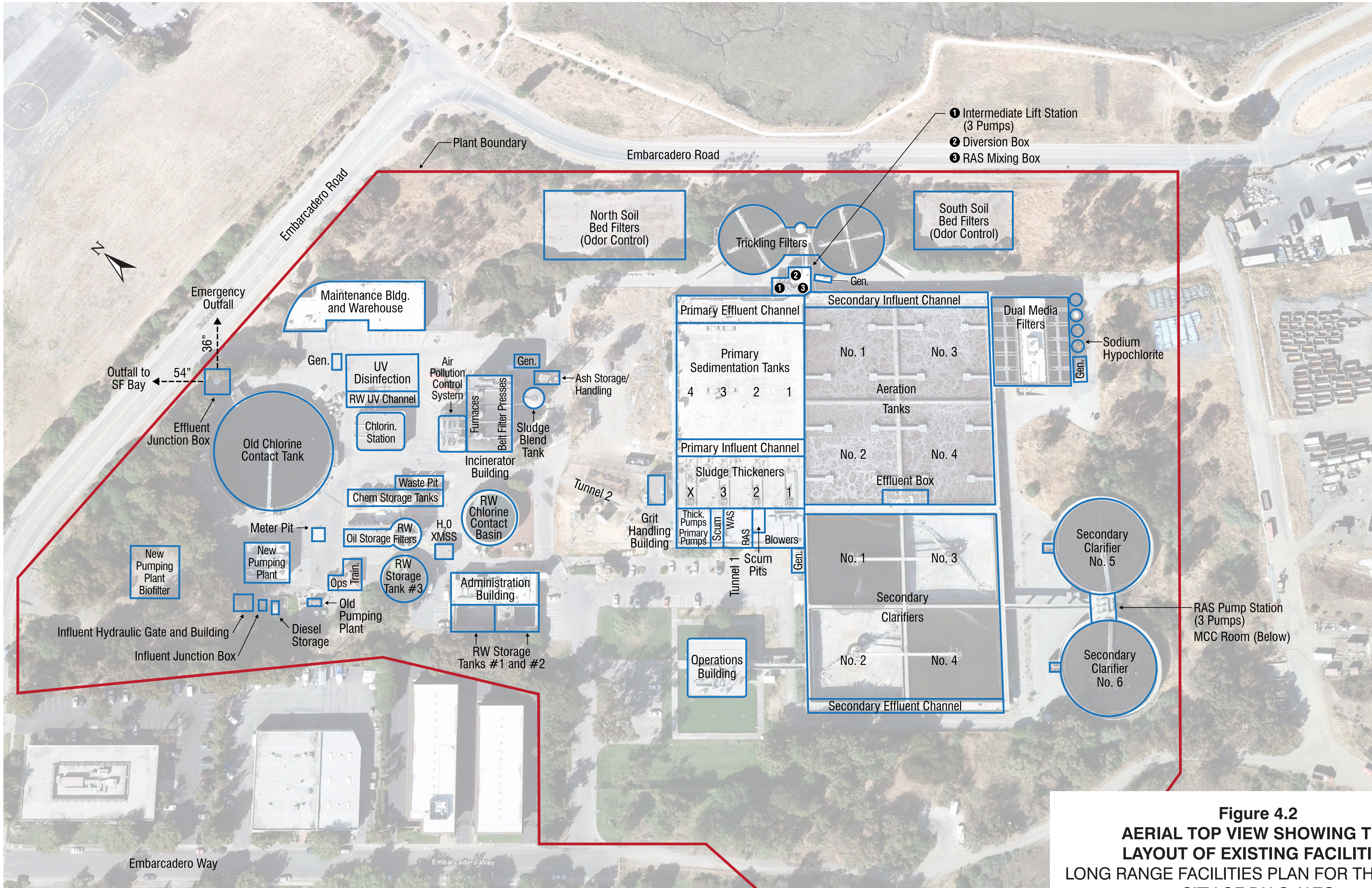


Figure 4.2
AERIAL TOP VIEW SHOWING THE LAYOUT OF EXISTING FACILITIES
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f5-8510.ai

Table 4.1 Summary of Existing Facilities	
Item	**Value**
Influent Box and Septage	
Number of units	1
Year of construction	1966
Headworks	
Old Pumping Plant	
Number of pumps	3
Type	Vertical Dry Pit
Year of construction	1956 (Nos. 7, 8, 9)
Motor size (horsepower)	No. 7 – 150, No. 8 – 70/100, No. 9 – 75
Total pumping capacity, million gallons per day	34.6(1)
New Pumping Plant	
Number of pumps	6
Type	Centrifugal
Year of construction	1972 (Nos. 1, 3, 4, & 6) 1987 (Nos. 2 & 5)
Motor size (horsepower)	Nos. 1-5 – 200, No. 6 – 100
Total pumping capacity, million gallons per day	88.7
Bar Screens	
Number of units	3
Year of installation	3 in 1993 (screen retrofit in 1995)
Width, feet	6
Depth, feet	6
Opening size, inches	0.75
Capacity, million gallons per day (each)	30

Note:
(1) City notes that it can only deliver 20 mgd due to force main hydraulics.

Table 4.1 Summary of Existing Facilities	
Item	**Value**
Screw Screenings Press	
Number of units	3
Year of installation	1993
Type	Rotating Helical Screw
Capacity	Unknown
Grit Removal	
Number of classifiers	1 (screw)
Diameter, inches	12
Year of installation	1988 (cyclone and classifier replaced in 2005)
Number of pumps	3
Type	Submersible
Motor size (each), horsepower	5
Total pumping capacity, gallons per minute	200
<u>Primary Treatment</u>	
Primary Sedimentation Tanks (PST)	
Number of units	4
Year of construction	1972
Length, feet	220
Width, feet	40
Side water depth, feet	11
Effective surface area (each), square feet	8,800
Overflow rate, gallons per day per square foot	870
Number of muffin monsters	4
Year of installation	1985
Type	In-line Muffin Monster
Total motor size (each), horsepower	2
Primary Sludge Pumps	
Number of pumps	7
Year of installation	1972
Type	Recessed Impeller (Nos. 1a/b, 2a/b, 4a/b) Submersible Chopper (No. 3)
Motor size (each), horsepower	3

Table 4.1 Summary of Existing Facilities	
Item	**Value**
<u>Secondary Treatment</u>	
Intermediate Lift Station (bypass)	
Number of pumps	3
Year of installation	1988
Type	Centrifugal Impeller VFD
Motor size (each), horsepower	100
Fixed Film Reactors	
Number of units	2 (North Tower or Reactor No. 1, South Tower or Reactor No. 2)
Year of construction	1980
Diameter, feet	95
Total top surface area, square feet	14,170
Media depth, feet	20
Total media volume, cubic feet	304,660
Media Composition	Corrugated PVC Plastic
Number of pumps	6 (3 per unit)
Type	Centrifugal VFD (Nos. 1, 2, 5, 6) Constant Speed (Nos. 3, 4)
Motor size, horsepower	100 (Nos. 1, 2, 5, 6), 75 (Nos. 3, 4)
Aeration Basins 1-4	
Number of units	4
Year of construction	1972
Length, feet	134
Width, feet	120
Side water depth, feet	15
Total volume, cubic feet	964,800
Total volume, million gallons	7.2
Number of blowers	5
Year of installation	1972

Table 4.1 Summary of Existing Facilities	
Item	**Value**
Air flow capacity, standard cubic feet per minute	Nos. 1 and 3 @ 8,000 No. 2 @ 17,000 No. 4 @ 6,400 No. 5 @ 15,200
Motor size, horsepower	Nos. 1 and 3 @ 350 (Turblex) No. 2 @ 500 (Lamson) No. 4 @ 300 (Sutorbilt) No. 5 @ 600 (Turblex)
Secondary Clarifiers 1-4 (Square)	
Number of units	4
Year of construction	1972
Length, feet	120
Width, feet	120
Side Water Depth, feet	11
Volume, million gallons (each)	1.18
Effective surface area, square feet (each)	12,250
Secondary Clarifiers 5-6 (Round)	
Number of units	2
Year of construction	1988
Diameter, feet	120
Side Water Depth, feet	16
Volume, million gallons (each)	1.35
Effective surface area, square feet (each)	11,300
RAS Pumps	
Number of units	6 (Nos. 1, 2, and 4-7)
Year of installation	1972 (Nos. 1, 2, 4)
	1988 (Nos. 5-7)
Type	Horizontal Propeller VFD
Motor size (each), horsepower	Nos. 1, 2, 4 – 50,
	Nos. 5, 6, 7 – 42.9

Table 4.1 Summary of Existing Facilities	
Item	**Value**
WAS Pumps	
Number of units	4 (Nos. 1, 2, 3, and 4)
Year of installation	1972
Type	Horizontal Side-Suction VFD
Motor size (each), horsepower	5
Tertiary	
Dual Media Filters (DMF)	
Number of units	12
Year of construction	1980
Length, feet	30
Width, feet	15
Depth, feet	13
Media depth, feet	3 (2' anthracite coal over, 1' sand)
Support bed for media, feet	1' graded gravel #10 mesh to 1" over porcelain balls placed in a Wheeler inverted pyramid concrete underdrain
Effective surface area (each), square feet	450
DMF Backwash Supply Pumps	
Number of pumps	2
Year of installation	1980
Type	Centrifugal Constant Speed
Motor size, horsepower	150
DMF Surface Wash Pumps	
Number of pumps	2
Year of installation	1980
Type	Centrifugal Constant Speed
Motor size, horsepower	25
DMF Backwash Waste Pumps	
Number of pumps	2
Year of installation	1980
Type	Centrifugal Constant Speed
Motor size, horsepower	30

Table 4.1 Summary of Existing Facilities	
Item	**Value**
DMF Lift Pumps	
Number of pumps	4
Year of installation	1980
Type	Centrifugal VFD
Motor size, horsepower	75
Recycled Water Filters	
Number of units	4
Year of construction	1976 (1948 original structure)
Diameter, feet	35
Media depth, feet	3 (coarse sand)
Effective surface area, square feet (each)	217.25
Maximum filtration rate, million gallons per day (each)	1.565
Number of blowers	1
Year of installation	1976
Type	Sutorbilt (air wash compressor)
Motor size, horsepower	40
Recycled Water Filtration Backwash Supply Pump	
Number of pumps	1
Year of installation	1976
Type	Centrifugal
Motor size, horsepower	60
<u>Disinfection</u>	
Ultraviolet (UV) Channels	
Number of channels	4
Year of construction	2010
Length, feet	48
Width, inches	40
Side water depth (maximum), inches	34.3
Number of banks per channel	3
Number of lamps per bank	80

Table 4.1 Summary of Existing Facilities	
Item	**Value**
<u>Recycled Water</u>	
Recycled Water Chlorine Contact Tank	
Number of units	1
Year of construction	1976 (1934 original structure)
Diameter, feet	70
Side water (operating) depth, feet	23.44
Volume, gallons	569,000
Abandoned Chlorine Contact Tank	
Number of units	1
Year of construction	1972 (1956 original structure)
Diameter, feet	150
Side water depth, feet	9.5
Palo Alto Golf Course Recycled Water Pump	
Number of pumps	1
Year of installation	1975
Type	Centrifugal Constant Speed
Motor size, horsepower	30
Main Recycled Water Pumps	
Number of pumps	4 (Nos. 1-4)
Year of installation	2009
Type	Centrifugal VFD
Motor size, horsepower	Nos. 1,3 & 4 – 125, No. 2 - 40
<u>Solids Handling</u>	
Sludge Gravity Thickeners	
Number of units	3
Year of construction	1972
Length, feet	41
Width, feet	41
Side water depth, feet	11.5
Total effective surface area, square feet	4,219
Rotating mechanism drive motor, horsepower (each)	1.5

Table 4.1 Summary of Existing Facilities	
Item	**Value**
Sludge Transfer Pumps	
Number of pumps	6 (Nos. 1a/b, 2a/b, 3a/b)
Year of installation	1980
Type	Wound Rotor VFD
Motor size (each), horsepower	6
Scum Transfer Pumps	
Number of pumps	2 (Nos. 1 and 2)
Year of installation	1980
Type	Progressive Cavity
Motor size (each), horsepower	5
Sludge Blend Tank	
Number of units	1
Year of construction	1999
Volume, gallons	100,000
Number of mixing pumps	3
Type	Mixing
Motor size, horsepower (each)	100
Belt Filter Presses (BFP)	
Number of units	1 duty, 2 standby
Year of construction	1985
Belt width, meters	1.5
Capacity, gallons per minute (each)	300
BFP Sludge Feed Pumps	
Number of pumps	3
Year of construction	1999
Type	Progressive Cavity VFD
Motor size (each), horsepower	Unknown
BFP Wash Pumps	
Number of pumps	3 (1 in service)
Year of construction	1985
Type	Impeller
Motor size (each), horsepower	10

Table 4.1 Summary of Existing Facilities	
Item	**Value**
Multiple Hearth Furnaces	
Number of units	2
Year of construction	1972 (Rehab in 1999)
Diameter, feet	18.75
Height, feet	23.25
Number of hearths (each)	6
Total hearth area, square feet	2,200
Number of natural gas burners (each)	9
Normal operating temperature range, degrees Fahrenheit	1,200-1,600
Combustion Air Fans	
Number of units	2
Year of construction	1972 (rehab in 1999)
Type	Constant Speed
Motor size, horsepower (each)	40
Induced Draft Fans	
Number of units	2
Year of construction	1972 (rehab in 1999)
Type	constant speed
Motor size, horsepower (each)	150
Air Pollution Control	
Wet Scrubbers	
Number of units	2
Year of construction	1999
Afterburner Combustion Air Fans	
Number of units	2
Year of construction	1999
Type	VFD
Motor size, horsepower (each)	25

4.2.1 Interceptor

The 72-inch joint intercepting sewer (built in 1972) conveys wastewater from the cities of Mountain View, Los Altos, Los Altos Hills, and the southern portion of Palo Alto to the

RWQCP. As shown in Figure 4.3, the reinforced concrete pipe is approximately 8,600 linear feet and runs from the intersection of Casey Avenue and San Antonio Road in Palo Alto, below the flood control basin, and to the RWQCP.

The capacity of the trunk line is reported to be 80 mgd, although the interceptor was specifically excluded from the capacity evaluation in the most recent collection system master plan completed in 2004. As recently as January 2, 2006 at 12:45 p.m., and January 20, 2010 at 10:51 a.m., peak hourly influent flows to the RWQCP reached 67.9 mgd and 64.3 mgd (respectively) with no overflows; typical flows at this time are 30 to 35 mgd.

The 72-inch diameter joint interceptor sewer experienced overflow conditions during an extreme wet weather event lasting from February 1, 1998 through February 4, 1998. On February 2, 1998, at 7:00 am crews responded to sewer system overflows on Tallsman Drive, Louis Road, Ross Road, and Corina Way. At noon, manholes at Center Drive and Martin Avenue and Center Avenue and Telvis Place were reported overflowing. By 10:00 p.m., flows at the RWQCP exceeded 70 mgd. In the early hours of February 3, 1998, water overflowed the banks of San Francisquito Creek. Subsequent street flooding and submerged manholes led to additional sewer flows and the RWQCP reached its maximum capacity of 80 mgd at 3:00 a.m. At this time, the trunklines to the plant were throttled down to plant capacity to store the flows. The plant continued to operate at 80 mgd for the remainder of the day. By February 4, 1998, at 9 a.m., no manholes were overflowing and the RWQCP was operating at 65-70 mgd.

4.2.2 Influent Junction Box and Septage

There are two trunk sewers that direct raw influent wastewater into the influent junction box from the City of Palo Alto and partner agencies. The 42-inch diameter trunk sewer carries the combined flow from the East Palo Alto Sanitary District, the City of Palo Alto, and Stanford University. The 72-inch diameter trunk sewer carries the combined flow from the City of Palo Alto, Mountain View, Los Altos, Stanford University, and Los Altos Hills. Stanford and EPASD flows enter into the very end of the 72-inch trunkline near the RWQCP. Many plant sewers discharge into the lower reaches of the 72-inch trunkline. In addition, a 15-inch diameter clay pipe takes liquid waste discharged from septic haulers into the influent junction box. The box has two hydraulically operated sluice gates. One gate passes the wastewater to the old pumping plant (OPP) 42-inch diameter pipe (built in 1956) and the other gate passes the wastewater to the new pumping plant (NPP) 72-inch diameter pipe (built in 1972). Both gates are intended to be open with both pumping plants operating at the same liquid level. During historic peak storm events when influent flows reach 80 mgd, these gates have been partially closed to limit plant influent flow, while surcharging the influent sewers. The wastewater level in the sewers is usually 15 to 20 feet below ground level. The raw wastewater influent is then screened and pumped 15 to 16 feet above ground level to treatment units.

Figure 4.3
72-INCH JOINT INTERCEPTING SEWER
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f15-8510.ai

4.2.3 Headworks

The bar screens, OPP, NPP, and grit removal system are collectively referred to as the "Headworks."

4.2.3.1 Bar Screens

Screening raw wastewater is necessary to reduce the size and volume of the solids, rags, and debris that may interfere with operation of downstream equipment. The RWQCP returns recycle stream flow (i.e., belt filter press filtrate, incinerator scrubber drain water, and scum concentrator decant) to the raw influent wastewater downstream of the influent junction box and upstream of the three raked bar screens. The bar screens and screenings press were designed for 30 mgd each and were installed in 1993 to replace the three barminutors that had been in place since 1972. The bar screens were retrofitted in 1995 from 1/2-inch to 3/4-inch spacing to decrease excessive organics buildup on the screens. The screenings are raked off the bar screens for discharge into the screw screenings press for dewatering. The dewatered screenings are picked up twice weekly by the city's waste hauler (currently Green Waste) and disposed of at a landfill.

4.2.3.2 Old and New Pumping Plant

After screening, the wastewater is lifted through a 60-inch diameter force main to the primary sedimentation tank influent channel via the OPP and NPP lift pumps. The original 1934 pumping plant (now the "ops shop") was retired in 1956 with the construction of the OPP. The "ops shop" now serves as the motor control center (MCC) for the OPP. The OPP has three lift pumps (Nos 7, 8, and 9). In 1972, the NPP was constructed with a motor room and four lift pumps (Nos. 1, 3, 4, and 6) with space reserved for two additional lift pumps. During the 1988 capacity expansion, two additional lift pumps (Nos. 2 and 5) were installed. The NPP pumps are operated with a suction level setpoint, which causes a continuous backwater in the 72-inch joint interceptor trunk line to prevent cavitation of the pumps. The NPP and OPP flow meters are in the Meter Pit just before the tie-in to the 60-inch diameter force main.

During high flow (or backup) situations, some of the raw influent is directed through a channel monster in the OPP to grind rags and debris. The ground solids flow with the wastewater and are processed downstream.

4.2.3.3 Grit Removal

Grit is removed from the wastewater in the primary sedimentation tank influent channel. Grit consists of sand, gravel, cinders, and/or other heavy materials that settle. The grit removal system was installed in 1988 to protect rotating equipment (e.g., pumps) from abrasion, excessive wear, and to avoid heavy build-up of grit in downstream processes.

The grit enters a cyclone, which sends dewatered grit to the inclined screw grit classifier. The grit classifier discharges the washed grit into a bin inside the grit building. The bin is emptied into a waste container and hauled to a landfill twice weekly. The excess water from the cyclone flows into the sewer of the grit building eventually entering the 72-inch interceptor trunk line. The grit cyclone and classifier system was replaced in 2005.

4.2.4 Primary Treatment

The purpose of primary treatment is to remove most of the settleable and floatable solids by gravity separation. Removal of these solids reduces the organic loading on the secondary treatment process. This section describes the existing primary treatment process at the RWQCP, which consists of the influent channel, primary sedimentation tanks (PST), sludge removal, scum removal, effluent channel, and a bypass gate.

Primary treatment at the RWQCP begins as the 60-inch diameter force main discharges screened wastewater into the 7-foot wide influent channel located at the head of the sedimentation tanks. This channel also collects the effluent from the adjacent four sludge thickeners. Grit is removed from the primary influent channel (see Section 4.2.3.3). Dual media filter (DMF) backwash as well as secondary effluent channel scum is discharged into the southerly end of the primary influent channel prior to entering the PSTs.

The wastewater flows into four PSTs, each 220 feet long by 41 feet wide by 14 feet deep, and covered with a concrete slab. The purpose of these tanks is to remove the majority of the settleable solids. Settled solids are removed from the floor by a collector system, which includes longitudinal and cross collector mechanisms. The solids, or sludge, are pushed into a sludge sump and pumped to three (of the original four) sludge thickeners. Floating solids, or scum, are moved to the end of the sedimentation tank by the longitudinal sludge removal mechanism and skimmer. The scum is collected and pumped to the scum concentrator and fed directly into the incinerators.

Due to problems with corrosion, maintenance, operations, and safety, in 1985 plastic assemblies replaced the original 1972 cast iron chain and redwood flights. The steel shafts and stub shafts were replaced in 1998 along with new wear strips.

Downstream of the sludge and scum removal mechanisms, the wastewater flows into concrete collector troughs, which discharge into an 8-foot wide effluent channel spanning the end of each PST. A motor-operated 72-inch sluice gate is located at the upstream end of the primary effluent channel providing an emergency bypass of secondary and tertiary treatment processes. A 72-inch diameter pipeline carries the bypass flow to a junction box upstream of the ultraviolet (UV) disinfection facility. Bypass of primary effluent is not allowed by the RWQCP NPDES permit. There is no known use of the emergency bypass in the plant’s history. The primary effluent channel also has a 36-inch butterfly valve between PST Nos. 2 and 3. The valve provides an alternate return activated sludge (RAS) discharge point. Normally, this valve is closed and the RAS discharges into the RAS mixing box.

The primary clarifiers are providing adequate removal of BOD and TSS under the current flows and loadings.

4.2.5 Secondary Treatment

The secondary treatment system uses two stages to remove organic material (i.e., BOD) – fixed film reactors (FFR) followed by aeration basins and secondary clarifiers (activated sludge process). The FFR (a.k.a., “roughing towers”) is a "fixed growth" biological process, compared to the aeration basins and secondary clarifiers, which are "suspended growth" biological process. The RWQCP’s discharge permit does not currently require nitrogen or phosphorous removal.

4.2.5.1 Fixed Film Reactors

Primary effluent flows through a diversion box to each set of centrifugal feed pumps (3 each) below the FFRs. The FFRs are trickling filter unit processes specially designed to operate at high hydraulic loading rates. The feed pumps lift the primary effluent to the rotary distributor in each of the two reactors (North and South Towers). The rotary distributors dispense the wastewater over plastic media in the towers where a gelatinous coating of biological growth reduces the carbonaceous biochemical oxygen demand (CBOD) in the primary effluent. This reduction of CBOD makes nitrification possible in the activated sludge process. An underdrain collects the treated wastewater below the media, where there is also ventilation to provide an aerobic environment.

An aerobic environment must be maintained in the reactor for a healthy bacterial film to grow on the plastic media and reduce odors. The towers are ventilated either by natural draft or forced draft. In the forced draft mode, the exhaust air is directed through biofilters of sand to remove any potential odors. In case of emergency, the influent to the FFR can be chlorinated before it flows to the tower lift pumps.

A continuous flow of water over the towers is needed to keep the biological growth healthy. A manual or automatically operated recirculation valve can be opened to return tower effluent to the towers for additional passes of treatment; the valve is normally set in a fixed position at the SCADA tower screen and setup for single pass treatment. Tower effluent is directed to the activated sludge facilities for further treatment.

When influent flows exceed the capacity of the towers, the excess flow bypasses the FFRs via the Intermediate Pump Station (IPS) and flows directly into the aeration basins influent channel. According to staff, when flow exceeds 60 mgd, the PSTs can start to flood. Flooding of PSTs causes undesirable carryover of floating scum and plastics to the secondary process, but does not directly limit hydraulic throughput. The construction of the aeration basin effluent boxes in 1988 required the water level in the basins be raised in order to provide sufficient head to control the flow to the secondary clarifiers. This made flooding more severe.

4.2.5.2 Activated Sludge Process (Aeration Basins and Secondary Clarifiers)

The activated sludge process is comprised of aeration basins and secondary clarifiers. Effluent from the FFRs is mixed with solids (referred to as RAS) that have settled by gravity in the secondary clarifiers in the RAS mixing box to create mixed liquor. The mixed liquor flows into the aeration basins and is aerated to remove BOD by converting it to biological solids that can be settled out of the flow. The aeration basins are continuously aerated and mixed in order to provide a suitable environment for the activated sludge microorganisms. The microorganisms convert the soluble organics, colloidal solids, and ammonia-nitrogen to settleable biomass. A portion of the settled solids is wasted directly from the aeration basins to control the population of the microorganisms in the activated sludge process. These solids are referred to as “waste activated sludge” (WAS) and are pumped to the sludge thickeners. The remaining solids (RAS) settle in the secondary clarifiers by gravity and are returned to the aeration basins via RAS mixing box to seed the biological process. The effluent from the secondary clarifiers then flows to the tertiary filter facilities.

Five centrifugal blowers supply compressed air to the aeration basins via ceramic fine bubble dome diffusers to provide oxygen for the activated sludge microorganisms and mixing of the mixed liquor. Blowers 1 and 3 run approximately 25 percent of the time on average, Blowers 2 and 4 are not currently in operation, and Blower 5 runs continuously providing the minimum air requirements for the aeration basins. The fine bubble ceramic domes (19,000) were initially installed in 1988 to replace an air sparger and mixer system installed in 1972. The fine bubble ceramic domes have been replaced in 1999 and 2009, and will likely need to be replaced every 10 years.

4.2.6 Tertiary Treatment

Secondary effluent is lifted by four pumps to the 12 dual media filters (DMFs). The DMFs remove suspended solids, oil, and grease carried over from the secondary clarifier effluent. During filtration, solids and scum are trapped by the filter media as the wastewater flows downward through it. The filter media consists (from top to bottom) of a 24-inch layer of anthracite coal, 12 inches of sand, and 12 inches of graded gravel, ranging from #10 mesh to 1-inch size. The sand and coal make the filter a "dual media" filter. All filters are in use under normal operating conditions; however, they are piped so that any single or combination of filters can be removed from service for maintenance or backwashing.

Eventually, the accumulation of the matter in the spaces between the media grains affects the performance of the DMFs. The DMFs are backwashed regularly to flush out the accumulated solids from the filter media grains and restore the filter to its full capacity/performance. The filter backwash waste flows by gravity into one of the six mud wells and is pumped to the influent channel of the PSTs. Six clear wells provide storage of filtered water for use in backwashing and surface washing. Filter effluent flows in to the DMF final junction box (formerly the chlorine mixing chamber), discharges into twin overflow weirs to the 96-inch diameter pipe, and on to disinfection by ultraviolet (UV) light.

Wet weather flows exceeding the DMF lift pump capacity of 40 mgd can be directed to either the empty secondary clarifiers or bypass the DMF directly to the UV disinfection facility.

4.2.7 Disinfection

From 1972 to 2008, final effluent was disinfected with gaseous chlorine and dechlorinated with gaseous sulfur dioxide. In 2008, an interim disinfection system of liquid sodium hypochlorite and sodium bisulfite was used. Ammonia was added to create a more stable chlorine residual and reduce chlorodibromomethane levels in the final effluent, which is a byproduct of chlorination. In August 2010, UV became the primary means of disinfection. Disinfection via sodium hypochlorite, dechlorination via sodium bisulfite, and ammonia addition became unnecessary and are now used for backup purposes only.

The RWQCP's UV system is designed to disinfect water to meet the permit limit of 35 colonies Enterococcus per 100 milliliters (mL) over a 30-day geometric mean set by the U.S. EPA for coastal recreational waters and estuaries. Radiation from UV lamps penetrates an organism's cell walls, permanently altering the DNA structure of the microorganism and destroying its ability to reproduce. The system design meets the 35 MPN per 100 mL limit for flows up to 54 mgd when TSS is less than 10 mg/L and can disinfect up to the peak wet weather flow of 80 mgd for short periods.

From the UV disinfection system, most of the treated wastewater flows through the effluent junction box to the 54-inch diameter outfall to the South San Francisco Bay, and the remainder of flow is discharged through a controlled outfall to Matadero Creek. In the event the 54-inch diameter outfall pipeline is out of service due to an emergency or for maintenance, a wall of stop logs in the effluent junction box and a 36-inch diameter pipeline discharging to the old yacht club harbor provide for emergency discharge location.

During recycled water mode, the recycled water will be taken from channel 4 of the UV facility. When in outfall mode, channel 4 water is directed to the receiving waters and is disinfected at a much lower dose.

4.2.8 Outfalls

After UV disinfection, the final effluent flows into the former chlorine contact tank outlet box and over a weir wall into the outfall box where final sampling takes place. The RWQCP discharges to two receiving waters: South San Francisco Bay and Matadero Creek. Approximately 95 percent of the treated wastewater is discharged to South San Francisco Bay through a 2,100-foot long 54-inch diameter reinforced concrete outfall pipe directing final effluent to an unnamed, manmade channel that is tributary to the Bay. The remaining approximately 5 percent of the treated wastewater is discharged to the Emily Renzel Marsh Pond where it flows through a controlled outfall to Matadero Creek.

4.2.9 Recycled Water

The RWQCP can produce recycled water (RW) meeting state standards (i.e., CCR Title 22 and the NPDES permit) in two ways:

- Dual media filtration followed by UV disinfection (6.3 mgd capacity).
- Recycled water plant filtration followed by chlorination (4.5 mgd capacity – designed for 6.26 mgd, but limited due to the allowable hydraulic head over the top of the filters).

Production of RW using the DMF/UV system will serve as backup only to the filtration/chlorination system.

The RW plant at RWQCP consists of both filtration and disinfection by sodium hypochlorite to satisfy state reuse regulations. The filters were converted from a former vacuator. There are four filters in compartments divided by steel walls and a steel floor (containing an underdrain system). Each compartment contains deep-bed mono-media, which is a coarse sand, and can be operated independently. The majority of filtration is accomplished at the DMFs, but coarse sand is needed as a polishing filter to meet the State’s requirements for recycled water. Sodium hypochlorite is injected into the two filter effluent lines that combine together before flowing into the RW Chlorine Contact Tank.

Plans for providing RW to the Palo Alto Golf Course began during the RWQCP’s original design in 1934. However, it was not until 1975, when Santa Clara Valley Water District (SCVWD) built a state-of-the-art water treatment facility that could produce 2 mgd of water for ground water recharge and some (treated to a lesser extent) for landscape irrigation, that RW was used. Distribution systems were expanded from 1977 through 1979. Since there was no saltwater barrier for the groundwater, the advanced treatment system was decommissioned by SCVWD and transferred to Palo Alto in 1986. Palo Alto continued to operate the RW facilities for landscape irrigation in Mountain View. In 1990, RW distribution was extended to Greer Park from the existing line. In 1993, it was extended to Palo Alto's Municipal Service Center (MSC) yard and a new pipeline was installed to the Palo Alto Golf Course.

In 2008, the RW Pump Station was upgraded and a new distribution system was built to supply new customers in Mountain View in addition to restoring an existing pipeline that had been out of service since 2001. The goal of the new pump station and pipeline was to deliver 1,503 acre-feet per year (or 489 million gallons per year). As of February 2012, the system was delivering 39 percent of this goal.

4.2.10 Solids Treatment and Handling

The RWQCP solids treatment and handling facilities consist of screenings handling (see Section 4.2.3.1), grit handling (see Section 4.2.3.3), sludge and scum handling, and ash handling. Sludge and scum handling and ash handling are described in this section.

4.2.10.1 Sludge and Scum Handling

Four gravity sludge thickeners (thickeners) were originally constructed in 1972 and are located adjacent to (along) the PST influent channel. Each thickener is aligned with a PST (i.e., thickeners 1, 2, 3, and 4, align with PSTs 1, 2, 3, and 4, respectively). The thickeners provide gravity thickening of the primary sludge and WAS. The thickener overflow is discharged into the PST influent channel. Thickener No. 4 has never been used due to hydraulic issues, and its mechanical equipment was removed in 2002. In addition, the rotating mechanisms for Nos. 1, 2, and 3 were replaced in 2002.

A sludge blanket of about one foot is normal in the thickeners. Sludge depths less than one foot deep can cause “rat holing” around the sludge hopper allowing water (instead of sludge) into the sludge lines. Thickened sludge (approximately 3 to 6 percent solids) is pumped to the sludge blend tank outside the Incinerator Building. After the thickened sludge is blended, it is pumped to belt filter presses (BFPs) inside the Incinerator Building. The sludge blend tank and new sludge feed pumps were installed in 1999 to address problems with diurnal variations in sludge composition in the incinerator.

The BFPs along with polymer and sodium hypochlorite addition provide dewatering and odor control of the thickened sludge before it is fed into one of the two multiple hearth furnaces (MHF). Dewatering of the thickened sludge is necessary to reduce the need for auxiliary fuel (i.e., natural gas) in the MHFs. The BFPs can produce up to a concentration of 38 percent solids on average, however typical sludge cake is 28 percent solids for optimal MHF operation (i.e., higher percent solids cake can combust prematurely in the upper levels of the furnace).

Scum can be collected from the PSTs, grease deliveries, thickeners, and secondary effluent channel. Existing operations regularly receive scum from the PSTs and grease deliveries. The thickener's scum system is not used in order to avoid clogging the scum pipes and the scum concentrator. Scum from the secondary effluent channel is removed seasonally and sent to the primary influent channel for reprocessing by the PSTs. Collected scum is pumped into the scum concentrator, which was originally installed in 1980 (completely replaced in 2001), and sits inside the Incinerator Building. It removes up to 50 percent of the water from the scum prior to sending it into the MHFs. The scum is blended with dewatered sludge (i.e., after the BFPs) as it is conveyed to the MHFs because incinerating scum in the absence of dewatered sludge cake is unsafe.

Thermal destruction of dewatered sludge and scum takes place in two MHFs, which were originally constructed in 1972 and rehabilitated in 1999. For operations and maintenance reasons, only one MHF runs at a time for yearlong periods. The MHFs are capable of operating at partial or full capacity.

The sludge cake in Hearth No. 1 (uppermost hearth of the MHF) is moved by rabble teeth on the radial arms towards an opening near the central shaft. The sludge drops to Hearth No. 2 and the feed material is rabbled to drop holes at the periphery. This alternating pattern causes a countercurrent flow of sludge cake and hot gases of combustion. The rabble pattern was improved in 1999 to increase the amount of time sludge spends in each hearth and avoid problems with plowing and clinker formation.

The RWQCP air permit limits the total capacity of the MHFs to 32 dry tons per day in any 30-day period and 55 dry tons per day for any 24-hour period (i.e., monthly max and daily max, respectively). Currently, the MHFs process approximately 18 dry tons per day. The flue gas is cleaned in an afterburner followed by a wet-scrubber with a packed bed and multiple venturis before discharging to the atmosphere. The scrubber waste washwater and the BFP filtrate are discharged into a plant sewer and returned to the NPP barscreen channel.

As part of the LRFP, a seismic assessment of the incinerator's anchorage was performed (see Chapter 5). It was determined that the anchorage will withstand the 2009 CBC required ground acceleration of the earthquake at its given location; however, localized damage may occur within the furnace and become non-functional. Loss of natural gas could lead to thermal shock if the furnace cooled down too quickly and created thermal stress upon the bricks, leading to collapse of the hearths. An emergency/backup option needs to be established for solids processing and handling, should localized damage or hearth collapse occur.

4.2.10.2 <u>Ash Handling</u>

Ash is generated from the incineration of the dewatered sludge and scum. The ash is cooled in Hearth No. 6 of each MHF and moved by the rabble arms to a drop chute in the Incinerator Building basement. The original 1972 ash handling system was inside the Incinerator Building, but a new ash handling system was installed outside the Incinerator Building adjacent to the sludge blend tank in 2002. The ash is broken up, pneumatically conveyed into a storage hopper, and trucked weekly to a landfill as non-Resource Conservation and Recovery Act (RCRA) hazardous waste.

4.2.11 Utility Systems

The RWQCP has various utility systems that are important to the overall operation of the facilities. These systems require careful operation and maintenance for achieving maximum performance and producing an effluent meeting NPDES permit requirements. The utility systems included in this section are:

- Water systems
- Compressed air systems
- Plant drainage systems
- Methane gas systems
- Diesel fuel systems
- Plant communication systems
- Power and communication/SCADA systems
- Heating, ventilating, and air conditioning systems

4.2.11.1 Water Systems

Water for the RWQCP is provided from two sources:

- City of Palo Alto Utilities (CPAU) Department potable water supply, which supplies No. 1 Water (W1), No. 2 Water (W2), and fire sprinkler standpipe water.
- RWQCP effluent process water, which supplies No. 3 Water (W3) and No. 4 Water (W4).

No. 1 Water (W1)

The CPAU supplies W1 to:

- Operations Building – laboratory, toilets, sinks, floor drain trap primers, and the hot water heater
- Administration Building – laboratory, toilets, sinks, and the hot water heater
- Maintenance Building
- Incinerator Building bathroom
- Water transmission shop sinks
- Hose bibs – oil storage, septic haulers

- Eye wash stations

No. 2 Water (W2)

After W1 has passed through an onsite plant-owned backflow preventer, it becomes W2. W2 is primarily used as pump seal water (except at the NPP, FFRs, DMFs, and blowers) and for other in-plant processes, such as:

- Seal water
  - Normal operation – recycled water pump room
  - Backup to W4 supply
- Operations Building – boiler makeup water and the hot water storage tank
- Alum mixing water
- Reclamation plant air compressor water cooler
- Hose bibs – street sweeper pad, equipment rooms

Nos. 3 and 4 Water (W3 and W4)

The W3 and W4 are supplied from the UV disinfection facility effluent bay or the recycled water storage tank (not at the same time). W3 is low-pressure water, which is used for the air pollution control quench unit, for the air pollution control packed bed in the wet scrubbers, and for backup water to the belt filter press spray water system. W4 is high-pressure water used in the following ways:

- Process water: pump seal water, incinerator scrubber venturis, polymer mixing water and dilution water, belt filter presses, ashveyor cooling water, and blower oil cooling.
- Spray systems: gravity thickener launders, bar screens, secondary clarifiers (square), outfall box (turned off due to chlorine residual in water), biofilters, and mud well cleaning.
- Trough water: primary sedimentation tank scum trough, screenings press, and grit classifier.
- Washwater: hose bibs, flushing connections, blend tank, wash pads (liquid septic haulers, grease haulers, street sweepers, etc.), and hydrants (closed landfill service road and salt-water marsh intake screen).
- Miscellaneous: plant landscaping (Operations Building, Administration Building, and onsite redwood trees), Operations Building moat supply water, and Operations Building chiller heat exchanger cooling water.

4.2.11.2 <u>Compressed Air Systems</u>

The RWQCP produces high-pressure air through four compressors (one lead, one lag, and two standby) that supply compressed air for:

- Quick-connects throughout the RWQCP
- Valve actuators at the Reclamation Plant, DMFs, and incinerator induced draft fan/exhaust stack/bypass damper
- Ash handling equipment
- Level bubblers at the NPP and OPP influent wells
- Tool power at the Maintenance Building

4.2.11.3 <u>Heating, Ventilating, and Air Conditioning Systems</u>

The RWQCP's heating, ventilating, and air conditioning (HVAC) equipment services staff facilities, which include Administration Building, Operations Building, Maintenance Building, and the Incinerator Building's control room. Programming logic control (PLC) cabinets are air-conditioned, while most process and electrical areas are ventilated with exhaust fans to ensure air circulation and changes. HVAC maintenance is provided through a service contract.

4.2.11.4 <u>Power Systems</u>

The RWQCP has two key sources of power: electricity and an onsite photovoltaic (PV) system. Electricity is purchased from CPAU. The origin of CPAU electricity changes periodically. In wetter years, the energy mix is comprised of more hydroelectric-derived energy; while in dryer years, the energy mix is comprised of more fossil fuel-derived energy (such as natural gas and oil). By 2015, CPAU electricity is expected to be 50 percent hydroelectric, 33 percent other renewable energy sources, and 17 percent (i.e., the balance) from fossil fuel based energy sources in the short-term electricity markets. The RWQCP purchases 50 percent of its energy demand through CPAU's PaloAltoGreen program supporting energy suppliers that provide 100 percent renewable energy resources.

A small portion of the RWQCP's energy demand is met by the onsite PV system. In 2007, SolFocus of Mountain View entered into an agreement with Palo Alto to provide free solar power in exchange for use of the RWQCP site for research and development of solar arrays. In 2011, the UV disinfection facility rooftop began transmitting solar power to the RWQCP's onsite electrical grid.

Electrical power serving the RWQCP is distributed through a 12,470-volt underground system to nine load centers. Each load center consists of a fused disconnect switch, oil-cooled or dry-type transformer, and secondary power circuit breakers. The secondary power circuits feed motor control centers and panels located in various buildings across the RWQCP.

4.2.11.5 Instrumentation and Control System

The RWQCP instrumentation system provides operational control and surveillance of the facility operation. Newer equipment at the RWQCP includes PLCs, SCADA, alarm text messaging, digital radios, and advanced HMI graphics. The system includes various traditional instrument loops (a computer system and main instrument console with an alarm annunciator panel and graphic display) housed in the Operations Building Control Room. The types of instrumentation operated and/or measurements taken at the RWQCP include: sludge density meters; wet well level measurements; raw wastewater, primary effluent, and aeration basin influent pH measurements; primary effluent channel level measurements; recirculation sump level measurement and control; aeration tank air flow measurements; dissolved oxygen measurements; secondary clarifier effluent channel level measurement and control; DMF influent channel level measurement and control, clear well and mud well level measurements, backwash flow rate and control, effluent flow measurements and control, loss of head measurements, effluent turbidity measurements, and effluent flow measurement; MHF oxygen measurements and control, draft measurement and control, and temperature measurements and control; and RWQCP air and water pressure measurements.

4.3 PLANT PERFORMANCE AND CRITERIA REVIEW

This section summarizes the overall performance of the RWQCP with respect to meeting conventional, non-conventional, and effluent ammonia limits in the NPDES Discharge permit. In addition, recommended criteria for estimating the RWQCP's process capacity is summarized. Since the existing facility's performance provides an important benchmark for the planning of new facilities, historical performance and capacities for each process are also reviewed using operating data from January 2005 through August 2010.

4.3.1 Overall Performance Summary

Conventional and non-conventional pollutants regulated in the RWQCP's NPDES permit include 5-day carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids (TSS), oil and grease, pH, total chlorine residual, turbidity, and Enterococcus bacteria. In addition to these pollutants, the RWQCP has established limits for various toxic pollutants including ammonia. Table 4.2 provides a summary of the effluent concentrations for conventional, non-conventional, and toxic pollutants during the review period, as well as the effluent limits in the most recent NPDES permit. See Chapter 6 for a discussion of the RWQCP's regulatory requirements and toxic pollutants.

Table 4.2 Overall Pollutant Removal Performance Summary		
Constituent	**NPDES Limit (Order No. R2-2009-0032)**	**2005 – 2010 Performance**
Conventional and Nonconventional Pollutants		
$CBOD_5$, mg/L		
Monthly Max	10	3.7
Daily Max	20	7.5
TSS, mg/L		
Monthly Max	10	2.0
Daily Max	20	5.0
Oil and Grease, mg/L		
Monthly Max	5	<0.8
Daily Max	10	<0.8
pH, Standard Units		
Instantaneous Min	6.5	6.0
Instantaneous Max	8.5	7.5
Instantaneous Max of Total Residual Chlorine(1), mg/L	0.0	<0.1
Instantaneous Max of Turbidity, NTU	10	8.8
30-day Geometric Mean Enterococcus Bacteria, colonies/100 mL, Max	35	27
Toxic Pollutants		
Total Ammonia, mg/L		
Monthly Max	2.7	1.9
Daily Max	9.5	3.2
Copper, µg/L		
Monthly Max	12	11.2
Daily Max	16	11.3
Nickel, µg/L		
Monthly Max	26	4.9
Daily Max	31	5.1
Cyanide, µg/L		
Monthly Max	7.1	5.8
Daily Max	14	7.3
Dioxin TEQ, µg/L		
Monthly Max	1.4×10^{-8}	NA
Daily Max	2.8×10^{-8}	NA
Chlorodibromomethane, µg/L		
Monthly Max	34	37.5
Daily Max	62	39.0

Notes:
(1) Chlorine disinfection discontinued after August 2010.
(2) NA – (data) not available.

During the review period, the RWQCP has performed very well and met almost all pollutant limits established in its NPDES permit. There have been some violations of pH and chlorodibromomethane limits over the review period. The implementation of UV disinfection eliminated the formation of chlorodibromomethane.

Figure 4.4 shows the monthly average effluent concentrations for BOD_5, TSS, and ammonia. Note that concentrations for all of these constituents were consistently low. TSS concentrations were consistently less than 2 mg/L with no observable trends during the review period. In the spring of 2007, there was a small, but distinct increase in the effluent BOD_5 and ammonia concentration. This coincides with the time the RWQCP began adding ammonia to the disinfection process, which would explain the minor increase in the effluent concentration for these constituents. Even with this operational change, effluent BOD_5 and ammonia have been consistently less than 4 mg/L and 1.5 mg/L, respectively, for the last 3 years. In August 2010, the City stopped practicing chloramination and staff has reported a slight decrease in ammonia and a slight increase in BOD.

4.3.2 Process Performance Summary

Table 4.3 summarizes key performance (e.g., loading) data from 2009. Although data from prior years was reviewed, they are not discussed in this section since data sets prior to 2009 were not complete (e.g., the primary sedimentation tank removal rates were not available until September of 2008). In addition to summarizing 2009 performance data, the original design criteria, as well as the typical and recommended criteria used for the capacity analysis are provided.

The following sections review key findings from the performance review for each process.

4.3.2.1 <u>Headworks and Influent Pumping</u>

The capacity of the headworks and influent pumping facilities is established by the firm pumping capacity (i.e., capacity with the largest unit out of service) and the hydraulic capacity of the bar screens and channels. The bar screens and channels have been sized to maintain a minimum and maximum velocity during low and peak flow conditions, respectively.

The influent pumping is divided into the NPP (Pump Nos. 1-6) and the OPP (Pump Nos. 7-9). A hydraulic test was conducted on December 11, 2010 that established the NPP and OPP total and firm capacities. Table 4.4 shows the results of the hydraulic tests.

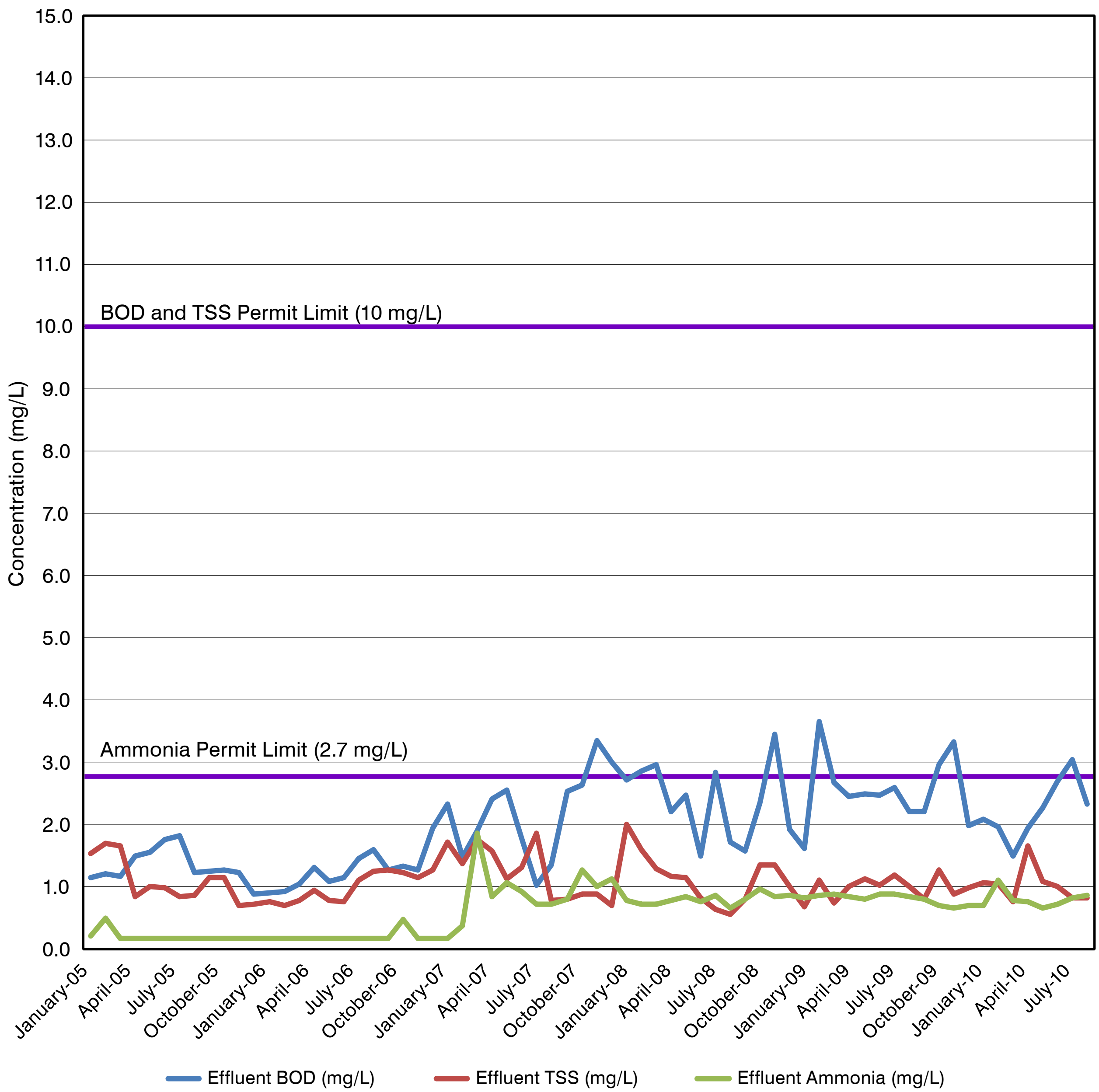


Figure 4.4
MONTHLY AVERAGE EFFLUENT BOD, TSS, AND AMMONIA
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f16-8510.ai

Table 4.3 Plant Design Criteria and Performance Summary

Process/Design Parameter	Units	1988 Phase I Expansion or Later Design Criteria	1977 AWT Expansion Design Criteria	2009 RWQCP Average	MOP-8 [1] or Typical Values [2]	Recommended Value for Capacity Analysis
Influent Characteristics						
Average Dry Weather						
Flow	mgd	38	30.6	See Chapter 3, Flow and Load Analysis	Not Applicable	See Chapter 3, Flows and Loads Analysis
BOD	lb/d (mg/L)	Not Available	55,200 (216)			
TSS	lb/d (mg/L)	Not Available	48,200 (189)			
Peak Wet Weather Flow	mgd	80	70			
Primary Clarifiers						
Overflow Rate						
ADWF	gpd/sf	1,080	620	724	800 - 1,200	1,200
PHWWF	gpd/sf	2,275	962	1,123	1,500 - 4,000	3,000
% BOD removal	%	Not Available	30	36	25 - 35	25 - 30
% TSS removal	%	Not Available	60	64	50 - 70	55 - 65
Fixed Film Reactors						
Application Rate	gpm/sf	1.9	1.5	1.47	0.9-2.9	2.0
BOD Loading Rate	ppd/1000cf	147 at Max Week	126 at ADWF	98	100-220	200 at ADMM
BOD Removal	%	Not Available	50	49	40-70	40 at ADMM
Aeration Basins						
Hydraulic Retention Time (HRT)	hours	4.5 at ADWF	5.6 at ADWF	6.9	Variable	Not Used for Sizing
F/M Ratio	ppd BOD/lb MLVSS	0.11	0.11	0.09	0.1 – 0.2	Not Used for Sizing
Solids Retention Time (SRT)	days	Not Available	10 to 15 [3]	11.8	5 - 10	4 aerobic SRT at ADMM [4]
MLSS Concentration	mg/L	Not Available	Not Available	2,730	1,000-4,000	3,500 at ADMM [5]
Temperature	deg C	Not Available	25	23.3	Variable	20 [6]
Sludge Volume Index (SVI)	mL/g	Not Available	Not Available	33.2 (based on data from 2011 to 2012)	50-150	50

Table 4.3 Plant Design Criteria and Performance Summary

Process/Design Parameter	Units	1988 Phase I Expansion or Later Design Criteria	1977 AWT Expansion Design Criteria	2009 RWQCP Average	MOP-8 (1) or Typical Values (2)	Recommended Value for Capacity Analysis
Secondary Clarifiers						
Overflow Rate						
ADWF	gpd/sf	560	625	448	300 – 600	Not Used for Sizing
PHWWF	gpd/sf	1,179	1,430	839	1,000 – 1,500	1,180 (7)
Dual Media Filters						
Peak Hydraulic Loading Rate	gpm/sf	6	6	2.9	2 – 6	6
Chlorine Contact						Decommissioned
Detention Time						
ADWF	min	95	45	88	30 – 60	
PHWWF	min	45	19.5	47	15 – 30	
Ultraviolet Disinfection						
Disinfection Dose	mJ/cm^2	35	Not Applicable	Not Available	35	35
UVT	% trans at 254 nm	62	Not Applicable	Not Available	50 – 80	62
Expected Residual Enterococcus	MPN/ 100 ml	<35	Not Applicable	Not Available	<35	<35
Recycled Water Filters						
Peak Hydraulic Loading Rate	gpm/sf	5	Not Applicable	Need to Verify Recycled Water Flow	5	5
Recycled Water Chlorine Contact						
Detention Time						
Average	min	88	Not Applicable	Need to Verify Recycled Water Flow	90 (8)	90 (8)
Peak	min	63	Not Applicable		90 (8)	90 (8)
Gravity Thickening						
Solids Loading	ppd/sf	14.8	8.4	16.9 (9)	5 - 14	16.9 at ADWF
Hydraulic Loading	gpm/sf	Not Available	Not Available	0.05 (9)	0.10 - 0.14	0.1
Percent Capture	%	Not Available	Not Available	Not Available	80 - 90	85
Thickened Sludge Concentration	% TS	Not Available	Not Available	3.3	4.0 - 6.0	3.3

Table 4.3 Plant Design Criteria and Performance Summary

Process/Design Parameter	Units	1988 Phase I Expansion or Later Design Criteria	1977 AWT Expansion Design Criteria	2009 RWQCP Average	MOP-8 [(1)] or Typical Values [(2)]	Recommended Value for Capacity Analysis
Solids Dewatering						
Type		Belt Filter Press	Centrifuge	Belt Filter Press	Belt Filter Press	Belt Filter Press
Solids Loading	lb/hr/unit	1,670	2,000	1,620	1,600 - 2,000	1,800 at ADMM
Solids Capture	%	Not Available	Not Available	Not Available	95	95
Cake % Solids	% TS	28	18 (Decommissioned)	26.5	20 - 28	28
Multiple Hearth Furnace Incineration						
Solids Loading (wet)	lb wet cake/hr/sf	7.6	Not Available	6	8 - 10	8 at ADWF

Notes:
(1) Water Environment Federation / American Society of Civil Engineers, 1998.
(2) Typical values based on Carollo experience.
(3) Estimated based on original criteria of 20 day MCRT, which includes aeration basin and clarifier inventory. SRT was calculated using only aeration basin inventory.
(4) Based on minimum MLSS temperature of 20 degrees Celsius and monthly average effluent ammonia target concentration of 2.7 mg/L. Longer SRT would be required for effluent ammonia less than 1 mg/L.
(5) Maximum MLSS allowable calculated from settling flux analysis based on SVI of 100 mL/g and PHWWF of 80 mgd to existing secondary clarifiers.
(6) 10^{th} percentile temperature from statistical analysis of 1989 through 2011 daily data.
(7) Based on SVI of 100 mL/g and MLSS of 3,500 mg/L.
(8) Based on Title 22 Regulations.
(9) Estimated performance based on model.

Table 4.4 Influent Pumping Capacity			
	New Pumping Plant	**Old Pumping Plant(2)**	**Combined**
Total (mgd)	104.6	27.8	132.4
Firm (mgd)(1)	83.8	17	100.8

Notes:
(1) Based on the largest unit being out of service.
(2) Pump No. 8 is a two-speed pump. The values shown are for the higher speed (8,400 gpm).

During the data review period, maximum peak flows of 67.6 and 64.3 mgd were recorded on January 1, 2006 and January 20, 2009, respectively. A peak hour wet weather flow (80 mgd) was recorded and treated by the RWCQP during a February 1998 storm event.

Although the pumping capacity is higher, the limit is in the bar screens. The headworks are comprised of three bar screens each with a capacity of 30 mgd each. A hydraulic analysis was not performed to verify that maximum channel velocities are not exceeded during peak flow conditions.

4.3.2.2 Primary Sedimentation Tanks

During the review period, the RWCQP typically operated with all four (4) primary sedimentation tanks in service. They have performed well within the range for typical primary sedimentation tanks with BOD_5 and TSS removal in 2009 averaging 36 and 64 percent, respectively. This is better than previous design criteria, which estimated BOD_5 and TSS removal to be 30 and 60 percent, respectively. It is possible that the improved performance may be due to the fact that the actual overflow rates are less than the original design criteria. Another plausible explanation could be that the settleable solids have a higher volatile solids (VS) content than typical settleable solids; however, additional wastewater characterization would be needed to confirm or refute this explanation. Although performance has been better than original design criteria, it is recommended that the capacity analysis be based on achieving slightly reduced removal compared to the current operation. This is recommended since future operation will be at higher overflow rates, which will likely result in reduced removal rates. At high overflow rates typical removal rates for BOD and TSS removal range from 25 to 30, and 50 to 60 percent, respectively. The capacity analysis will be based on these removal rates.

It should also be noted that the previous design overflow rate criteria are conservative when compared to typical criteria used today in designing primary sedimentation tanks (see MOP-8 values in Table 4.3). Since the criteria are conservative and the primary sedimentation tanks have demonstrated satisfactory performance to date, the recommended peak hour overflow rates for establishing capacity are higher than the original design criteria.

4.3.2.3 Fixed Film Reactors

In 2009, the RWQCP had both FFRs in operation and averaged approximately 49 percent removal of BOD_5. Although this matches the original design objective of 50 percent removal, it was achieved at BOD loading rate of 98 ppd BOD_5/kcf (1,000 cubic feet) of media, which is lower than the original design loading of 126 ppd BOD_5/kcf during ADWF conditions. As flows to the FFRs increase, they will be operating at higher loadings, which may result in reduced BOD_5 removal. However, with sufficient recirculation and forced air ventilation, practical experience demonstrates that BOD_5 loading rates of up to 200 ppd BOD_5/kcf can be sustained by the process as long as there is sufficient solids retention time (SRT) in the downstream activated sludge process. In order to maximize the capacity of the FFRs, it is recommended that their capacity be established based on an ADMM loading rate of 200 ppd BOD_5/kcf. At this loading rate, BOD removal is expected to be reduced to 35 to 40 percent.

4.3.2.4 Aeration Basins

During the review period, the RWQCP typically operated with all four (4) aeration basins in service. In 2009, this process has been operated at an average SRT of 11.8 days, an average mixed liquor suspended solids (MLSS) concentration of 2,730 mg/L, and a dissolved oxygen concentration of 4 mg/L.

As expected, the aeration basins have performed well with respect to removing soluble organics from the mixed liquor stream. The process has also consistently removed ammonia as effluent concentrations are typically less than 1 mg/L.

The key criterion for establishing aeration basin capacity for a nitrifying process is the aerobic SRT. The SRT is defined as the total mass of solids in the aeration basins divided by the mass of solids leaving the secondary process every day (i.e., WAS and secondary effluent solids). The required SRT will depend on the minimum monthly temperatures and the required effluent ammonia limits. In general, colder temperatures and lower effluent requirements will require longer SRT's to obtain adequate treatment. A review of 23 years of daily liquid temperature data found that 20 degrees C is the 10th percentile value, which reflects a reasonable minimum month condition. Accordingly, it is recommended that 20 degrees C be used as a basis for establishing an appropriate SRT.

Figure 4.5 illustrates the relationship between temperature, effluent ammonia requirements, and the minimum recommended aerobic SRT. If it is desired to only meet the City's current NPDES ammonia limit of 2.7 mg/L, a four-day SRT would be adequate, even during the cold weather periods when minimum monthly temperatures drop down to 20 degrees C. However, experience in the San Francisco Bay Area shows that maintaining nitrification at a four-day SRT will require a very high degree of operator attention. In addition, operation at this SRT may result in periodic ammonia breakthrough during cold weather periods.

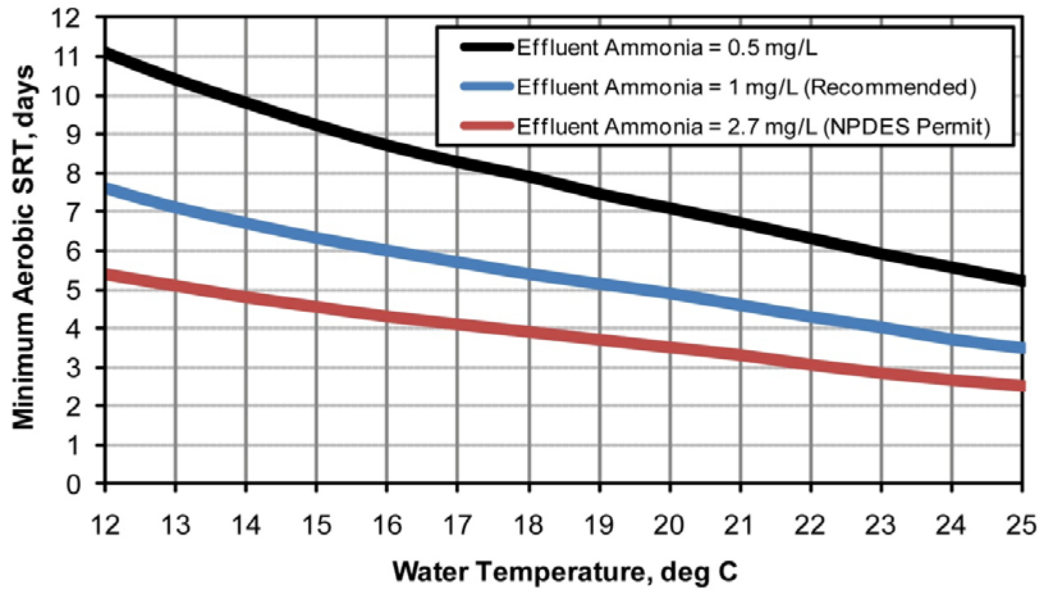


Figure 4.5 Minimum Recommended Solids Retention Time

At a five-day SRT, an effluent ammonia concentration of 1 mg/L would be achievable even during cold weather periods. In addition, operating at a five-day SRT will improve process stability and reduce the risk of periodic ammonia breakthrough.

The recommended maximum MLSS concentration is 3,500 mg/L, which is a typical upper limit for this type of process. Operating above 3,500 mg/L will reduce the effective oxygen transfer capacity of the aeration equipment. Also, unless an anaerobic selector is implemented, operating above 3,500 increases the risk of having settleability issues. A solids flux analysis indicates that the secondary clarifiers will be able to accommodate the solids loading associated with increasing the MLSS concentration up to 3,500 mg/L.

4.3.2.5 Secondary Clarifiers

During the review period, the plant has typically operated with four (4) of the six (6) secondary clarifiers in operation and has achieved adequate removal of solids, even during wet weather periods.

A solids flux analysis was performed to develop a recommended overflow rate for establishing the clarifier capacity. The allowable overflow rate depends on the operating MLSS concentration and the settleability, or sludge volume index (SVI) of the mixed liquor. The SVI measurement reflects the volume that solids in a mixed liquor sample will compress to after 30 minutes. In general, the lower the SVI, the faster the solids will settle. As MLSS concentrations and SVI’s increase, settling velocities will decrease and the clarifiers will need to be operated at lower overflow rates to prevent a solids loading failure. Using a solids flux analysis, allowable overflow rates were estimated for a range of conditions. Figure 4.6 illustrates the relationship between allowable clarifier overflow rates and the MLSS concentration and SVI.

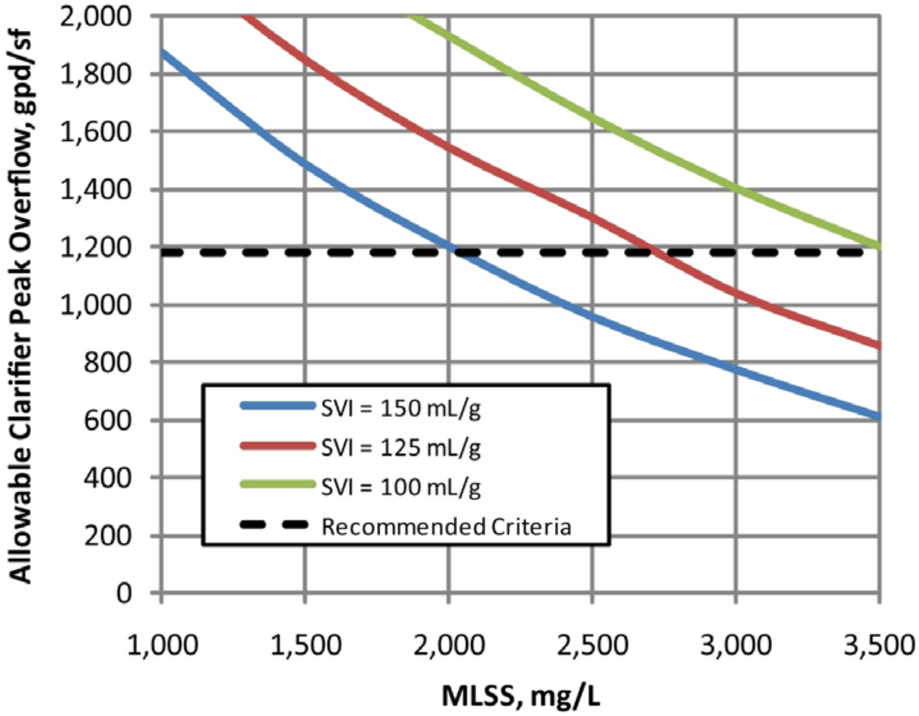


Figure 4.6 Allowable Clarifier Overflow Rates

Although no SVI data was collected during the review period (2009), the SVI of 12 mixed liquor samples were measured between 3/23/11 and 4/18/11 and used for the capacity analysis during the LRFP effort. The SVI data collected ranged from 26 to 33 mL/g with an average of 28 mL/g. SVI's for this type of process typically range from 50 to 150 mL/g, therefore, it appears the plant has a very well settling mixed liquor.

Based on the solids flux analysis, it is recommended that the peak overflow rate not exceed the original criteria of 1,180 gpd/sf. It is also recommended that the rated capacity be based on the radial area for the square clarifiers, as experience has shown the corners do not provide effective settling area. At the recommended overflow rate, the clarifiers should be able to accommodate the solids loading resulting from an MLSS of 3,500 mg/L at an SVI up to 100 mL/g. The rated capacity of the secondary clarifiers is therefore 80 mgd. It should be noted that the secondary clarifiers are currently operating below this rated capacity even at the peak wet weather flows recorded, and this capacity is not expected to be exceeded at build out if there are no regulatory changes.

Subsequent to the capacity analysis, additional SVI data was collected through 2012 (almost one year's worth of data). The average of this SVI data from 2011 to 2012 is 33.2 mg/L. This is consistently below 50 mg/L. This means that it is possible to increase the loading rate to the secondary clarifiers. However, given the fact that these are square clarifiers with a relatively shallow side water depth, it is not recommended to operate at higher overflow rates unless stress testing is conducted. A stress test would determine if higher overflow rates are sustainable and the re-rated capacity of the units.

If there are regulatory changes and the process changes in the future, the current SVI data will not be applicable and any future evaluation will be based on an SVI value of 100 mg/L.

4.3.2.6 Dual Media Filters

The dual media filters were originally designed for a peak hydraulic loading rate of 6 gpm/sf. In 2009, the average loading rate was 2.9 gpm/sf with short-term peak loading rates approaching 6 gpm/sf. Performance has been adequate during the review period and it is recommended that the original design criteria of 6 gpm/sf be used for evaluating their capacity.

4.3.2.7 Recycled Water Filters

The recycled water filters were originally designed for a peak hydraulic loading rate of 5 gpm/sf based on Title 22 requirements. In 2009, the average loading rate was 0.5 gpm/sf with short-term peak loading rates approaching 1.5 gpm/sf. This was based on the assumption that recycled water flows occurred over an eight-hour period with one filter out of service. Performance has been adequate during the review period and it is recommended that the original design criteria of 5 gpm/sf be used for evaluating future capacity.

4.3.2.8 Recycled Water Chlorine Contact Basin

Based on the recycled water flow rates in 2009, the average theoretical detention time in the recycled water chlorine contact basin was significantly greater than the 90-minute minimum modal time required by Title 22. The 2009 tracer study on the recycled water chlorine contact basin determined that the 90-minute modal contact time was achieved at a flow rate of 8.25 mgd. Based on the limitation of the recycled water filters however, the design capacity of the recycled water chlorine contact chamber is rated at 4.5 mgd. At this flow rate, the modal contact time is 165 minutes, which is greater than the 90-minutes required by Title 22.

4.3.2.9 Ultraviolet Disinfection

The UV disinfection system was designed to achieve a 30-day geometric mean of less than 35 colonies/100 mL of Enterococcus bacteria. The 2009 data show performance has been adequate.

4.3.2.10 Gravity Thickening

During the review period, the RWQCP has operated with two (2) of the four (4) gravity thickeners in operation. In 2009, the average solids loading was 16.9 ppd TS/sf, which is higher than its original design loading, and higher than the typical range of 5 to 14 as noted in MOP-8. The average thickened solids concentration in 2009 was 3.3 percent, which is adequate, but lower than expected. For a feed stream with WAS and primary sludge, a thickened solids concentration ranging from 4 to 6 is more typical. The lower than expected concentration may be partially explained by the relatively high solids loading rate. It may be possible to increase the thickened solids concentration if another gravity thickener is brought on-line. It is recommended that an average solids loading rate of 16.9 ppd TS/sf be used for establishing the rated capacity of the gravity thickeners.

Sufficient information was not available to estimate the solids capture across the process, which is another important performance metric for a thickening process.

4.3.2.11 Solids Dewatering

During the review period, the plant typically operated only one (1) of its three (3) BFPs. Performance has been excellent, achieving an average cake solids concentration of 28 percent. This is likely due to the fact that the solids have not been digested and are therefore more easily dewatered. The typical range in solids loading rate is 1,600 to 2,000 lb TS/hr/m of belt per MOP-8. While the original design rating is 1,670 lb TS/hr/m, it is recommended that an average solids loading of 1,800 lb TS/hr/m of belt be used for establishing process capacity.

Sufficient information was not available to estimate the solids capture across the process, which is another important performance metric for a dewatering process.

4.3.2.12 Incineration

During the review period, the plant typically operated only one (1) of its two (2) incinerators. Each incinerator has six (6) multiple hearth furnaces with a total area of 2,200 sf. Based on the 1972 RWQCP construction, the incinerators have a design capacity rating of 7.6 lb cake/hr/sf. Rehabilitation of the incinerators was done in 1999, and the capacity was re-rated at 5.2 – 6.9 lb cake/hr/sf (based on the VonRoll process flow diagrams) In 2009, the average loading was 6.0 lb cake/hr/sf. The typical range in solids loading rate is 8 to 10 lb cake/hr/sf per MOP-8. It is recommended that an average solids loading of 8 lb cake/hr/sf be used for establishing process capacity.

4.4 CAPACITY ANALYSIS

This section summarizes the results of the capacity analysis. Capacities were estimated for each of the treatment processes based on the recommended criteria provided in Table 4.3.

4.4.1 Peak Flow Capacity

The Peak Hour Wet Weather Flow (PHWWF) capacity was estimated for facilities where sizing is established by the peak flow. These facilities include influent pumping and bar screens, primary sedimentation tanks, secondary clarifiers, dual media filtration, UV disinfection, and the chlorine contact basins. Capacities for process units are estimated based on all units being in service, while pumping capacities are based on the largest unit being out of service. Table 4.5 summarizes the PHWWF capacity for each of these processes.

Table 4.5 Peak Hour Wet Weather Flow Capacity

Process	PHWWF Capacity (mgd)
Influent Pumping	100.8(1)
Bar Screens	90(2)
Primary Sedimentation Tanks	106(3)
Secondary Clarifiers	80(4)
Dual Media Filtration	45
UV Disinfection	80

Notes:
(1) Based on hydraulic testing performed December 11, 2010.
(2) Three bar screens with a capacity of 30 mgd each.
(3) Process capacity based on peak overflow rate of 3,000 gpd/sf. Hydraulic profile analysis should be performed to confirm adequate hydraulic capacity.
(4) Based on an MLSS concentration of 3,500 mg/L and an SVI of 100 mL/g.

4.4.2 Organic Loading Capacity

The organic loading capacity was estimated for facilities where sizing is established by influent BOD_5 and TSS loading to the plant. These facilities include the FFRs, aeration basins, gravity thickeners, dewatering, and incineration.

To determine the capacity for these facilities, a plant process model was developed and calibrated to historical operating data from the year 2009. Using the process model to simulate maximum month conditions, the influent flow and load was increased until the operating limits (as established in Table 4.3) were exceeded for each particular unit. This BOD_5 load was taken as the maximum month capacity limit for that particular unit. The maximum month load capacity was converted to an equivalent maximum month flow based on the anticipated wastewater strength identified from the flows and loads analysis. The maximum month capacity was also converted to an equivalent average dry weather capacity based on the historical peaking factors observed (see the flows and loads analysis in Chapter 3).

Table 4.6 summarizes the calculated capacity for each process for all units in service and also one unit out of service.

Table 4.6 Organic Loading Capacity

	ADMM Capacity		Equivalent ADWF Capacity		Equivalent ADWF Capacity – One Unit Out of Service	
Process	Influent BOD_5, lb/d	mgd(1)	mgd (2)	Influent BOD_5, lb/d(3)	mgd (2)	Influent BOD_5, lb/d(3)
Fixed Film Reactors	73,500	38.3	31.7	64,200	17.5(4)	35,500(4)
Aeration Basins (Existing Effluent Ammonia Target = 2.7 mg/L)(5)	87,300(7)	45.5(7)	37.6(7)	76,300(7)	37.6(8)	76,300(8)
Aeration Basins (Future Effluent Ammonia Target = 1 mg/L)(6)	78,800(7)	41.1(7)	34.0(7)	68,900(7)	34.0(8)	68,900(8)
Gravity Thickeners(9)	97,800	51.0	42.2	85,500	33.1	67,100
Dewatering	121,000	63.0	52.1	99,900	37.2	75,400
Incineration(10)	104,000	54.0	44.7	90,500	25.6	52,000

Notes:
(1) Based on ADMM BOD_5 and TSS concentration of 230 and 213 mg/L, respectively.
(2) ADWF capacity = ADMM capacity divided by 1.20.
(3) Based on ADWF BOD_5 and TSS concentration of 243 and 220 mg/L, respectively.
(4) During periods when one FFR is out of service, a portion of primary effluent can be bypassed around the FFR and sent directly to the aeration basins.
(5) Based on 4-day aerobic SRT.
(6) Based on 5-day aerobic SRT.
(7) Based on MLSS concentration of 3,500 mg/L.
(8) Based on MLSS concentration of 4,500 mg/L.
(9) Assumes fourth unit will be rehabilitated and used.
(10) Based on cake concentration of 25 percent.

Based on the ADWF projections of 28.6 to 34.0 mgd in 2062 (as presented in Chapter 3), it appears there is adequate organic loading capacity at the plant for virtually the entire planning period. Although the FFR capacity is noted as 31.7 mgd, it may be preferable to operate the units at a slightly higher loading rate (less than 5 percent greater than recommended criteria) to avoid the high cost of constructing another unit. Alternatively, when the FFRs are rehabilitated, the cost-effectiveness of raising the height of the media and walls should be considered in relation to the potential process benefits. The gravity thickeners and incineration capacity fall short of the projected 2062 flow if a unit is taken out of service. Should this occur, the City would need to plan accordingly with temporary facilities or by constructing additional capacity.

It is important to note that the results of the organic loading capacity analysis are based on the number and configuration of the existing process units at the plant. If the secondary process is expanded in the future and the process configuration is changed to meet future regulations, the capacity of the solids handling facilities (i.e., thickening, dewatering, and incineration) will increase. This is due to the fact that the aeration basins would be operated at longer SRTs, which will reduce the amount of sludge generated and increase the capacity rating of the solids handling facilities.

The capacity ratings identified for the aeration basin are calculated based on the volume needed to maintain a minimum SRT. To realize this rated capacity, the City may need to increase the capacity of the aeration equipment if anaerobic digestion is implemented in the future. The existing total capacity of the aeration system is 54,600 scfm with all blowers in service. This much aeration would be necessary due to the increased ammonia load and oxygen demand returned in the dewatering filtrate if anaerobic digestion were implemented. Additional aeration equipment capacity may also be needed if the City desires to continue to operate the aeration basins at a dissolved oxygen (DO) concentration of 4 mg/L, which was the average concentration in 2009. The City began testing the performance of the existing activated sludge process at DO levels of 2.0 mg/L and experienced rising nitrites, ammonia, and and breakpoint chlorination at the recycled water plant. The City decided to return DO levels to 4.0 and lower them 0.1 mg/L every 2 weeks to determine the lowest setpoint at which nitrite levels will not increase. The City should continue to monitor the progress of lowering the DO levels in the basins. If lower DO levels are not achievable, the sizing for aeration equipment may need to be revisited as loads increase over time and when and if anaerobic digestion is implemented. Aeration air requirements for each of the liquid treatment alternatives are presented in Chapter 8 of this report.

4.4.3 Operational Data Collection

The RWQCP currently tests for approximately 70 different parameters in 10 different main process sample streams. This monitoring allows for a very good assessment of the performance of most unit processes. However, there was some additional special sampling required as part of this LRFP to better assess the performance of more specific process units. SVI readings were taken to characterize the settleability of the activated sludge to be used for assessing the capacity of the secondary treatment system. In addition, primary sludge, DMF backwash, gravity thickener overflow, incinerator belt press filtrate and scum hopper overflow samples were also collected to help assess the performance of the existing solids handling systems.

It is therefore recommended that SVI, primary sludge, DMF backwash, gravity thickener overflow, incinerator belt press filtrate, and scum hopper overflow samples be included in the regular sample schedule so that performance evaluations on these units can be trended, and thickening and dewatering capture rates can be more accurately calculated in the future.

Additionally, because of the emphasis on solids treatment in this LRFP and the impact that sludge flows can have on the treatment train capacity, it is also recommended that a flow meter be installed on the primary sludge stream to the gravity thickeners.

Chapter 5
EXISTING PLANT ASSESSMENT

5.1 INTRODUCTION

An assessment of the physical condition and remaining useful life of the existing mechanical equipment was performed as part of this Long Range Facilities Plan (LRFP). This mechanical assessment also provided the opportunity to identify operating deficiencies and potential modifications or enhancements necessary to optimize operations including energy efficiency measures. The results of the assessment are used to estimate the cost to modify or rehabilitate existing facilities. The structural components of the facilities were assessed in 2006 and results of that assessment were also considered as part of this LRFP in order to determine future process and equipment needs and to develop data for comparing existing facilities/equipment with alternative technologies.

5.2 CONDITION ASSESSMENT

Carollo Engineers, Inc (Carollo) performed a visual condition assessment on December 9, 2010 of the facilities with the focus on assessing mechanical equipment. The assessment used a standard asset management approach as established in the International Infrastructure Management Manual (IIMM), Version 3.0, 2006, written by the Association of Local Government Engineering New Zealand, Inc (INGENIUM) and the Institute of Public Works Engineering of Australia (IPWEA). The assessment team consisted of specialists in the process, mechanical, and electrical engineering disciplines. The Regional Water Quality Control Plant (RWQCP's) veteran operator/assistant manager, Howard Yancey, accompanied the team throughout the assessment and provided information on operations and maintenance history for each process area. In some instances, operators of specific process areas were also available to provide additional information. The mechanical equipment assessment findings are summarized in this section.

The information provided in this chapter on existing RWQCP structures and some process piping is based on the findings presented in the 2006 Facility Condition Assessment (FCA) Final Report compiled by Kennedy/Jenks (K/J) Consultants. K/J performed a comprehensive FCA evaluating the condition of concrete and metal structures and limited process piping that was of concern to the RWQCP staff, but did not cover mechanical equipment. Appendix C contains K/J's assessment summary and Appendix D contains the list of recommended retrofits (costs in 2006 U.S. dollars) for RWQCP structures as presented in the 2006 FCA Final Report.

5.2.1 Summary

The general findings of the condition assessment are that while much of the RWQCP unit processes and equipment are nearing the end of their useful life and will be considered for replacement, they have been well maintained and operated. Figure 5.1 shows an aerial view of the existing facilities, major pipelines, and plant boundary. A summary of the major findings and replacement costs by process area are shown in Table 5.1. Appendix E contains the complete and detailed list of the facilities by asset, useful life, condition, assessment notes, the recommended actions, and cost estimates. Condition of each asset is ranked on a scale that is an internationally accepted, industry-wide standard for designating asset condition. The ranks range from 1 (very good) to 5 (unserviceable). The repair/replacement cost estimates shown in Table 5.1 and Appendix E are planning-level project cost estimates based on the standard procedure described in the LRFP Basis of Cost TM (Appendix M). For those construction costs that are taken from K/J's 2006 FCA, the 20-Cities average ENR CCI for 2006 was assumed with a 40 percent contingency to account for engineering, legal, administrative fees, construction management, and environmental permitting/mitigation necessary. This additional contingency brings these estimated construction costs to project costs. In Table 5.1, we are only showing the costs for structural projects identified by K/J that have not been completed as of July 2010.

Appendix E also includes a repair and replacement schedule based on the results of the condition assessment. The resulting recommendations were determined based on both the original useful life of the equipment and the condition as noted/available during the assessment. Detailed findings of the condition assessment are summarized in the following sections, organized by process area.

5.2.2 Headworks

The following is a list of specific findings related to the headworks process area of the RWQCP.

1. The Motor Control Center (MCC) for the New Pumping Plant (NPP) pumps was originally constructed with the NPP building and installed in 1972. The air duct piping clearance within the building is not built to code since it is too close to the MCC.
2. The NPP Pump Nos. 1, 3, 4, and 6 were installed in 1972, and Pump Nos. 2 and 5 were installed in 1987. The pumps have been well maintained since – regularly rotated based on the number of hours operated and were rebuilt in the late 1990s. The pumps have minimal vibration, but were a source of significant noise and require continuous backwater in the 72-inch diameter joint interceptor sewer line in order to prevent cavitation. The NPP pump motors were upgraded to variable frequency drives (VFDs) – Pump Nos. 1 and 2 in 1987, Pump Nos. 3, 5, and 6 in 1993, and Pump No. 4 in 1998. Motors do not have vibration monitoring and their termination domes are too close to the MCC creating a work clearance issue. The manual-auto VFDs on Pump Nos. 5 and 6 were not connected and corrosion was showing at the coupling.

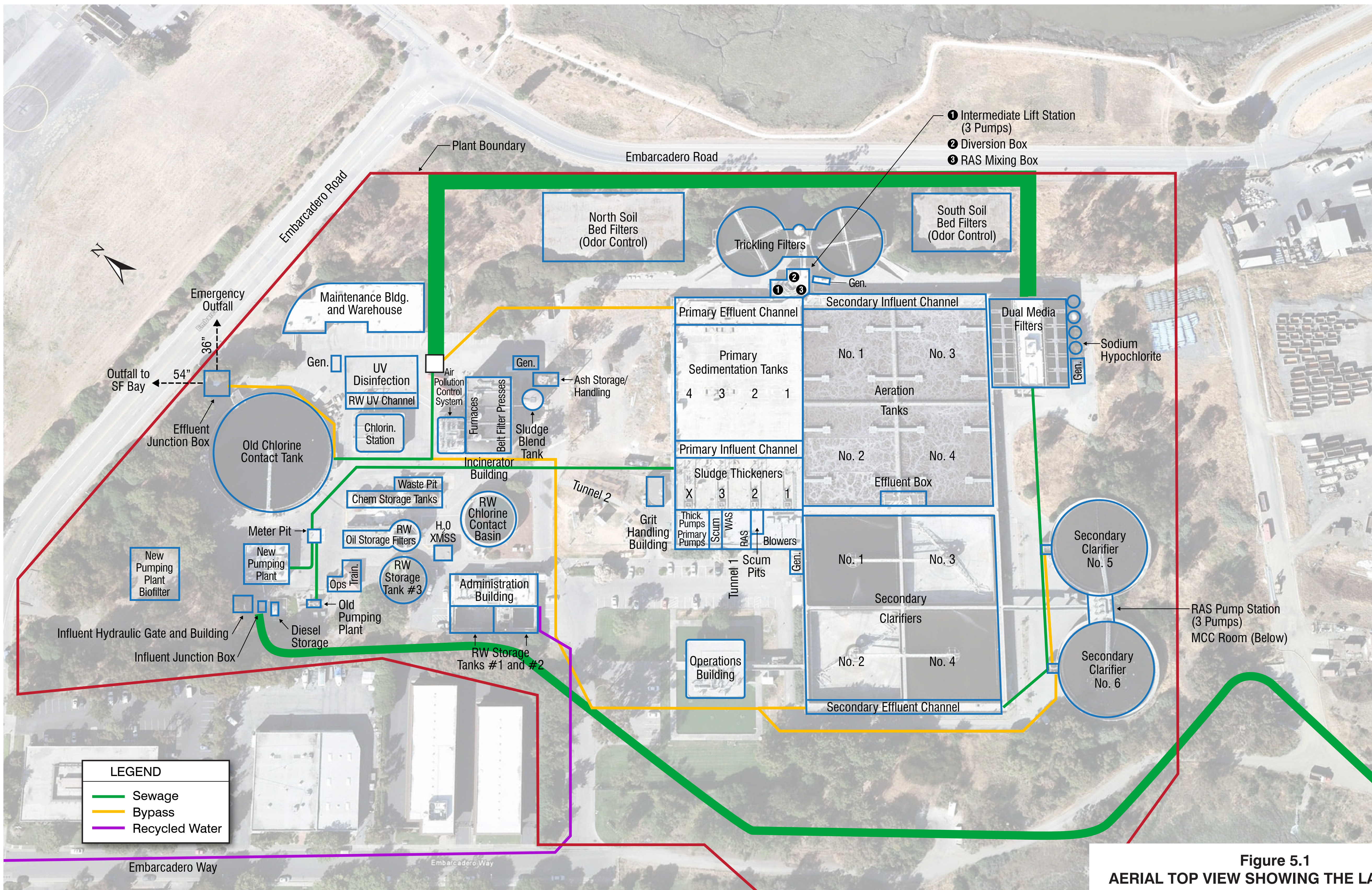


Figure 5.1
AERIAL TOP VIEW SHOWING THE LAYOUT OF EXISTING FACILITIES WITH MAJOR PIPELINES
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f6-8510.ai

Table 5.1 Summary of Condition Assessment Findings					
Process/Area	Installation Year	Condition[1]	Project Costs for R&R[2]	Comments	Recommended Action
Headworks					
Headworks Buildings	1956 (OPP) 1972 (NPP)	N/A	$1,166,000	OPP near the end of its useful life. Air duct piping in NPP too close to MCC (not to code). NPP in good condition.	New Headworks identified to replace the NPP & OPP within next 10-20 years.
Headworks Pumps	NPP 1, 3, 4, & 6 - 1972 NPP 2 & 5 – 1987 OPP 7, 8, & 9 - 1956	3/4	$1,694,000	OPP pumps not controlled by SCADA. Pumps are older but well maintained, have minimal vibration, but high noise.	New Headworks identified to replace the NPP & OPP within next 10-20 years.
Grit Handling System/Facility	1988	3	$550,000	Cyclone and classifier replaced in 2005 and are in good condition. Facility is in fair condition.	Replace in next 10-20 years & relocate to new Headworks.
Screening	1993	3	$1,833,000	Spray water noisy. Exhaust fan noisy. Near the end of their useful life.	Replace in next 5-10 years.
Primary Treatment					
Primary Sedimentation Tanks, Influent Channel, & Effluent Channel	1972	3	$7,313,000	Near end of useful life. Corrosion and grease buildup inside, including corroded gates. Cracks and exposed rebar on the roof.	Perform rehabilitation measures per K/J 2006 FCA retrofit recommendations in next 5-10 years.
Primary Sludge Grinding/Pumping	1985/1972	3	$657,000	Pumps 1, 2, and 4 near end of useful life.	Replace in next 5-10 years.
Secondary Treatment					
Fixed Film Reactors, Equipment Room, & Soil Bed Filters	1980 & 1999	4	$912,000	Structural assessment needed. Leakage. Top layers of media weathered.	Rehab the facility per K/J 2006 FCA retrofit recommendations. Replace top layers (3-4 ft) of media.
Aeration Basins	1972	3	$2,466,000	Structural inspection needed to determine remaining useful life.	In next 5-10 years, rehab the facility per K/J 2006 FCA retrofit recommendations.
Aeration Ceramic Dome Diffusers	2009	N/A		New.	No immediate action necessary. Replace by 2019.
Secondary Clarifiers 1-4 & 5-6 and Slide Gates	1972 & 1988	3	$6,931,000	Verify mechanisms level across basin. Corrosion. Short-circuiting occurs due to sidewall not being deep enough. Corners and corner sweeps are problematic.	Rehab mechanical equipment in next 5-10 years. Structural rehab in next-25 years per K/J 2006 FCA retrofit recommendations.
Blowers/Building	1972	3	$1,673,000	Old units. Require frequent attention but work sufficiently.	Replace in next 5-10 years.
RAS Pumping	1972 & 1988	3	$648,000	Pumps appear in good working order. Minimal corrosion.	Replace in next 5-10 years.
Intermediate Pump Station	1988	3	$339,000	Motors not high efficiency. Added for pumping high wet weather flows. Infrequently operated. Reasonably good shape.	Replace in next 10-15 years.

Table 5.1 Summary of Condition Assessment Findings					
Process/Area	**Installation Year**	**Condition[(1)]**	**Project Costs for R&R[(2)]**	**Comments**	**Recommended Action**
Tertiary Treatment					
Dual Media Filters & Equipment Room	1980	2	$604,000	Old but functionally sufficient.	Rehab facility per K/J 2006 FCA retrofit recommendations.
Dual Media Filter Pumping	1980	3	$476,000	Functional but at end of their useful life and piping is thin.	Replace in next 5-10 years.
Disinfection / Recycled Water					
Ultraviolet Disinfection	2009	1		New – excellent condition.	No immediate action necessary.
Chlorine Contact Tank	1972	N/A		Repurposed tank to serve as a chlorine contact tank. Functional but nearing the end of its useful life.	Replace chlorine contact tank by end of its useful life to accommodate future changes to RWQCP layout.
Recycled Water Filters	1975	N/A		Repurposed structure to serve as recycled water filters. Functional but nearing the end of its useful life.	Replace recycled water filters by end of its useful life to accommodate future changes to RWQCP layout.
Recycled Water Pumping	2009	N/A	$372,000	New.	Replace at end of its useful life.
Solids Treatment and Handling					
WAS Pumping	1988	4	$100,000	Requires significant maintenance.	Replace in next 5-10 years.
Gravity Thickeners	1972	3	$625,000	Grease line shared with other thickeners. Requires significant effort to recondition due to corrosion. Work well.	Rehab facility per K/J 2006 FCA retrofit recommendations.
Sludge Transfer Pumping	1980	3	$342,000	Approximately 10 years of useful life remaining.	Replace in next 5-10 years.
Scum Pumps, Grinders, & Concentrator	1980	3	$420,000	Concrete corrosion.	Replace in next 5-10 years. Replace with new RWQCP solids process.
Sludge Blending Tank & Mixing Pumps	1999	3	$222,000	Some corrosion. Functionally sufficient, but verify with structural assessment.	Replace in next 10-15 years. Perform K/J 2006 FCA Retrofit Recommendations.
Belt Filter Press Dewatering, Pumping, & Polymer System	1985 & 1999	2	$232,000	Some corrosion, but unit works well.	Replace when new RWQCP solids process implemented.
Air Pollution Control Vessels	1999	2		Sufficient.	No immediate action necessary. Costs included in solids alternatives with thermal conversion processes.
Ash Storage System	2002	2	$20,000	Good condition.	Perform K/J 2006 FCA retrofit recommendations. Replace if solids handling process is replaced with a thermal conversion process.
Miscellaneous Plant Buildings					
Oil Storage Building	1956	N/A	$419,000	Refer to Appendices C and D.	Likely need to replace facility to accommodate changed layout.
Administration Building	1975	N/A		Near end of useful life. Refer to Appendices C and D.	Replace with new RWQCP Environmental Services Building.
Operations Building	1972	N/A	$770,000	Refer to Appendices C and D.	Renovate and move laboratory into new RWQCP Environmental Services Building.
Tunnels 1 and 2	1972	N/A	$92,000	Refer to Appendices C and D.	Perform measures recommended by K/J 2006 FCA within next 5-10 years to existing facility.
Maintenance Facility and Warehouse	1983	N/A	$273,000	Refer to Appendices C and D.	Perform measures recommended by K/J 2006 FCA within next 5-10 years to existing facility.

Table 5.1 Summary of Condition Assessment Findings

Process/Area	Installation Year	Condition[1]	Project Costs for R&R[2]	Comments	Recommended Action
Miscellaneous Plant Buildings (continued)					
Chemical Storage	1972	N/A	$59,000	Refer to Appendices C and D.	Perform measures per K/J 2006 FCA within next 5-10 years to existing structure. Need to reexamine structure in next 5-10 years as decisions are made for changes to RWQCP layout.
Influent Gate Hydraulics Building	1956	N/A	$50,000	Refer to Appendices C and D.	Rehab with NPP and OPP Buildings or replace with new Headworks.
Plant Power					
Generators	1984	2	$1,296,000	Old generators do not work with transfer switches due to MCC age and VFDs at the NPP, DMF, and FFRs.	Replacement of older generators (from mobile to stationary) already under way.
MCC (between Secondary Clarifiers 5 and 6)	1988	N/A	$135,000	Has 5 to 10 years of useful life remaining.	Replace in the next 5 to 10 years.
MCC (Sludge Pump Room)	1972	N/A	$488,000	Has exceeded its useful life.	Replace in the next 5 to 10 years.
MCC (NPP)	1972	N/A	$352,000	Has exceeded its useful life.	Replace in the next 5 to 10 years.

Notes:
(1) Condition rating ranges from 1 (very good) to 5 (unserviceable). The condition shown is the lowest condition of the items in each project package. When the condition is not available, an N/A is inserted.
(2) Planning level project costs in 2015 dollars.

3. The Old Pumping Plant (OPP) building was originally constructed in 1956 and the original MCC is still in use. The OPP was not in operation during the assessment and is only used during heavy wet weather events, for NPP maintenance, and for NPP isolation knife gate valve exercising (i.e., the OPP is infrequently operated). However, there are reports of excessive noise and vibration while the pumps (nos. 7, 8, and 9) are in operation. It is not controlled by the RWQCP Supervisory Control and Data Acquisition (SCADA) system. There has been flooding of the OPP in the past and electrical conduit is exposed within the structure. There is existing budget to rehabilitate the OPP if it is decided to do so.

4. The three bar screens are nearing the end of their useful life (latest construction was complete in 1993) and need better accessibility. The spray water is noisy at Bar Screen No. 1 and the exhaust fan is noisy at Bar Screen No. 3 (Bar Screen No. 2 was out of service during the assessment).

5. The Meter Pit, originally constructed in 1972, is nearing the end of its useful life and needs to be upgraded. However, the meters and gate valves were replaced in 2007 and are in good functioning condition.

6. The Grit Handling facility was originally constructed in 1988 (refer to Appendices C and D for K/J’s assessment and recommended retrofit). The electrical system panels are corroded and in poor condition. The lighting in the facility needs to be replaced.

7. The 60-inch diameter force main taking screened influent to the Primary Sedimentation Tanks was recently (2011) patched for repair at the meter pit due to a 0.5-inch hole in the spool piece that was promptly replaced. It appears to be an isolated incident due to a post-construction field weld.

5.2.3 Primary Treatment

1. Primary sludge Pump Nos. 3a and 3b were replaced with a single pump in 2001. Pump Nos. 1 a/b, 2 a/b, and 4 a/b are at the end of their useful life and need to be replaced.

2. The four Primary Sedimentation Tanks (PSTs) Nos. 1 through 4 and their influent and effluent channels are enclosed structures originally constructed in 1972 and are nearing the end of their useful life. The plant staff stated there is corrosion and grease buildup in areas inside, including corroded gates. Cracks and exposed rebar were observed on the roof of the PSTs during the assessment. It is suspected that there is corrosion of concrete at the water line as well.

Figure 5.2 Cracks Observed on the Primary Sedimentation Tanks Roof

3. The Intermediate Pump Station (IPS) was incorporated into the plant for high flow events to bypass the Fixed Film Reactors (FFRs) since the RWQCP staff found that the FFRs did not perform well under high flow conditions. Pump motors are not high efficiency motors, and are rarely used. The RWQCP needs to exercise the IPS at least weekly to maintain the facility. Staff need to consider the life of the pumps before upgrading the IPS. Pump Nos. 2 and 3 currently have some vibration and noise during operation and are showing some corrosion.

5.2.4 Secondary Treatment

1. The North and South FFRs appear to have structural damage (e.g., leakage) and corrosion and need to be re-assessed to determine the level of rehabilitation required (refer to Appendices C and D for K/J's assessment and recommended retrofits).

2. The North and South FFR Equipment/Pump Room's lighting level is low and needs to be increased.

3. There is a mobile 500-kilowatt (kW) generator with a manual transfer scheme outside the FFRs – the City is planning to replace it with a stationary one that has an automated transfer switch scheme.

4. The top layers (~3 feet deep) of the FFR media needs to be replaced since it is degrading from age and exposure to the sun. There is also buildup of scum on the media resulting in decreased performance.

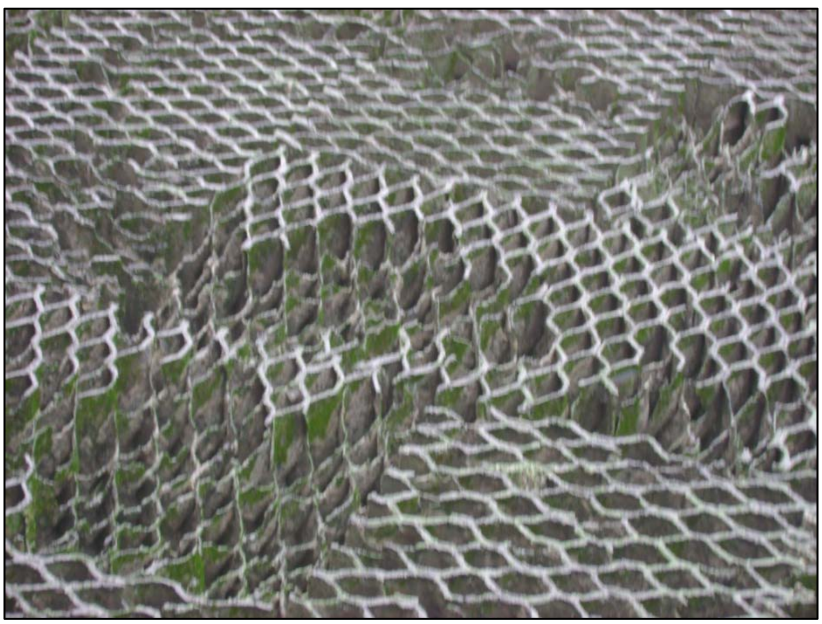


Figure 5.3 Top Layers of Fixed Film Reactor Media are Aging and Showing Buildup

5. The Aeration Basin (AB) influent channel's air piping needs to be checked for leaking (i.e., efficiency) and needs to be recoated.

6. K/J's assessment recommended retrofits on additional AB equipment and structures (included in Appendices C and D).

7. A blower control project was completed in January 2012 led by Turblex (the manufacturer replaced three of the five blowers in use).

8. The AB slide gates appear to be in good working condition.

9. The AB fine bubble diffusers were last replaced in 2009 and have a 10-year original useful life. The remainder of the air system will need to be replaced when the next bubble diffuser replacement is due (2019). While the ceramic dome air diffuser system appeared to be working sufficiently, the RWQCP staff would like to evaluate other diffuser technologies in the future.

10. The coal tar epoxy coating of the MLSS steel piping is flaking.

11. The four Square Secondary Clarifier (Nos. 1 through 4) structures appear to be in working condition (refer to Appendices C and D for K/J's assessment and recommended retrofits), but there is visible corrosion. A structural evaluation is recommended for the effluent channel. There is also short-circuiting occurring due to the sidewalls not being deep enough and the corners of the structures pose problems for the sweepers. The weirs need to be checked to ensure they are level across the basins. In addition, the slide gate has visible corrosion.

Figure 5.4 Visible Corrosion on the Secondary Clarifier Equipment

12. Square Secondary Clarifier collector mechanisms were rehabilitated in 1999 (inner rings are rusting), but should have been replaced. Secondary Clarifier No. 2 has experienced failure since rehabilitation. The RWQCP staff would like to replace existing mechanisms with more stainless steel components at next replacement.

13. The stationary generator serving the Round Secondary Clarifiers, Blower Room, and Operations Building needs provisions for a permanent load bank, currently the City uses the actual load to exercise the generator set which has automated transfer switches.

14. The torque switches at the Square Secondary Clarifiers need to be tested since the RWQCP staff is not sure how well they perform/function. While the electric connection works, there is uncertainty about whether the switches would activate in a high torque situation.

15. There is effective scum removal from the Square Secondary Clarifiers. Need to install a mechanism at lower level to get scum out. Scum is sometimes entering the Dual Media Filters (DMFs) negatively affecting its performance since the scum carries media away and/or blinds the filter media reducing filtration capacity.

16. The City has not frequently taken the two Round Secondary Clarifiers (Nos. 5 and 6) out of service since they were constructed in 1988 (refer to Appendices C and D for K/J's assessment and recommended retrofits). Weirs appear to be relatively level across the round clarifiers. Bird droppings and sea air appear to be negatively affecting the metal surfaces as is evident on the control panels and there is concern about the impact to the rake arms. The slide gate has visible corrosion. The structures require paint and corrosion protection for the motors and bull gear to extend their useful life.

17. The Round Secondary Clarifier electrical room contains MCC and needs new lighting. The existing VFDs (Allen Bradley) replaced older ones (Eaton) that failed frequently. The isolation transformers were disconnected after replacing the VFDs since the City said they were too noisy.

18. The Round Secondary Clarifiers do not experience the same problems as the Square Secondary Clarifiers – the energy dissipation sidewall depth is better (refer to Appendices C and D for K/J's assessment and recommended retrofits).

19. Return Activated Sludge (RAS) pumps 1, 2, and 4 are located indoors and appear to be in good working condition. The pumps have minimal corrosion and are in much better condition than equipment located outdoors.

5.2.5 Tertiary Treatment

1. The DMFs were originally constructed in 1980 and are functional (refer to Appendices C and D for K/J's assessment and recommended retrofits), but have since undergone some modifications to the controls.

2. A 500-kW portable generator is outside the DMFs and needs to be replaced with a permanent generator having automatic transfer switches.

3. Refer to Appendices C and D for K/J's assessment and recommended retrofits for the DMF Equipment Building.

4. The DMFs had high efficiency motors installed in 1980. While the pumps are functional, they are at the end of their useful life and piping is thin. Backwash supply water header is 24 inches. End cap blew out. Coating is coal tar epoxy. Penetrations project has been done – there may be more pipe penetration issues at floor level. Piping needs to be rehabilitated with an FRP pipe wrap.

5. Energy consumption is a concern at the DMFs. The RWQCP wants to reduce the Total Suspended Solids (TSS) coming into the DMFs since the DMF media is clogging, requiring backwash every 24 hours to achieve a TSS of 1 to 2 parts per million (ppm) out of the DMFs and an Ultraviolet Transmittance (UVT) of 65-69 percent. A filter run time of 36 hours is a targeted goal.

5.2.6 Disinfection / Recycled Water

1. The UV disinfection system is new and started running in 2009, and is in excellent condition.

2. The former and now abandoned Chlorine Contact Tank may be rehabilitated and retrofitted with a cover in order to increase recycled water storage capacity and reduce algal growth in the retrofitted storage tank.

3. While the Chlorine Contact Tank and Recycled Water Filters are functional, both facilities were repurposed to function as they are now. Both facilities are nearing the end of their useful lives, the RWQCP staff should consider relocating and replacing each facility to accommodate future changes to RWQCP process/building layout.

4. Refer to Appendices C and D for K/J's assessment and recommended retrofits for the Water Reclamation Filters structure.

5. Refer to Appendices C and D for K/J's assessment and recommended retrofits for the Water Reclamation Tank.

5.2.7 Solids Treatment and Handling

1. The four Thickeners (Nos. 1 through 4) were originally constructed in 1972 and were rehabilitated in the 1990s. Thickener No. 4 was never fully functional due to hydraulic issues; therefore, its mechanical equipment was removed in 2002. The other units (Nos. 1 through 3) work well; however, reconditioning is required due to corrosion (refer to Appendices C and D for K/J's assessment and recommended retrofits).

2. The sludge muffin monsters are working well, but need to be rehabilitated to maintain reliability.

3. Scum Pit A is clogged with debris and needs significant cleaning. Scum Pit B is well maintained, but the concrete is showing some corrosion.

4. The sludge feed pumps are located in the same room as some of the MCCs and require considerable maintenance. Need to consider replacing the sludge feed pumps and relocating them to a new pump room in the next 5 to 10 years.
5. The three mixed sludge pumps (installed in 1980) are nearing the end of their useful life, but appear to be working well with some maintenance.
6. The Sludge Blend Tank appears to be functioning properly (refer to Appendices C and D for K/J's assessment and recommended retrofits). It is recommended to have a structural assessment to better understand its remaining useful life.
7. The City wants a VFD for the Induced Draft (ID) fans as the motors consistently run at 100 percent and the furnace draft is controlled by the way of a damper valve, potentially wasting energy. As part of adding a VFD, the fan would need to be replaced and the controls system modified to accommodate a switch from damper control to VFD control.
8. Separate reports present results of the seismic analyses for the existing Multiple Hearth Furnaces (MHFs) and the Incinerator Building – they are entitled "Incinerators - Seismic Evaluation Technical Memorandum" (Appendix F) and the "Seismic Evaluation of the Piles Supporting the Incinerator and Operations Buildings Technical Memorandum" (Appendix G), respectively. The latter of the two technical memorandums found the piles of the Incinerator Building are seismically deficient and need to be retrofitted.
9. The two MHFs were originally constructed in 1972 (are now 40 years old) and are one of only two incineration operations at a wastewater treatment plant in California. They are of an older generation and are not a good candidate for producing renewable bioenergy.
10. There is visible corrosion within the hearths of each MHF. The controls have been upgraded and each MHF is regularly rehabilitated (i.e., the RWQCP rotates use of them each year – while one is in operation for the year, the other is being cleaned and rehabilitated). They need more complex repairs as they age (steel is rusting, bricks are shifting, etc.).
11. While the MHFs could go offline for repairs due to an earthquake for example, temporarily hauling the solids to a landfill is complicated.

Figure 5.5 Corrosion Inside the Hearths of the Multiple Hearth Furnaces

12. The MHF's original manufacturer (BSP Thermal Systems) is supporting manufacture of replacement parts such as specialty refractory bricks, rabble arms and teeth, furnace doors, center shaft lute caps, and bearings for the older sewage sludge MHFs around the U.S. Multiple hearth furnaces continue to be used for industrial applications, but are no longer designed for sewage sludge applications. A critical part of maintenance is manufacturer support of legacy products. BSP Thermal Systems has indicated that they plan to remain in business and support parts replacement. If BSP Thermal Systems was sold or went out of business, engineering records would be transferred to a new owner and the cast iron parts and brick designs would continue. Should this support system change, the furnaces would need to be retired as soon as possible.
13. The MHFs produce a hazardous waste ash due to a high level of soluble copper, requiring that it be hauled a long distance to a hazardous waste landfill.
14. The Ash Storage System is in good condition (refer to Appendices C and D for K/J's assessment and recommended retrofits).
15. The two Air Pollution Control Vessels (Nos. 1 and 2) appear to be functioning well (refer to Appendices C and D for K/J's assessment and recommended retrofits). However, U.S. EPA air regulations are heading in a direction where compliance may not be possible. New air pollution control equipment is costly and could be on an implementation timeline that the RWQCP cannot meet.

5.2.8 General

1. K/J found that loads transferred to the Operations Building piles during a design seismic event may exceed the allowable axial and horizontal pile load capacities recommended by ENGEO, Inc. by as much as 30 percent. Refer to Appendix G (Seismic Evaluation of the Piles Supporting the Incinerator and Operations Buildings Technical Memorandum) for the detailed analysis.

2. K/J found that the soil bearing pressure beneath a footing for one of the Maintenance and Warehouse Facility's lateral force resisting steel frames would exceed the allowable pressure recommended by Treadwell & Rollo. It was also determined that the Mezzanine Level Storage Platform located in the Maintenance and Warehouse Facility needed to be bolted to the floor and the existing Platform cross-bracing system needed to be improved in order to withstand a design seismic event.

3. There are seven Generators onsite at RWQCP (two inside the NPP, one north of the UV structure, one south of the IPS, one northeast of the Ash Storage System, one adjacent to Secondary Clarifier No. 1, and one near the southwest corner of the DMFs) – the older generators do not work with transfer switches due to the age of the MCC and the Adjustable Frequency Drives (AFDs) and VFDs at the NPP. The RWQCP wants to pair VFDs with any new motor. The transfer switch at the NPP needs to be addressed as part of the generator project (i.e., Arc Flash study).

4. In general, MCCs have not been replaced. The City wants to consider Smart MCCs.

5. In the 1970s, conductors were repaired and in 1988 a short-circuiting study was performed on the conduits. However, no short circuiting study was conducted prior to or following the construction of the UV system in 2010. A short circuit study needs to be performed to ensure the equipment is adequately rated and can safely interrupt the worst-case fault.

6. The OPP, NPP, DMF, and Incinerator Buildings (i.e., areas of lift pumps having 2-inch conduit) have conduit showing with visible corrosion. The RWQCP needs to replace the conduit and wants to modify their specifications for the conduit to have a plastic cover.

7. Spiral weld steel and electric resistance welded (ERW) piping is not the standard wall thickness - too thin.

8. Plant staff stated that the 12-kilovolt (kV) cable may not be in good condition and needs to be assessed to determine if it needs to be replaced.

9. Plant air – need to check for leaks, may need to modify air storage and blowers. Largest use of plant air is to transfer ash. Plant air accounts for approximately three percent of total power use plant-wide.

5.3 OCCUPIED BUILDING DEFICIENCIES

The Administration Building, Operations Building, and Maintenance Building and Warehouse are the occupied buildings on the RWQCP site. This section documents each building's deficiencies and needs as determined by LRFP project team.

5.3.1 Administration Building

The Administration Building was originally constructed in 1975 as a recycled water process and pumping facility with two deep open top rectangular tanks and one open top rectangular equipment pit. During the three remodeling projects (in 1992, 1995, and 1998), administrative offices were constructed over the open top equipment pit. The recycled water pumps are still in the basement of the building. The building was originally constructed of cast-in-place reinforced concrete roof, walls, and floors. The heavy concrete basement floor slab and walls are supported on concrete piles. Each remodeling effort added office spaces with wood framed structures constructed over the original open top equipment pit.

Based on K/J's FCA, there was visible deterioration and a potential structural deficiency with the wood framing at the anchorage to wall making it subject to cross-grain bending under seismic loads. In general, the administration building is very cramped and inadequate for the number of people utilizing the space.

Staff has identified the following issues and elements to be addressed for the Administration facilities:

- Need an office building for more people and uses (i.e., ≥35 people, a laboratory, conference rooms, etc.).
- There is no clear plant entrance/public access area for visitors and tour groups. Visitors frequently go to the operations building instead of the administration building.
- There is inadequate parking for visitors, especially educational tour groups.
- Need to consider the building's architecture, vegetation buffer, etc., especially if the Administration Building is relocated to along Embarcadero Road.
- Supervisors need walled-in offices for private conversations.

5.3.2 Maintenance Building and Warehouse

The maintenance building and warehouse structure was originally constructed in 1986. The building is a steel-framed structure supported by a concrete slab-on-grade foundation with continuous interior and exterior spread footings. Maintenance and storage areas are located on the southeast side of the building and office spaces are located on the northwest side. While the structure has exceeded its original useful life, it is in relatively good condition with few visible signs of damage or deterioration. Only one calculated structural deficiency was noted for this structure in K/J's FCA. Re-purposing has resulted in lack of maintenance and warehouse space. Supervisors lack walled-in offices for private conversations. In general, the space utilization could be improved if office space was provided elsewhere. Additional storage and warehouse space is needed at the plant due to the increased need to store spare parts as a result of plant expansions and discharge permit requirements to maintain the plant in a state of "operational readiness."

5.3.3 Operations Building

The operations building was originally constructed in 1972 and houses laboratory testing stations and equipment, offices, a large lunchroom, and locker rooms. The building is constructed of reinforced concrete supported by a structural slab-on-grade foundation with pier and grade beams. As discussed in Appendix G, this building's foundation piles are inadequate to resist seismic loading and a structural retrofit is required. Additionally, staff has identified the following issues:

- The existing laboratory space and layout within the Operations Building is deficient given current testing space requirements and number of laboratory staff.
- Having a laboratory on the second floor of a building with no elevator causes issues for the frequent deliveries required.
- Laboratory needs to be relocated and expanded.
- The lunch and training room should be combined.
- Additional locker room space is needed.
- The building should be retrofitted with dual-paned windows.
- Supervisors require walled-in offices for private conversations.

5.4 OVERALL PLANT SPATIAL CONSIDERATIONS

Prior to, during, and following the condition assessment and project alternatives development, meetings were held with plant staff to discuss the needs for both occupied/unoccupied and process related structures. Because the RWQCP site is very limited in spatial extent, it was important that the needs for staff and process operations were well documented and considered throughout the LRFP process. This section describes the needs that were identified while considering existing structural deficiencies and future needs.

The overall spatial considerations will be discussed starting from the north to the south end of the plant site.

In general, as permanent structures are being considered for the LRFP, the major pipelines within the RWQCP site and Outfall Box need to be avoided, including the:

- 72-inch diameter joint interceptor sewer line
- 60-inch diameter line to the PSTs
- 72-inch diameter emergency bypass line
- 60-inch diameter line from Secondary Clarifiers to DMFs
- 60-inch diameter DMF bypass line
- Two 96-inch diameter effluent lines (with the exception of implementing a new effluent line)

The Administration Building needs to be replaced in the near term and the RWQCP staff prefers that it be relocated closer to the Maintenance Building (i.e., north side of the RWQCP site) and toward the periphery of the site. Therefore, space needs to be preserved for a two-story building and parking lot west of the Maintenance Building and south of the outfall box. Alternative locations include a commercial site nearby the RWQCP. Another potential location is adding to the Operations Building and modifying the existing moat feature. Each option has tradeoffs.

Due to the Palo Alto Airport runway path, the buffer lands located on the east side of the plant should not be utilized for any occupied space (per Airport Land Use Commission Guidelines issued by Santa Clara County). Use of this area for unoccupied facilities such as additional warehouse space or unit processes would be acceptable. Additional Warehouse space has been identified for the area behind the existing Maintenance Building/Warehouse space.

The area between the Maintenance Building and the UV Disinfection process is limited and the plant staff prefers to remove the parking spaces from that area to allow solids hauling trucks to use the western entrance, if necessary. The existing Oil Storage Building can also be relocated as necessary. However, the Chemical Storage area needs to remain in its location.

The structures (tanks and buildings) southwest of the Meter Pit and Chemical Storage area can be removed and relocated as necessary to clean up the site. Specifically, the buildings that can be removed or relocated include the Ops Training Building, Oil Storage Building, Recycled Water Filters, Recycled Water Chlorine Contact Basin, Recycled Water Storage Tanks 1, 2, and 3, Administration Building, and Utilities Department Transmission group field offices.

The Household Hazardous Waste (HHW) Building is currently sited southwest of the Operations Building. The RWQCP staff needs to consider that it needs to be staffed and the use of it will increase with the closing of the recycling center.

The RWQCP staff prefers that unit process structures be placed toward the center of the site, if possible. The solids treatment alternatives layouts are to be placed in the area southeast of the existing incineration process (i.e., northwest of the PSTs). If the preferred liquids treatment alternatives layouts require too much area onsite, the RWQCP staff will consider using a nearby building for a new Laboratory and Environmental Services Building. It is assumed that the existing commercial building would need to be demolished and rebuilt to satisfy the needs of the new Laboratory and Environmental Services Building.

Space needs to be allocated for several structures common to all project alternatives, a new Headworks building, new Recycled Water Filters, new Chlorine Contact Tank, and new Recycled Water Storage in the northwest corner of the RWQCP site. Space also needs to be allocated for the potential addition of an ozonation process (i.e., liquid oxygen tanks and an ozone dissipation chamber) to meet potential future regulations.

The new facilities requirements and layouts will be discussed in more detail in the subsequent chapters of this LRFP Report, specifically in Chapter 7 (Solids Treatment Alternatives Development and Screening) and Chapter 8 (Liquid Treatment Alternatives Development and Screening).

5.5 INFLUENT JOINT INTERCEPTOR SEWER ANALYSIS

The 72-inch diameter Joint Interceptor Sewer (Joint Interceptor) was built in 1972. The trunk sewer receives wastewater from the Cities of Palo Alto, Mountain View (including flow from Moffett Field) and Los Altos, as well as the Town of Los Altos Hills. East Palo Alto Sanitary District (EPASD) and Stanford University do not discharge into this trunk sewer. The land above the interceptor consists of primarily wetlands and parkland, varies from 3 to 18 feet in depth, and has limited construction access.

The last inspection and cleaning of the Joint Interceptor took place in 2006. As part of this LRFP, a separate analysis was performed on the interceptor to determine repair and replacement needs. The complete details and findings of this analysis are provided in Appendix H (Technical Memorandum No. 2: Sewer Interceptor Rehabilitation and Replacement Study). Major findings are that the interceptor and manholes are deteriorated in sections and in need of repair. The analysis includes evaluation of options for repair and replacement of the interceptor. Major recommendations from this analysis are discussed below.

If the RWQCP staff decides that rehabilitation of the interceptor is the preferred alternative, then cleaning and spot repairs should be made to allow for either spiral wound lining (SPR) or cured-in-place pipe (CIPP) rehabilitation. If the SPR or CIPP rehabilitation method is selected, the interceptor would require bypass pumping, cleaning, repair, and CCTV prior to construction. This work could be done on a segment-by-segment basis. The information that can be obtained from a CCTV inspection of a sewer is only as good as the quality of the image. It is recommended that the next CCTV inspection follow Pipeline Assessment and Certification Program (PACP) guidelines.:

1. Use a camera lens with a minimum 65-degree viewing angle with either automatic or remote focus and iris controls.
2. Camera lighting shall be sufficient for use with color inspection cameras with a minimum of 1,000,000 candlepower lighting in the 3,200 degree Kelvin range.
3. The camera should be pulled through the interceptor not faster than 30 feet per minute.
4. Flow depths should be less than 20 percent at the time of inspection.
5. CCTV Operator should be certified by either NAASCO/PACP or WrC.
6. Sewer condition should be classified following the PACP guidelines.
7. CCTV footage should be labeled on screen by both manhole location and distance from manhole along pipe.

A 3-D laser scan could be performed to provide an accurate description of the pipe geometry above the water level. Internal diameter and deflection graphs are used to determine pipe-wall material loss/gain or deformation at a given location. Pipe cross sections obtained from high resolution scans are used to determine pipe ovality. This can help the City prioritize which segments require replacement.

In 2006, approximately 119 vertical feet of 48-inch manholes and the influent box were rehabilitated using PERMACAST MS with Con Shield liquid admixture and an epoxy coating of Cor-GARD epoxy. Manholes were high pressure washed, joint sealed, and all voids sealed. Exact locations of which manholes were rehabilitated were not available. A manhole condition assessment is recommended to document what was completed and what needs to be done. This will allow the RWQCP to include any rehabilitation or replacement required in the future interceptor work. Significant leakage at several manholes can be seen on the CCTV footage, making this a priority.

A collection system model for all the contributing areas into the interceptor should be developed to determine the projected flows during wet weather. This can then be used to determine the needed capacity of the sewer and whether options that reduce the inner diameter are viable.

5.6 OUTFALL CAPACITY ANALYSIS

The Palo Alto RWQCP relies on two existing outfalls for effluent discharge: one 54-inch diameter reinforced concrete pipe (RCP) that is currently in use and one 36-inch diameter RCP could be used during emergency peak flows. The existing 54-inch diameter outfall was identified in the 1983 Plant Capacity Study by WWi Consulting Engineers as potentially being capacity constrained without the use of the supplemental emergency outfall. The Outfall Capacity Analysis TM No. 3 (Appendix I) evaluates the capacity of the existing 54-inch diameter outfall to convey existing and future peak wet weather flows up to 80 million mgd at all current tide levels. It also analyzes the capacity of the outfall to handle 80 mgd flow under various global climate change scenarios related to sea/tide level rise. The findings of this study were that the 54-inch outfall capacity is not adequate to pass the peak wet weather flow of 80 mgd on its own. Joint use of the 36-inch outfall would be needed during low tide; however, their combined capacity during high tide is not adequate. Therefore, under the existing and 2050 conditions, additional pumping capacity is required in order for the RWQCP to discharge 80 mgd through the 54-inch and 36-inch diameter outfalls.

The projected ranges of sea level rise presented in the TM should be considered a minimum for planning purposes. As the U.S. Army Corps of Engineers' (ACE) South San Francisco Bay Shoreline Study progresses, it is recommended that efforts be taken to coordinate results, specifically with respect to any proposed projects and funding mechanisms. It is also recommended that the projected range of sea level rise be evaluated regularly (at least every five years), as models are improving and producing more accurate results.

The RWQCP site needs to be protected from flooding. Continued coordination with the U.S. ACE South San Francisco Bay Shoreline Study and FEMA mapping is recommended. The City should conduct a hydrology study to project water levels around the RWQCP site and to confirm levee elevations surrounding the plant. The FEMA flood insurance study for the Palo Alto area concluded that an Army Corps of Engineers approved sea wall system needs to have a minimum height of 10 feet above mean sea level. Rebuilding the levees to meet future sea level rise would protect the plant from future flooding and should be investigated further. It is recommended that implementation and operations and maintenance costs be estimated as well.

5.7 PLANT PIPELINE ANALYSIS

Existing plant pipeline length between buildings and tanks, diameter, material and year constructed were estimated based on existing drawings. In some cases pipeline material was not shown on the drawings in the year it was built, and an educated guess was made based on later drawings or similar use. A summary of the existing plant pipeline material types found within the RWQCP site boundary and their original life expectancy is shown in Table 5.2.

The estimated remaining useful life (RUL) was calculated for each pipe for the year 2015 based on the expected life by pipe material and pipe age. Based on pipe age, it was calculated whether a pipeline would need replacement prior to year 2042. If the pipe required replacement, it was replaced in kind if the material is still commonly used today. If a pipe material was used that is not available, a typical material for the pipe contents was assumed. Replacement cost was then calculated based on a cost per linear foot ($/LF) basis shown in Table 5.3.

Table 5.2 Summary of Existing Pipeline Material Types

Pipe Material	Expected Life (years)
AB Corrugated Pipe	50
Acrylonitrile Butadiene Styrene(ABS)	50
Asbestos Cement Pipe	50
Cast Iron (>10")	100
Cement Mortar Lined & Coated Steel	50
Concrete Cylinder Pipe	100
HDPE	80
Polyvinyl Chloride (PVC)	100
Reinforced Concrete Pipe	100
Vitrified Clay Pipe	100

Table 5.3 Pipe Replacement Unit Costs

Pipe Diameter (inches)	Ductile Iron Pipe Replacement ($/LF)	PVC Replacement Pipe ($/LF)	CML&C Steel Pipe Replacement ($/LF)	HDPE Pipe Replacement ($/LF)
3				$364
4				$365
6				$371
8		$396		
12			$616	
14			$653	
16			$701	
18			$770	
27	$1,033			
30			$1,381	
42			$2,001	

The following are the assumptions used for developing the replacement cost estimates for the pipelines:

- Only pipelines within the RWQCP property limits are included.
- Chemical feed piping and water piping have not been included.

- Plant piping was defined as buried pipe located outside of buildings and tanks.
- Recycled water pipelines with diameters smaller than 12 inches will be replaced with PVC pipe.
- Recycled water pipelines with diameters equal to or larger than 12 inches will be replaced with cement mortar lined and coated steel pipe.
- Acrylonitrile Butadiene Styrene (ABS) natural gas pipe will be replaced with high-density polyethylene (HDPE) pipe. The Utilities Department already change the ABS pipe throughout the RWQCP to HDPE.
- AB Corrugated Pipe will be replaced with cement mortar lined and coated steel pipe.
- Pipe depth is assumed to be 12 feet below ground.
- Vertical shoring is required.
- Pavement replaced is assumed to be 3-inch thick asphalt concrete (AC) on 6-inch thick aggregate base course (ABC).
- Trench width is assumed to be the pipeline outer diameter plus 8 inches on each side for pipes with 30-inch diameters or less, and pipeline outer diameter plus 12 inches on each side for pipes having greater than 30-inch diameters.
- Pipeline bed depth is 4 inches for pipes with 10-inch outer diameters or less, and 6 inches for pipes with 12-inch outer diameters or greater.
- No corrosion protection is included.

Table 5.4 illustrates a summary of the plant pipeline analysis**.**

Table 5.4 Plant Pipeline Analysis										
Pipe Name	Diameter (inches)	Contents	Origin	Terminus	Material	Year Installed	Approximate Length (feet)	Original Useful Life	Remaining Useful Life in 2015	Cost to Replace in 2015 $
72" RS (Joint Intercepting Sewer)	72	Raw Sewage	Station 13+80	Plant Influent Box	Reinforced Concrete Pipe	1972	1,284	100	54	$0
27" RS (not in use)	27	Raw Sewage	27" VCP RS	36" RCP RS	Asbestos Cement Pipe	1966	45	50	1	$0
36" RS	36	Raw Sewage	27" ACP RS	JB EPASD Trunkline	Reinforced Concrete Pipe	1966	127	100	51	$0
42" RS	42	Raw Sewage	JB EPASD Trunkline	Old Pumping Plant	Concrete Cylinder Pipe	1966	123	100	51	$0
42" CPA2 Influent	42	Raw Sewage	JB No. 1	Old Pumping Plant	AB Corrugated Pipe	1956	19	50	-9	$38,200
60" RS	60	Raw Sewage	Meter Pit	Primary Sed. Basin No. 4	Concrete Cylinder Pipe	1972	505	100	54	$0
72" PE (Bypass)	72	Primary Effluent	Primary Sed Tank Effluent Channel	Effluent Junction Box No. 2	Concrete Cylinder Pipe	1972	484	100	54	$0
60" SE	60	Secondary Effluent	Clarifier No. 2	72" PE	Concrete Cylinder Pipe	1972	588	100	54	$0
60" SE Bypass	60	Secondary Effluent	Bypass Junction Box	Clarifier No. 6	Reinforced Concrete Pipe	1988	385	100	73	$0
36" SE	36	Secondary Effluent	SE Junction Box	Clarifier No. 6	Reinforced Concrete Pipe	1988	100	100	73	$0
42" SE Bypass	42	Secondary Effluent	Clarifier No. 5	Clarifier No. 6	Reinforced Concrete Pipe	1988	140	100	73	$0
36" SE	36	Secondary Effluent	Clarifier No. 5	SE Junction Box	Reinforced Concrete Pipe	1988	25	100	73	$0
60" SE	60	Secondary Effluent	SE Junction Box	Clarifier No. 4	Reinforced Concrete Pipe	1979	170	100	64	$0
60" SE	60	Secondary Effluent	Dual Media Filters	SE Junction Box	Reinforced Concrete Pipe	1979	220	100	64	$0
42" RCP ML with Steel Fittings	42	Mixed Liquor	Aeration Tank	Clarifier No. 6	Cement Mortar Lined & Coated Steel	1988	225	50	23	$452,300
42" RCP ML with Steel Fittings	42	Mixed Liquor	Aeration Tank No. 4	Clarifier No. 5	Cement Mortar Lined & Coated Steel	1988	215	50	23	$432,200
8" SSM/D	8	Secondary Scum/Drain	Clarifier No. 6	72" RS	Polyvinyl Chloride (PVC)	1988	245	100	73	$0
8" SSM/D	8	Secondary Scum/Drain	Clarifier No. 5	Clarifier No. 6 Box	Polyvinyl Chloride (PVC)	1988	20	100	73	$0
24" RAS	24	Return Activated Sludge	Clarifiers No. 4 & 5	Fixed Film Reactors	Reinforced Concrete Pipe	1988	840	100	73	$0
12" RAS	12	Return Activated Sludge	RAS Pumps	24" RAS	Reinforced Concrete Pipe	1997	30	100	82	$0

Table 5.4 Plant Pipeline Analysis										
Pipe Name	**Diameter (inches)**	**Contents**	**Origin**	**Terminus**	**Material**	**Year Installed**	**Approximate Length (feet)**	**Original Useful Life**	**Remaining Useful Life in 2015**	**Cost to Replace in 2015 $**
12" SE	12	Secondary Effluent	60" SE	Activated Sludge Pump Room	Cement Mortar Lined & Coated Steel	1972	233	50	4	$143,700
2-96" FE	96	Filter Effluent	Dual Media Filters	Junction Box No. 2	Reinforced Concrete Pipe	1977	2,070	100	62	$0
84" FPE	84	Filter Effluent	UV	Mixing Box	Reinforced Concrete Pipe	2009	130	100	94	$0
84" FE	84	Filter Effluent	Diversion Structure	UV	Reinforced Concrete Pipe	2009	45	100	94	$0
16" Backwash	16	Backwash	Dual Media Filters	Primary Sed. Tanks pump deck	Cement Mortar Lined & Coated Steel	1979	210	50	14	$147,800
42" FE/SE/PE	42	Filter Effluent/Secondary Effluent/Primary Effluent	72" FE/SE/PE	Chlorine Contact Tank	Cement Mortar Lined & Coated Steel	1972	156	50	4	$313,600
30" PLE (abandoned)	30	Plant Effluent	Chlorine Contact Tank	Old Flash Mixer (?)	AB Corrugated Pipe	1956	265	50	-9	$0
16" Recl Filtered Water Line	16	Recycled Water	Chlorination Station	Recl Storage Tank B	Cement Mortar Lined & Coated Steel	1979	300	50	14	$211,200
48" Filter Effluent/Secondary Effluent/Primary Effluent	48	Filter Effluent/Secondary Effluent/Primary Effluent	Chlorine Contact Outlet Box	54" FE/SE/PE	Reinforced Concrete Pipe	1988	30	100	73	$0
48" PLE	48	Plant Effluent	Chlorine Contact Outlet Box	54" PLE	Reinforced Concrete Pipe	1972	15	100	54	$0
54" FE/SE/PE	54	Filter Effluent/Secondary Effluent/Primary Effluent	60" FE/SE/PE	Outfall Box	Reinforced Concrete Pipe	1972	75	100	54	$0
60" FE/SE/PE	60	Filter Effluent/Secondary Effluent/Primary Effluent	Chlorine Tank Inlet Box	54" FE/SE/PE	Reinforced Concrete Pipe	1972	147	100	54	$0
72" FE/SE/PE	72	Filter Effluent/Secondary Effluent/Primary Effluent	72" FE/PE	Chlorine Contact Tank	Reinforced Concrete Pipe	1972	115	100	54	$0
72" FE/PE	72	Filter Effluent/Primary Effluent	72" FE/SE/PE	Effluent JB #2	Concrete Cylinder Pipe	1972	130	100	54	$0

Table 5.4 Plant Pipeline Analysis										
Pipe Name	**Diameter (inches)**	**Contents**	**Origin**	**Terminus**	**Material**	**Year Installed**	**Approximate Length (feet)**	**Original Useful Life**	**Remaining Useful Life in 2015**	**Cost to Replace in 2015 $**
Total W4 (usually 6" or 8")	8	Recycled Water			Asbestos Cement Pipe	1972	6,840	50	4	$2,715,500
16" W4	16	Recycled Water	Exist W4 at Chlorine Contact Tank	UV	Cement Mortar Lined & Coated Steel	2009	30	50	44	$0
16" W4	16	Recycled Water	Chlorination Station	Chlorine Contact Tank	Cast Iron (>10")	1969	30	100	54	$0
15" Recycle Line	15	Waste Recycle	Solids Incineration Bldg	Influent Junction Box	Vitrified Clay Pipe	1969	293	100	54	$0
15" Recycle Line	15	Waste Recycle	Exist 15" Recycle	Influent Pumping Plant	Vitrified Clay Pipe	1998	23	100	83	$0
12" SD	12	Storm Drain	Yard Near UV Control	15" Sewer	Vitrified Clay Pipe	1972	849	100	54	$0
15" SD	15	Storm Drain	Yard Near Inf. JB	15" Sewer	Vitrified Clay Pipe	1972	309	100	54	$0
12" SD	12	Storm Drain	Yard Near UV Control	RW Filters	Polyvinyl Chloride (PVC)	1972	33	100	54	$0
8" D	8	Drain	Sludge Pump Room	MH	Vitrified Clay Pipe	1972	140	100	54	$0
4" D	4	Drain/Raw Sewage	Steam Cleaning Slab	8" D	Vitrified Clay Pipe	1972	90	100	54	$0
6" D	6	Drain	Grit Building	MH	Polyvinyl Chloride (PVC)	1988	175	100	73	$0
8" D	8	Raw Sewage	1986 MH	72" Sewer Interceptor	Vitrified Clay Pipe	1972	115	100	54	$0
12" SD	12	Storm Drain	CB at Clarifier No. 2	15" Sewer	Vitrified Clay Pipe	1972	130	100	54	$0
12" SD	12	Storm Drain	Inlet No. 1	Discharge at South Corner of Plant	Vitrified Clay Pipe	1988	140	100	73	$0
4" VC Waste	4	Raw Sewage	Operations Bldg	8" Sewer	Vitrified Clay Pipe	1972	90	100	54	$0
18" WS Recycled Water	18	Recycled Water	Storage Tank B	Process Bldg	Cement Mortar Lined & Coated Steel	1978	94	50	13	$72,700
12" WS Recycled Water	12	Recycled Water	Process Bldg	Property Line (to Golf Course)	Cement Mortar Lined & Coated Steel	1978	321	50	13	$198,400
12" WS Recycled Water	12	Recycled Water	Process Bldg	Property Line (to Injection Wells)	Cement Mortar Lined & Coated Steel	1978	302	50	13	$186,600
12" WS Recycled Water	12	Recycled Water	Process Bldg	72" Sewer Interceptor	Cement Mortar Lined & Coated Steel	1978	65	50	13	$40,200

Table 5.4 Plant Pipeline Analysis

Pipe Name	Diameter (inches)	Contents	Origin	Terminus	Material	Year Installed	Approximate Length (feet)	Original Useful Life	Remaining Useful Life in 2015	Cost to Replace in 2015 $
14" WS Recycled Water	14	Recycled Water	18" RW	Process Bldg	Cement Mortar Lined & Coated Steel	1978	32	50	13	$21,000
18" WS Recycled Water	18	Recycled Water	Storage Tank A	Process Bldg	Cement Mortar Lined & Coated Steel	1978	89	50	13	$68,800
14" Backwash Supply to Filters Recycled Water	14	Recycled Water	RW Filters	Process Bldg	Cement Mortar Lined & Coated Steel	1978	203	50	13	$133,200
12" WS From Filter System A	12	Recycled Water	RW Filters	Process Bldg	Cement Mortar Lined & Coated Steel	1978	200	50	13	$123,600
12" WS From Filter System B	12	Recycled Water	RW Filters	Process Bldg	Cement Mortar Lined & Coated Steel	1978	222	50	13	$137,200
16" WS Backwash Waste	16	Recycled Water	Process Bldg	Near Oil Storage	Cement Mortar Lined & Coated Steel	1978	135	50	13	$95,000
12" WS To Filter System A	12	Recycled Water	Process Bldg	RW Filters	Cement Mortar Lined & Coated Steel	1978	95	50	13	$58,700
12" WS To Filter System B	12	Recycled Water	Process Bldg	RW Filters	Cement Mortar Lined & Coated Steel	1978	127	50	13	$78,500
18" WS	18	Recycled Water	RW Tank 3	Process Bldg	Cement Mortar Lined & Coated Steel	1978	70	50	13	$54,100
6" ABS Natural Gas	6	Natural Gas	Solids Incineration Bldg	Gas Meter	Acrylonitrile Butadiene Styrene	1972	390	50	4	$145,600
3" ABS Natural Gas	3	Natural Gas	6" ABS	Pumping Plant	Acrylonitrile Butadiene Styrene	1972	56	50	4	$20,500
4" ABS Natural Gas	4	Natural Gas	Gas Meter	Property Line	Acrylonitrile Butadiene Styrene	1972	405	50	4	$148,600
3" HDPE Natural Gas	3	Natural Gas	6" HDPE	Scum/WAS area	HDPE	1972	169	50	4	$61,600
									Total Cost	**$6,037,200**

5.8 IMPROVED OPERATIONS AND ENERGY EFFICIENCY

This section summarizes current or planned projects led by the plant staff for improving operations and overall energy efficiency at the RWQCP.

5.8.1 Source Control for Energy Savings

The RWQCP seeks to reduce energy consumption through source control by supporting indoor water use conservation with water agencies that send wastewater to the plant. The following water agencies participate:

- Purissima Hills Water District (uses Los Altos Hills wastewater system)
- CalWater (uses Los Altos/East Palo Alto Sanitary District wastewater system)
- Mountain View (uses Mountain View wastewater system)
- Stanford University (uses Stanford University’s wastewater system)
- City of Palo Alto Utilities (uses Palo Alto’s wastewater system)

The RWQCP also supports wastewater collection agencies in their efforts to develop inflow and infiltration reduction strategies including groundwater pumping, source detection, tracking illegal connections, lateral maintenance and replacement policies, CCTV surveillance, suspect lateral programs, and mainline/lateral sewer rehabilitation

5.8.2 Miscellaneous Energy Saving Projects

The following list of potential energy savings projects were identified by RWQCP staff and have already been identified and scheduled to be complete in the near future.

1. Turblex control system improvement for Blowers 1, 3, & 5 (completed January 2012)
2. Redesign the flare system to maximize landfill gas use (construction in 2013)
3. Submetering at each load center (construction in 2012)

The projects listed below are planned for some time in the next 10 years.

1. Develop and display cost data on a human-machine interface (HMI) screen for commodity, electric loads, and gas loads.
2. Motor replacement should occur in groups based on age, reliability, efficiency gains, and other criteria relevant to plant operations. Most existing large motors have efficiencies that are near or higher than premium efficiency motors.

3. Install variable frequency drive (VFD) motors in the DMF backwash supply pumps, the recycled water backwash supply pump, and the induced draft fans (ID fan) at the incinerators. Identify existing less efficient (or aging) VFDs and replace them with new VFDs.
4. New buildings with over 5,000 square feet are to satisfy Leadership in Energy and Environmental Design (LEED) silver certification, consistent with the City's 2007 Climate Protection Plan. Renovated buildings with over 5,000 square feet are to be evaluated by an appointed Green Building professional. Renovated buildings with less than 5,000 square feet should use a LEED or equivalent checklist as a guideline to enhance Green Building features.
5. Installation of "cool roofs" as roofs of conditioned air spaces need to be replaced.
6. Just prior to 2019, consider ceramic disks (versus the existing ceramic domes) for next fine bubble ceramic diffuser replacement project.

5.8.3 2012 Tertiary Upgrade Project

The Tertiary Upgrade Project is planned for 2013 and consists of the following major elements.

- Clarifiers (Nos. 5 and 6) rehabilitation of weir and launder cleaning system, as well as update and automation of scum system.
- Clarifiers (Nos. 1, 2, 3, and 4) rehabilitation
  - Installation of properly spaced weir notches for flow balancing and improved solids removal to account for square clarifier shape .
  - Rehabilitation of secondary effluent channel scum trough and pumping system.
  - Installation of isolation slide gates on effluent launders not in service.
  - Potentially filling in the corners of the square clarifiers.
- Replacement of the DMF surface wash system with an air wash system. Consideration of underdrain panel with integral airwash gravel replacement and additional media installation.
- DMF media replacement pilot with a larger effective size media.
- DMF backwash waste valve replacement (leaking valves).

Chapter 6

REGULATORY REQUIREMENTS

The purpose of this chapter is to summarize the existing discharge permit requirements and consider potential future regulatory requirements that may affect the Palo Alto Regional Water Quality Control Plant (RWQCP) discharge to the South San Francisco Bay and Matadero Creek.

6.1 SUMMARY OF THE EXISTING NPDES PERMIT

Under the Clean Water Act (CWA), the Environmental Protection Agency (EPA) regulates the RWQCP's effluent discharges through the issuance of National Pollutant Discharge Elimination System (NPDES) permits. The NPDES permitting program for the San Francisco Bay drainage basin has been delegated by EPA to the San Francisco Bay Regional Water Quality Control Board (Regional Water Board). The RWQCP's current permit – NPDES Permit No. CA0037834, Order No. R2 2009-0032 – was adopted on April 8, 2009 and expires on May 31, 2014. The City of Palo Alto owns and operates the RWQCP and is the discharger subject to the waste requirements set forth in the permit. The NPDES permit is included in Appendix J.

The RWQCP is permitted for an average dry weather flow (ADWF) design capacity of 39 million gallons per day (mgd) and a peak wet weather flow (PWWF) design capacity of 80 mgd. The ADWF capacity provides tertiary treatment and the PWWF capacity provides secondary treatment.

The RWQCP discharges to two receiving waters: South San Francisco Bay and Matadero Creek. Approximately 95 percent of the treated wastewater is discharged to South San Francisco Bay through an unnamed, manmade channel that is tributary to the Bay. Approximately 5 percent of the treated wastewater is discharged to the Emily Renzel Marsh Pond where it flows through a controlled outfall to Matadero Creek. The Emily Renzel Marsh Pond is a reclamation project initiated by the City of Palo Alto to restore natural habitat that has been cut off from natural freshwater and saltwater flows. The Emily Renzel Marsh Pond is not a water of the State or the U.S. because its water levels are exclusively maintained by the RWQCP discharge and the pond has a controlled outfall to Matadero Creek. As a result, Matadero Creek is considered to be the receiving water for all flows discharged to the pond. Both Matadero Creek and the unnamed manmade channel that is tributary to South San Francisco Bay are waters of the U.S.

The following sections summarize the City's discharge permit requirements.

6.1.1 Permit Effluent Limits

Table 6.1 summarizes the current NPDES permit effluent limitations. In addition to the limits in the table, the average monthly removal for biochemical oxygen demand (BOD) and total suspended solids (TSS) must be at least 85 percent by concentration. The permit also contains limits for acute and chronic toxicity. The RWQCP has an excellent track record of meeting these permit limits.

Table 6.1 Effluent Limits in 2009 NPDES Permit[1]

Constituent	Units[2]	Average Monthly	Maximum Daily	Instantaneous Min	Instantaneous Max
5-day CBOD @ 20°C	mg/L	10	20	---	---
Total Suspended Solids (TSS)	mg/L	10	20	---	---
Oil and Grease	mg/L	5	10	---	---
pH	standard units	---	---	6.5	8.5
Chlorine, Total Residual	mg/L	---	---	---	0.0
Turbidity	NTU	---	---	---	10.0
Enterococcus Bacteria[3]	MPN/100 mL	35	---	---	---
Copper, Total Recoverable	µg/L	12	16	---	---
Nickel, Total Recoverable	µg/L	26	31	---	---
Cyanide, Total Recoverable	µg/L	7.1	14	---	---
Dioxin-TEQ, Final Limitation [4]	µg/L	1.4×10^{-8}	2.8×10^{-8}	---	---
Dioxin-TEQ, Interim Limitation[4]	µg/L	6.3×10^{-8}	---	---	---
Chlorodibromomethane	µg/L	34	62	---	---
Ammonia, Total (as N)	mg/L	2.7	9.5	---	---
Dissolved Oxygen[5]	mg/L	---	---	---	---

Notes:

(1) Limits included in Waste Discharge Requirements Order No. R2-2009-0032, NPDES Permit No. CA0037834.

(2) Abbreviations: mg/L = milligrams per liter; µg/L = micrograms per liter; MPN = most probable number; NTU = nephelometric turbidity units.

(3) The 30-day geometric mean value for all samples analyzed for enterococcus bacteria shall not exceed 35 colonies per 100 mL.

(4) Final effluent limitations shall become effective starting June 1, 2019 (10 years from Order effective date). Interim effluent limitations for dioxin-TEQ are effective until May 31, 2019.

(5) The effluent shall not cause the dissolved oxygen concentration of the receiving waters to fall below a minimum of 5.0 mg/L within one foot of the water surface.

6.1.1.1 Mercury Effluent Limits

The RWQCP must also comply with mercury effluents limits set in the San Francisco Bay Mercury Watershed Permit (NPDES Permit No. CA0038849, Order No. R2-2007-0077). This permit sets mercury effluent limits for all discharges to the San Francisco Bay and its tributaries. The current and future mercury limits for the RWQCP are included in Table 6.2.

Table 6.2 Mercury Effluent Limits in San Francisco Bay Mercury Watershed Permit[(1)]					
Discharger	**Average Annual Effluent Limit (kg/yr)**	**Effective in 2018 Average Annual Effluent Limit (kg/yr)**	**Effective in 2028 Average Annual Effluent Limit (kg/yr)**	**Average Monthly Effluent Limit (µg/yr)**	**Average Weekly Effluent Limit (µg/yr)**
City of Palo Alto RWQCP	0.38	0.31	0.31	0.025	0.027

Note:
(1) Limits included in Waste Discharge Requirements Order No. R2-2007-0077, NPDES Permit No. CA0038849.

The permit requires the permitted dischargers to report mercury mass loads and source control activities on an annual basis. In 2010, the RWQCP reported an estimated annual mercury mass emission of 0.0633 kg/yr, which is well under the average annual effluent limit of 0.38 kg/yr. They also reported that the following mercury source control projects were completed or underway (2010 Mercury Watershed Permit Group Report, RMC Water and Environment):

- Dental Amalgam Program
- Fluorescent Light Recycling
- Household Hazardous Waste Collection
- Public Outreach/Education
- Thermometer and/or Thermostat Exchange
- Vehicle Service Facilities

6.1.1.2 Dioxin-TEQ Effluent Limits

When the NPDES permit was issued in 2009, the RWQCP was not immediately able to comply with the dioxin and furan toxic equivalents (dioxin-TEQ) limit and was issued interim effluent limits listed in Table 6.1. In February 2010, a blanket permit amendment for dioxin and furan compounds was issued for dischargers in the San Francisco Bay area (Order No. R2-2010-0054). The purpose of the amendment was to establish consistent standard requirements for all NPDES wastewater permits and to revise the method for calculating dioxin-TEQ for permits that require monitoring and reporting of dioxin-TEQ. Under the new method, all San Francisco Bay dischargers, including the RWQCP are in compliance with their dioxin-TEQ permit limits.

6.1.1.3 PCB Effluent Limitations

The RWQCP must also comply with PCB waste discharge effluent limits set in the amendment to the San Francisco Bay Mercury Watershed Permit (Order No. R2-2011-0012). This permit sets PCB effluent limits for a subset of discharges to the San Francisco Bay and its tributaries. The current PCB limits for the RWQCP are included in Table 6.3.

Table 6.3 PCB Effluent Limits in San Francisco Bay Mercury and PCB Watershed Permit		
Discharger	Average Monthly Effluent Limit (ug/L)	Maximum Daily Effluent Limit (ug./L)
City of Palo Alto RWQCP	0.00039	0.00049

Note:
(1) Limits included in Waste Discharge Requirements Order No. R2-2011-0012, NPDES Permit No. CA0037834.

The permit requires the RWQCP to identify controllable sources of PCBs to its treatment system by February 28, 2012. The controllable sources consist of PCB contributions to wastewater from industrial equipment and PCB contributions to wastewater from buildings with PCB-containing sealants that are scheduled for remodeling or demolition and identified as pilot projects required by Provision C.12.b of the Municipal Regional Stormwater Permit (Order No. R2-2009-0074). The RWQCP shall submit the results of this evaluation, including any proposed control actions with an implementation schedule, in its annual pollution prevention reports.

6.1.2 Other Permit Provisions

Other provisions in the permit include the following:

- Monitoring and reporting of selected constituents.
- Participating in an ambient background receiving water study.
- Investigating and studying sources of consistent toxicity and how they can be controlled or reduced.
- Conducting a receiving water ammonia characterization study.
- Optional investigation of mass offset programs for 303(d)-listed pollutants.
- Optional study of near-field, site-specific translators for chromium, zinc, and lead.
- Pollution prevention/minimization program and reporting.
- Evaluation and status reports for the wastewater facilities, the operations and maintenance manual, the reliability of the wastewater facilities, and the facility contingency plan.
- Implementation and enforcement of a pretreatment program.
- Appropriate management of all biosolids.
- Implementation of a sewer system management plan for operation and maintenance of the collection system and mitigation of sanitary sewer overflows.
- Implementation of action plans to control copper and cyanide discharges.
- Continued implementation of existing reclamation programs.

6.1.3 Wet Weather Discharges

The RWQCP wastewater treatment processes include screening, grit removal, primary sedimentation, fixed film reactors, activated sludge treatment, secondary clarification, dual media filtration, and UV disinfection. The fixed film reactors and dual media filters have a design capacity of approximately 40 mgd.

During wet weather events when the influent flow exceeds 40 mgd, the fixed film reactors and dual media filters treat the first 40 mgd. At the fixed film reactors, flows in excess of 40 mgd are routed around the fixed film reactors, blended with fixed film reactor effluent and routed to the activated sludge process. At the dual media filters, flows in excess of 40 mgd are routed around the filters, blended with the filter effluent, and routed back to the disinfection process. The final effluent produced during wet weather conditions is advanced secondary effluent. Bypass of the fixed film reactors and dual media filters is only permitted when the primary effluent flow exceeds the fixed film reactor capacity of 40 mgd, or when the effluent from the activated sludge treatment process exceeds the dual media filter capacity of 40 mgd. The City must report all incidents of blended effluent discharges and conduct additional monitoring of these discharges as detailed in the permit.

6.1.4 Recycled Water

A portion of the tertiary treated effluent produced at the RWQCP undergoes additional filtration and chlorination and is distributed for recycled water use throughout Palo Alto and the surrounding area. Refer to Chapter 3 Section 3.6 for more information on recycled water use and the City's recycled water program.

The State Water Resources Control Board (SWRCB), the San Francisco Bay Regional Water Board, and the California Department of Public Health (CDPH) have regulatory authority over Palo Alto's recycled water projects. The following sections summarize existing regulations that govern recycled water systems. The CDPH is the primary state agency responsible for the protection of public health, the regulation of drinking water, and the development of uniform water recycling criteria appropriate to particular uses of water.[1]

Title 22 regulations define four types of recycled water, which is determined by the water treatment level and total coliform, bacteria, and turbidity levels of the water. The four treatment types of recycled water that are currently permitted by CDPH under Title 22 regulations are summarized in Table 6.4. The RWQCP produces disinfected tertiary recycled water – the highest quality of the four recycled water types.

[1] The CDPH has promulgated regulatory criteria for recycled water use in Title 22, Division 4, Chapter 3, Section 60301 et seq., California Code of Regulations (Title 22). Additional information on recycled water regulations and a link to Title 22 of the CCR can be found at: http://www.cdph.ca.gov/CERTLIC/DRINKINGWATER/Pages/Lawbook.aspx.

Table 6.4 Approved Uses of Recycled Water		
Treatment Level	**Approved Uses**	**Total Coliform Standard (median)**
Disinfected Tertiary Recycled Water	Spray Irrigation of Food Crops	2.2 / 100 mL
	Landscape Irrigation(1)	
	Non-restricted Recreational Impoundment	
Disinfected Secondary - 2.2 Recycled Water	Surface Irrigation of Food Crops	2.2 / 100 mL
	Restricted Recreational Impoundment	
Disinfected Secondary - 23 Recycled Water	Pasture for Milking Animals	23 / 100 mL
	Landscape Irrigation(2)	
	Landscape Impoundment	
Undisinfected Secondary Recycled Water	Surface Irrigation of Orchards and Vineyards(3)	N/A
	Fodder, Fiber and Seed Crops	

Notes:
(1) Includes unrestricted access golf courses, parks, playgrounds, schoolyards, and other landscaped areas with similar access.
(2) Includes restricted access golf courses, cemeteries, freeway landscapes, and landscapes with similar public access.
(3) No fruit is harvested that has come in contact with irrigating water or the ground.

6.2 REGULATORY CONSIDERATIONS

This section provides insight into the existing and future regulatory considerations that may impact the RWQCP's discharges, biosolids production and disposal, and air emissions over the course of the 50-year planning horizon. Because continued regulatory compliance is a major objective of the LRFP, identifying future regulatory trends is critical for:

- developing treatment scenarios and alternatives
- planning for space requirements for future regulatory compliance
- making budget considerations for major design/construction projects

In identifying future pollutants of concern (POCs), such as metals, nutrients, and/or pathogens, the LRFP can be developed to include alternatives that are flexible and can be easily expanded or upgraded to treat future POCs. For example, the LRFP may include an alternative that reserves space in the site layout for membrane filtration, advanced oxidation, or an alternative disinfection method that would provide treatment of future POCs.

The following review of current environmental issues and regulatory developments describes the overall anticipated trends that are important considerations in the planning process for future wastewater facilities at the RWQCP.

6.2.1 Nutrient Removal

6.2.1.1 Nationwide

Nutrients, including nitrogen and phosphorus, are the leading cause of impairments to the nation’s surface waters and as a result are receiving greater regulatory scrutiny regarding their contribution to the overall quality of the nation’s receiving waters. Although appropriate amounts of nutrients are vital for the health and proper functioning of waterbodies, excessive nutrient concentrations can cause water quality degradation.

In November 2007, the National Resources Defense Council (NRDC) filed a petition with the EPA to require that nutrient removal be included in the definition of secondary treatment. The petition stated that “there are many [biological processes] which can achieve total phosphorus levels of 1.0 milligram per liter (mg/L) as a monthly average, and a total nitrogen of 6 to 8 mg/L as an annual average.” In response to the petition by NRDC, the National Association of Clean Water Agencies (NACWA) wrote to the EPA in February 2008, September 2009, and June 2010 urging the EPA to deny the petition to modify the secondary treatment regulations for several legal, technical, and political reasons including but not limited to: the potentially exorbitant cost to publicly owned treatment works (POTWs), the impact on energy demands and greenhouse gas emissions from additional treatment requirements and the inappropriateness of establishing national limits for local and regional water quality issues.

Due to the scientific uncertainties associated with the development of numeric nutrient criteria and the magnitude of the expected costs of compliance, nutrient water quality policies are very controversial and have sparked several legal actions across the country. The State of Florida has become the initial focus of environmental groups’ efforts to push the EPA to develop federal numeric nutrient criteria to be imposed on the states. The EPA has agreed to a consent decree in the environmental suit, and has made a determination that numeric nutrient standards are necessary in Florida. Proposed criteria for total nitrogen and total phosphorus were released in January 2010. This action is possibly precedential, and may result in environmental groups suing the EPA to impose nutrient criteria in other areas of the country.

In 2011, EPA stated their goal is to assist with the development and adoption of numeric nitrogen and phosphorus criteria, which will help states move toward establishing water quality standards for nitrogen and phosphorus.

6.2.1.2 State of California

The State Water Resources Control Board (SWRCB) intends to develop narrative nutrient objectives, with numeric guidance to translate the narrative objectives. This numeric guidance could include the Nutrient Numeric Endpoint (NNE) framework, which establishes numeric endpoints based on the response of a water body to nutrient over-enrichment. The technical foundation of the nutrient for freshwater lakes and streams has been developed and the SWRCB is initiating public scoping and peer review. The SWRCB held a scoping meeting in October 2011 to seek input on content for a proposed Nutrient Numeric Endpoint (NNE) framework and policy for inland surface waters. The SWRCB is working on similar projects to develop the nutrient policies for enclosed bays and estuaries.

6.2.1.3 San Francisco Bay

There is ongoing controversy concerning the impact of nutrient loadings to San Francisco Bay. Although the impact of nutrient loadings to San Francisco Bay, including those from wastewater treatment plant discharges, are not fully characterized or understood, it is known that nutrients do play a key role in the phytoplankton ecology of the Bay. Currently, there are information gaps about how the productivity rates of phytoplankton affect the higher organisms in the San Francisco Bay food webs, and how nitrogen and phosphorus loadings affect the Bay's beneficial uses. Additionally, there is some evidence that the Bay, which has been historically light-limited (i.e., sun-limited), is becoming nutrient-limited, and is therefore at risk of algal blooms. If future research shows that nutrient loadings need to be reduced in San Francisco Bay, water quality standards may be developed.

In March 2012, the Regional Water Board issued a Water Code Section 13267 Technical Report Order to Bay Area wastewater dischargers, including the RWQCP, requiring submittal of information on nutrients in wastewater discharges. This order requires submission of historical nutrient data. New data will be collected over a two-year period to aid in the understanding of loadings and development of nutrient water quality objectives for the San Francisco Bay estuary.

In the current NPDES permit, the RWQCP is given an effluent limit for ammonia, but not for total nitrogen or phosphorus. As the nutrient criteria for the Bay are developed, the RWQCP may need to implement nutrient removal. Initial issuance of nutrient criteria in the San Francisco Bay Region is expected to require nitrogen removal only. Issuance of phosphorus removal criteria is possible but is expected to be much less imminent. If phosphorous removal were required, the RWQCP would be well served by a meaningful discussion with the Regional Water Boards over the lack of nutrient impairment in the receiving waters, and the fact that phosphorus removal can have substantial impacts on energy consumption, greenhouse gas emissions, and production of sludge from chemical co-precipitation.

6.2.2 Microconstituents and Bioaccumulative Constituents

There is a trend towards increasing regulation of some inorganic constituents (e.g., ammonia), emerging microconstituents, and bioaccumulative pollutants (e.g., mercury, polychlorinated biphenyls (PCBs), and dioxins) in treated effluent discharges.

Microconstituents, also referred to as "contaminants of emerging concern" (CECs) by the EPA Office of Water, are substances that have been detected in surface waters and the environment and may potentially cause deleterious effects on aquatic life and the environment at relevant concentrations. CECs include:

- Persistent organic pollutants (POPs) such as polybrominated diphenyl ethers (PBDEs; used in flame retardants, furniture foam, plastics, etc.) and other organic contaminants.
- Pharmaceuticals and personal care products (PPCPs), including a wide suite of human prescribed drugs, over-the-counter medications, bactericides, sunscreens, and synthetic musks.
- Veterinary medicines such as antimicrobials, antibiotics, anti-fungals, growth promoters and hormones.
- Endocrine-disrupting chemicals (EDCs), including synthetic estrogens and androgens, naturally occurring estrogens, as well as many other compounds capable of modulating normal hormonal functions and steroidal synthesis in aquatic organisms.
- Nanomaterials such as carbon nanotubes or nano-scale particulate titanium dioxide.

Bioaccumulative constituents are substances that are taken up by organisms at faster rates than the organisms can remove them. As a result, these constituents accumulate in the organism, the food chain, and therefore in the environment and can remain there for long periods of time. Mercury, PCBs, and dioxins are some bioaccumulative constituents that are being increasingly regulated.

Monitoring requirements for these trace pollutants are increasing, including requirements to analyze constituents at lower detection limits. Over the 50-year horizon of the LRFP, it is likely that water quality criteria followed by new effluent limits will be added to permits. End-of-pipe requirements, with no dilution allowance, will likely continue to be required for bioaccumulative pollutants to the San Francisco Bay. Implementation of CEC standards is not expected to be imminent as the EPA is currently focused on assessing the potential impact CECs have on the environment and human health.

The RWQCP is considering options and alternatives that minimize sources of these pollutants and remove them from the influent wastewater through increased source control and pollution prevention programs, where practicable. However, many of these compounds of emerging concern are ubiquitous, such as those found in PPCPs, and will be difficult to control at the source. The RWQCP can work with legislative and industry representatives to reduce or restrict the use of certain products where feasible, and continue public outreach efforts to discourage improper disposal of consumer products. The RWQCP has already installed ultraviolet (UV) disinfection to reduce disinfection by-products.

Current pollution prevention efforts for mercury, PCBs, and dioxins may be close to the maximum extent practicable (MEP) for the service area of the RWQCP.

6.2.3 Toxicity

The SWRCB is developing an updated approach to assess toxicity in wastewater and stormwater. Toxicity testing is used to determine the toxic effects of pollutants in a water sample. A draft policy issued in 2011 is entitled “Policy for Toxicity Assessment and Control” and is intended to improve testing of water samples, as well as monitoring and reporting requirements, in a consistent manner. The draft policy establishes or requires:

- Numeric limits for chronic and acute toxicity for wastewater dischargers. (the new version separates out stormwater - in attachment D)
- Use of the Test of Significant Toxicity (TST) as the statistical method to determine toxicity.
- Single test failures triggering violation and accelerated monitoring.
- RWQCB discretion on inclusion of acute toxicity in permits and evaluation of toxicity tests using Instream Waste Concentration (IWC).

The SWRCB conducted an external peer review of the draft policy. The expert’s comments are posted on the SWRCB’s website. Local organizations are currently negotiating compliance provisions with the SWRCB. The revised policy may be released for public review in late May to early June 2012, with possible adoption by the SWRCB in the fall of 2012.

6.2.4 Recycled Water

6.2.4.1 California State Recycled Water Policy

The SWRCB has recognized that a burdensome and inconsistent permitting process can impede the implementation of recycled water projects. In response, the SWRCB adopted a Recycled Water Policy (RW Policy) in 2009 to establish more uniform requirements for water recycling throughout the State and to streamline the permit application process in most instances.

The RW Policy includes a mandate that the State increase the use of recycled water over 2002 levels by at least 200,000 acre-feet per year (AFY) by 2020 and by at least 300,000 AFY by 2030. It also includes goals for stormwater reuse, conservation and potable water offsets by recycled water. The onus for achieving these mandates and goals is placed on both recycled water purveyors and potential users.

Absent unusual circumstances, the RW Policy puts forth that recycled water irrigation projects that meet CDPH requirements, and other State or Local regulations, are to be adopted by Regional Boards within 120 days. These streamlined projects will not be required to include a monitoring component.

The RW Policy requires that salt/nutrient management plans for every basin in California be developed and adopted as Basin Plan Amendments by 2015. These management plans will be developed by local stakeholders and funded by the regulated community. Salt/nutrient management plans have not yet been developed in the Palo Alto area. However, the Santa Clara Valley Water District has provided research funds to the University of California to assess appropriate treatment levels for recycled waters to be used for irrigation of landscapes throughout Santa Clara County.

The RW Policy also specifies that “blue ribbon” advisory panels (Panels) be convened to guide future actions with respect to monitoring CECs in both recycled water and inland and coastal discharges. The two Panels of scientific experts will provide the State with recommendations for addressing CEC issues related to recycled water applications and inland and coastal ecosystems. The recommendations will be based on state-of-the-science information. The Southern California Coastal Water Research Project (SCCWRP) will collate and synthesize the recommendations for the SWRCB, CDPH, and the California Ocean Protection Council in two reports (one for recycled water and one for ecosystems).

This is the third year of the three-year project. The first year focused on engaging the Panel in a series of meetings to introduce and address the RW Policy and ambient environment issues. The second year focused on formulation and documentation of Panel recommendations for the RW Policy, and continued discussions with the inland and coastal systems Panel. The third year will focus on formulation and documentation of the recommendations for inland and coastal ecosystems.

The Panel completed their recycled water analysis and submitted a report of recommendations to the SWRCB in June of 2010. The SWRCB is currently reviewing the recommendations. If any regulations arise from new knowledge of risks associated with CECs, then projects will be given compliance schedules. Regulations are not expected to arise in the imminent future.

The Draft Report for Monitoring Strategies of Chemical of Emerging Concern (CECs) in California’s Aquatic Ecosystems was released in February 2012. In this draft document, a risk based screening approach was taken to identify CECs with the greatest environmental risk. Recommendations were made for monitoring of eleven compounds (17, beta-estradiol, estrone, cis-androstenen-dione, bifenthrin, permethrin, chlorpyrifos, fipronil, ibuprofen, bisphenolA, galaxolide, diclosfenac and triclosan) for freshwater discharges and another four compounds (bifenthrin, permethrin, and PBDEs 47 and 99) were identified for monitoring for sediments in coastal embayments. The Panel urges the State to incorporate CEC monitoring into regional and local monitoring programs and recommends a five-year re-evaluation.

6.2.4.2 Title 22 Draft Groundwater Recharge Reuse Regulations

Groundwater recharge with recycled water is the practice of spreading or injecting recycled water into groundwater aquifers to augment groundwater supplies and to prevent salt-water intrusion in coastal areas. While recycled water produced at the RWQCP is not currently being used for groundwater recharge, it may be in the future as the City expands its recycled water program.

Existing regulations and policies that pertain to groundwater recharge reuse include the Title 22 Draft Groundwater Recharge Reuse Regulations (November 2011), the Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan), and the California State Recycled Water Policy. The following websites include additional information about these regulations and policies:

- Title 22 Draft Groundwater Recharge Reuse Regulations - http://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Waterrecycling.aspx
- Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml

The latest CDPH draft recharge reuse regulations (November 2011) set treatment standards regarding pathogen microorganisms, nitrogen removal, total organic (TOC) carbon concentrations, and maximum contaminant limits (MCLs) for other organic and inorganic constituents. The Draft Groundwater Recharge Reuse Regulations (2011) have not been finalized and adopted as part of the Title 22 regulations. The California Water Code was revised via SB 918 to require that the CDPH must adopt uniform water recycling criteria for groundwater recharge by December 31, 2013.If the City begins to consider groundwater recharge alternatives it will be important to track any changes in status or updates to the draft regulations.

6.2.4.3 Filter Loading Rates

Current Title 22 regulations allow filter loading "[a]t a rate that does not exceed 5 gallons per minute per square foot of surface area in mono, dual or mixed media gravity, upflow or pressure filtration systems." While CDPH has recommended to the Regional Water Board to approve increased loading rates for Monterey Regional, others will be approved on a case by case basis (as an "Other Methods of Treatment" under Section 60320.5) until such time as an actual regulatory change to Title 22 is made. However, CDPH has indicated that they do not have any specific plans to allow greater than 5 gallons per minute per square foot as a general rule in the near-term (per personal communication with Jeff Stone at CDPH on June 29, 2011).

6.2.5 Land Application and Beneficial Use/Disposal of Biosolids

6.2.5.1 Governing Regulations

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

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

Biosolids are classified by the 40 CFR 503 regulations as Class B or Class A, according to the level of treatment to reduce pathogens. Biosolids must also meet vector attraction and metal concentration limits. All biosolids must meet the Ceiling Concentration Limits for pollutants. Class A biosolids that meet vector attraction criteria and the more stringent pollutant concentration limits for heavy metals are called exceptional quality (EQ) biosolids. Table 6.5 summarizes the ceiling pollutant concentration limits described above and shows how the RWQCP existing sludge compares. At this point, it appears that the RWQCP solids would meet the EQ pollutant loading concentration limits.

6.2.5.1.1 *Class B Biosolids*

Class B biosolids can be produced through any of the defined Processes to Significantly Reduce Pathogens (PSRP). The quantity and quality of the processed sludge and biosolids produced must be monitored and recorded by each biosolids producer. Quality parameters include pathogen reduction, vector attraction reduction, and inorganic content (i.e., heavy metals).

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

Table 6.5 Pollutant Limits for Land Applied Biosolids					
Pollutant	EPA Ceiling Concentration Limits, mg/kg dry weight basis	EPA Class A Pollutant Concentration Limits, mg/kg dry weight basis	RWQCP Sludge Cake 2011 Average, mg/kg 26.6% Solids	RWQCP Calculated mg/kg dry weight basis (Cake/26.6%)	Theoretical Anaerobic Digestate, mg/kg dry weight basis (Cake/(1-43%))
Arsenic	75	41	0.4	1.5	2.6
Cadmium	85	39	0.85	3.2	5.6
Chromium	3,000	1,200	3.9	14.7	25.7
Copper	4,300	1,500	83.4	313.5	549.1
Lead	840	300	4.92	18.5	32.4
Mercury	57	17	0.132	0.5	0.9
Molybdenum	75	-	0.3	1.1	2.0
Nickel	420	420	16.8	63.2	110.6
Selenium	100	36	1.55	5.8	10.2
Zinc	7,500	2,800	155.33	583.9	1022.7

The PSRPs considered in this study include mesophilic anaerobic digestion and static aerated pile composting. To meet Class B standards, the mesophilic anaerobic digestion process must be operated between 15 days at 35 to 55 degrees Celsius and 60 days at 20 degrees Celsius. Composting operations are required to raise the temperature of biosolids to 40 degrees Celsius or higher for five days. The temperature in the compost pile must also exceed 55 degrees Celsius for four hours during the five-day period.

6.2.5.1.2 *Class A Biosolids*

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

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

6.2.5.1.3 *Vector Attraction Reduction Requirement*

In addition to reducing pathogen levels, 40 CFR 503 requirements mandate that biosolids undergo treatment to reduce the risk of vectors such as flies, mosquitoes, fleas, rodents, and birds that can get into the biosolids. In order to prevent the spread of disease-laden pathogens, biosolids must be treated to reduce their attractiveness to these types of vectors. The alternatives considered for this study are expected to reduce the volatile solids by a minimum of 38 percent, which would meet the vector attraction reduction requirements. Alternatively, drying the biosolids would reduce the moisture content to 10 percent or lower, which also meets the requirement.

6.2.5.1.4 *Exceptional Quality Biosolids*

Biosolids that meet the pollutant concentration limits, one of the Class A pathogen reduction and one of the vector attraction reduction requirements, may be classified as EQ. EQ biosolids may be used and distributed in bulk or bag form and are not subject to general requirements and management practices other than monitoring, recordkeeping, and reporting to substantiate that the quality criteria have been met.

6.2.5.1.5 *Non- Hazardous Waste*

The biosolids must also be tested with a frequency based on the amount generated to demonstrate that they are non-hazardous.

6.2.5.1.6 *California County Ordinances for Land Application*

Use or disposal of biosolids is becoming progressively difficult in California. Land application of biosolids is being restricted by many California counties, and fewer landfills are accepting biosolids. Dewatered sludge is currently incinerated onsite at the RWQCP. Ash is hauled offsite to a hazardous waste landfill in Beatty, Nevada.

Numerous counties in California have developed or are currently developing ordinances for biosolids land application. Figure 6.1 summarizes the current status of County ordinances that affect land application of biosolids.

To comply with possible future restrictions, the planning process will need to consider alternative biosolids use and/or disposal scenarios that are cost effective and will operate within the existing RWQCP facilities.

6.2.6 Governing Regulations for Sewage Sludge Incineration

Sewage sludge incinerators are regulated under EPA’s 40 CFR 60 *Standards of Performance for New Stationary Sources and Emission Guidelines: Sewage Sludge Incineration Final Rule (40 CFR 60).* Sewage sludge or biosolids that are incinerated are classified as solid waste by these

Figure 6.1 Status of Biosolids Land Application Ordinances by County

new EPA regulations. Consequently, sewage sludge incinerators (SSI) are considered solid waste incinerators. The final rule sets limits for nine pollutants under section 129 of the Clean Air Act (CAA), which include cadmium, lead, mercury, carbon monoxide, hydrogen chloride, oxides of nitrogen, particulate matter, sulfur dioxide, and dioxins and furans. Specific limits are established for multiple hearth and fluidized bed incinerators, both existing and new units. This section required the US EPA to establish new source performance standards (NSPS) for new and modified SSIs, and emission guidelines (EG) for existing units.

The emission limits for SSIs were based on a Maximum Achievable Control Technology (MACT) floor methodology, or the minimum stringency level. Limits for new SSIs were based on the most recent SSI installations with advanced air pollution controls. Conversely, existing SSI limits were based on the best performing SSIs. Limits for either new or existing SSIs were specific to either multiple hearths or fluidized bed incinerators. Under section 129 of the CAA, the EPA is required to review and revise these limits as necessary every five years.

New and modified SSIs are subject to the requirements of Subpart LLLL of 40 CFR 60. Construction of a new SSI requires a preconstruction analysis; operator training and qualification; emission limits and standards; operating limits; initial and continuous compliance requirements; performance testing, monitoring, and calibration requirements; record keeping and reporting. New SSIs are those for which construction commenced after October 14, 2011. Modified SSIs are those for which modification commenced after September 21, 2011 and that meet one of the two following criteria:

- The cumulative costs of the changes made to a SSI unit exceed 50 percent of the original construction cost, updated in to current dollars, not including the cost of land.
- Physical changes in a SSI unit or operational changes to the SSI system that increase the amount of any air pollutant emitted for which section 129 and 111 of the CAA have established standards.

A SSI unit includes the solids feed system, auxiliary fuel feed system, grate system, flue gas system, waste heat recovery equipment, and bottom ash system, and the ash handling system. The ash handling system ends at the truck loading system. The air pollution control system is not considered part of the SSI unit.

Existing SSIs are subject to the requirements of Subpart MMMM of 40 CFR 60. Use of the Model Rule will address the regulatory requirements of this Subpart. The model rule includes requirements for increments of progress to achieve compliance, operator training and qualification; emission limits, standards, and operating limits; initial compliance requirements; continuous compliance requirements; performance testing, monitoring, and calibration requirements; and record keeping and reporting.

Sewage solids incineration must also comply with Subpart E of 40 CFR 503 and 40 CFR 61. Subpart E regulates total hydrocarbons and seven metals: arsenic, beryllium, cadmium, chromium, lead, mercury, and nickel. Limits for beryllium and mercury must meet the National Emission Standards for Hazardous Air Pollutants under 40 CFR 61. Mercury limits under section 129 of the CAA are more stringent than 40 CFR 61. Cadmium, lead, and mercury limits are listed in both 40 CFR 503 and 40 CFR 60. Under 40 CFR 503, these limits must be calculated. The lowest pollutant limit listed in any of the regulations must be used for the SSI to be in compliance.

Emission limits are specific to either multiple hearth or fluidized bed incinerators (MHI and FBI, respectively). Tables 6.6 and 6.7 summarize the emission limits for existing and new SSIs under 40 CFR 60. Emission limits for gasification systems have not been formerly established. Thermal conversion technologies other than multiple hearths and fluidized bed incinerators may be subject to 40 CFR 503. The EPA has suggested that the inclusion of other thermal conversion technologies into this regulation will be considered on a case-by-case basis. Biosolids gasification are assumed to follow 40 CFR 60 emission standards for new fluidized bed incinerators for the purposes of the LRFP.

Table 6.6 Emission Limits for Existing Sewage Sludge Incinerators

Pollutant	Units(1)	Existing MHI	Existing FBI
Cadmium	mg/dscm	0.095	0.0016
Carbon Monoxide	ppmvd	3,800	64
Hydrogen Chloride	ppmvd	1.2	0.51
Mercury	mg/dscm	0.28	0.037
Nitrogen Oxides	ppmvd	220	150
Lead	mg/dscm	0.30	0.0074
PCDD/PCDF,TEQ(2)	ng/dscm	0.32	0.10
PCDD/PCDF,TMB(3)	ng/dscm	5.0	1.2
Particulate Matter	mg/dscm	80	18
Sulfur Dioxide	ppmvd	26	15
Beryllium(4)	µg/m(3)	0.01	0.01
Total Hydrocarbons(4)	ppmv	100	100

Notes:
(1) mg: milligrams, dscm: dry standard cubic meter, ppmvd: parts per million volumetric dry, ng: nanograms, µg: microgram, m3: cubic meter, and ppmv: parts per million by volume.
(2) Polychlorinated Dibenzo-P-Dioxins (PCDD), Polychlorinated Dibenzofurans (PCDF), and Toxic Equivalency (TEQ).
(3) Polychlorinated Dibenzo-P-Dioxins (PCDD), Polychlorinated Dibenzofurans (PCDF), and Total Mass Basis (TMB).
(4) Emission limits are according to 40 CFR 503.

Table 6.7 Emission Limits for New Sewage Sludge Incinerators			
Pollutant	**Units(1)**	**New MHI**	**New FBI**
Cadmium	mg/dscm	0.0024	0.0011
Carbon Monoxide	ppmvd	52	27
Hydrogen Chloride	ppmvd	1.2	0.24
Mercury	mg/dscm	0.15	0.0010
Nitrogen Oxides	ppmvd	210	30
Lead	mg/dscm	0.0035	0.00062
PCDD/PCDF,TEQ(2)	ng/dscm	0.045	0.013
PCDD/PCDF,TMB(3)	ng/dscm	0.0022	0.0044
Particulate Matter	mg/dscm	60	9.6
Sulfur Dioxide	ppmvd	26	5.3
Beryllium(4)	µg /m(3)	0.01	0.01
Total Hydrocarbons(4)	ppmv	100	100

Notes:
(1) mg: milligrams, dscm: dry standard cubic meter, ppmvd: parts per million volumetric dry, ng: nanograms, µg: microgram, m3: cubic meter, and ppmv: parts per million by volume.
(2) Polychlorinated Dibenzo-P-Dioxins (PCDD), Polychlorinated Dibenzofurans (PCDF), and Toxic Equivalency (TEQ).
(3) Polychlorinated Dibenzo-P-Dioxins (PCDD), Polychlorinated Dibenzofurans (PCDF), and Total Mass Basis (TMB).
(4) Emission limits are according to 40 CFR 503.

These new incinerator regulations have been challenged in court by NACWA and the Sierra Club; they may be revised as a result of the lawsuits.

6.2.7 Air Emissions

The federal Clean Air Act (CAA) requires EPA to set national air quality standards to protect human health and welfare. The California Air Resources Board (ARB) is the agency responsible for coordination and oversight of State and local air pollution control programs in California and for implementing the CAA. The ARB has developed State air quality standards that are generally more stringent than federal standards. Other ARB duties include monitoring air quality in conjunction with local air districts, setting emissions standards for new motor vehicles, and reviewing district input or the State Implementation Plan (SIP). The SIP consists of emission standards for vehicles and consumer related sources set by ARB, and attainment plans and rules adopted by local air districts.

The following sections provide summaries of the relevant federal, state, and local air quality standards that need to be considered in the LRFP.

6.2.7.1 Federal Regulations

The EPA recently (March 21, 2011) promulgated new source performance standards and emissions guidelines for sewage sludge incineration (SSI) units at domestic wastewater treatment facilities (discussed in Section 6.2.5). Under Section 129, the CAA requires EPA to determine the maximum achievable control technology (MACT) for each subcategory of sources. The MACT floor analysis for existing sources results in emissions levels that each existing SSI unit is required to meet. These performance standards were set based on surveys of facilities operating SSI units across the country.

The existing emissions limits for multiple hearth incinerator units are shown alongside 2010 sampling results for those operating at the RWQCP in Table 6.8. The emissions limits apply at all times an incinerator is operating, including during start-up and shut-down.

As shown in Table 6.8 the RWQCP is currently in compliance with the newly adopted air emissions limits. However, EPA's draft regulation for 40 CFR 60 originally had more stringent mercury standards (0.02 mg/dscm) that were modified for the final version (0.28 mg/dscm). Since the EPA is required to review and revise these limits as necessary every five years (per section 129 of the CAA), lower mercury standards may be implemented in the future. The regulations require annual performance emissions testing or continuous emissions monitoring or sampling. The operation also sets operator training and qualification standards.

All SSI units subject to the MACT rule are required to obtain a Title V operating permit. Title V is one of several programs authorized by the U. S. Congress in the 1990 Amendments to the federal CAA.

The primary intent of the Title V program is threefold: enhance nationwide compliance with the CAA, provide the basis for better emission inventories, and provide a standard means to implement other programs in the federal CAA.

The Title V program requires State and local air quality agencies to issue comprehensive operating permits to facilities that emit significant amounts of air pollutants. For all implementing agencies in the country, there are standard requirements for permit programs and permit content. The MACT rule describes a variety of timing scenarios; however, the latest the Title V permit can be submitted is March 21, 2014.

Table 6.8 Emission Limits for Existing Sewage Sludge Incinerators and RWQCP Performance			
Pollutant	**Emission Limit(1)**	**RWQCP(2)**	**Units**
Cadmium	0.095	0.01	mg/dscm @ 7% O2
Carbon Monoxide	3,800	143.19	ppmvd @ 7% O2
Hydrogen Chloride	1.2	0.31	ppmvd @ 7% O2
Mercury	0.28	0.05	mg/dscm @ 7% O2
Nitrogen Oxides	220	199.55	ppmvd @ 7% O2
Lead	0.30	0.05	mg/dscm @ 7% O2
PCDD/PCDF, TEQ(3)	0.32	0.00215	mg/dscm @ 7% O2
PCDD/PCDF, TMB(4)	5.0	0.0893	mg/dscm @ 7% O2
Particulate Matter	80	14.85	mg/dscm @ 7% O2
Sulfur Dioxide	26	0.26	ppmvd @ 7% O2

Notes:
(1) Multiple hearth incinerator emissions limits.
(2) 2010 stack testing results.
(3) Polychlorinated Dibenzo-P-Dioxins (PCDD), Polychlorinated Dibenzofurans (PCDF), and Toxic Equivalency (TEQ)
(4) Polychlorinated Dibenzo-P-Dioxins (PCDD), Polychlorinated Dibenzofurans (PCDF), and Total Mass Basis (TMB)

6.2.7.2 State Regulations

Palo Alto currently operates seven standby diesel engines ranging in size from 740 to 1103 horsepower. Replacement engines will need to comply with the Airborne Toxic Control Measure (ATCM) for Stationary Compression-Ignition (CI) Engines. The ARB originally approved the ATCM in 2004. Subsequent to the adoption of the 2004 ATCM, the U.S. EPA promulgated new federal “Standards of Performance for Stationary Compression-Ignition Internal Combustion Engines” (referred to as “NSPS”). In October 2010, ARB approved amendments to the ATCM to closely align California’s requirements with those in the federal NSPS. The amended ATCM became effective May 19, 2011.

The ATCM requires a 0.15 gram per boiler horsepower-hour (g/bhp-hr) particulate matter (PM) emission limit for all new emergency standby stationary compression ignition engines greater than or equal to 50 hp. Annual maintenance and testing hours are limited to 50 hours per calendar year. New emergency standby engines are required to meet the applicable non-methane hydrocarbon plus nitrogen oxides (NMHC+NOx), hydrocarbon (HC), and carbon monoxide (CO) tier 2 or tier 3 non-road CI engine emission standards, and tier 4 standards that do not require add-on controls. Table 6.9 shows emission limits for engine sizes comparable to those currently in use at Palo Alto.

Table 6.9 ATCM Emission Standards for New Stationary Emergency Standby Diesel-Fueled CI Engines in g/bhp-hr (g/kW-hr)[(1)]

Maximum Engine Power	Particulate Matter	Non-Methane Hydrocarbon plus Nitrogen Oxides	Carbon Monoxide
600<HP<750 (450<kW<560)	0.15 (0.20)	3.0 (4.0)	2.6 (3.5)
HP>750 (kW>560)	0.15 (0.20)	4.8 (6.4)	2.6 (3.5)

Notes:
(1) May be subject to additional emission limitations as specified in current applicable district rules, regulations or policies. Applicable to model years 2008 and later.

6.2.7.3 <u>Bay Area Air Quality Management District Regulations</u>

The RWQCP is also subject to the regulations of the Bay Area Air Quality Management District (BAAQMD). The BAAQMD activities include rule development and enforcement, monitoring of air quality, a permit system for stationary and mobile sources, air quality planning, protection of the public from adverse affects for toxic air contaminants, and responses to public requests for information regarding air quality issues.

The BAAQMD administers rules and regulations that apply to stationary and mobile sources that emit air contaminants in the Bay Area. Generally, new and existing stationary sources are governed by requirements in Regulations 2 (Permits), 8 (Organic Compounds), 9 (Inorganic Gaseous Pollutants), and 10 (Standards of Performance for New Stationary Sources).

The RWQCP currently holds a permit to operate from the BAAQMD. The existing permit allows operation of numerous stationary sources, including several emergency standby diesel engines. Under the recently promulgated emissions guidelines for existing SSIs, the RWQCP will need to apply for a Title V permit through the BAAQMD.

Title V operating permits differ from other Air District issued operating permits in that they explicitly include the requirements of all regulations that apply to operations at Title V facilities. The important features of Title V operating permits include the following:

- Must include all federally enforceable requirements that apply to operations at the facility.
- Proposed permits undergo public notice.
- EPA has authority to terminate, modify or revoke and re-issue a permit if cause exists.
- Permits are federally enforceable and may also be enforced via citizen lawsuits.

- Permits must be renewed every five years with the full public notice and EPA review process.
- Modification procedures are dictated by EPA regulations.

Regulation 2, Rule 2 implements Federal New Source Review (NSR) and Prevention of Significant Deterioration requirements. This permitting process governs the construction, replacement, operation, or alteration of any source that emits or may emit contaminants. The process involves an Authority to Construct, followed by a Permit to Operate. Any new or modified source is required to comply with new source review requirements, including application of Best Available Control Technology (BACT), and emission offsets.

BACT is the level of emission control or reduction for new and modified sources of emissions that have the potential to emit 10 or more pounds of any criteria pollutant per day. BACT is intended to reduce emissions to the maximum extent possible considering technological and economic feasibility. The BAAQMD maintains a BACT/TBACT (Toxics-BACT) Workbook, and the California Air Pollution Control Officers Association (CAPCOA) also maintains a clearinghouse for statewide BACT determinations.

Emission Offsets, or Emission Reduction Credits (ERCs), are generated by reducing emissions beyond what is required by regulation, or by curtailing or shutting down a source. ERCs may be used to provide offsets for emission increases from a new or modified source, as required by New Source Review. The ERCs may be banked and the banking certificates may be traded or sold to another facility for use as offsets for that facility. These credits can be very valuable and consideration should be given to retaining them for future projects.

6.2.7.4 Greenhouse Gas Emissions

6.2.7.4.1 *State and Federal Mandatory Reporting*

The ARB adopted the Global Warming Solutions Act (also referred to as Assembly Bill 32, AB 32) in September 2006. This Act was the first regulatory program in the U.S. to require public and private agencies statewide to reduce greenhouse gas (GHG) emissions. The GHGs regulated under AB 32 are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. The Act does not affect wastewater treatment process emissions, but it does cover cogeneration facilities and onsite general stationary combustion sources. ARB’s Proposed Scoping Plan (released October 2008) listed two thresholds by which agencies are to check if they are required to report. The reporting thresholds shown in Table 6.10 include combustion emissions from both fossil fuel (i.e., natural gas and diesel) and non-fossil fuel (i.e., biogas) sources.

Table 6.10 Greenhouse Gas Emissions Thresholds for Reporting Years 2010, 2011 and Beyond

Facilities	Reporting Year 2010	Reporting Year 2011 and Beyond
Cogeneration	≥ 1 MW and ≥ 2,500 mt[(1)] CO_2 per year	≥ 1 MW and ≥ 10,000 mt CO_2e[(2)] per year (reports as “electricity generating and cogeneration unit”)
General Stationary Combustion	≥ 25,000 mt CO_2 per year	≥ 10,000 mt CO_2e per year

Notes:
(1) mt: metric tons.
(2) CO_2e: carbon dioxide equivalent emissions.

In addition, the U.S. EPA’s Mandatory GHG Reporting Rule (Reporting Rule) was adopted October 30, 2009. The Reporting Rule explicitly states that centralized domestic wastewater treatment systems are not required to report emissions; however, any stationary combustion of fossil or non-fossil fuels taking place at a wastewater treatment facility may be considered a “large” source of GHGs if they emit a total of 25,000 metric tons or more of CO_2 equivalent (CO_2e) emissions per year.

The RWQCP’s 2009 general stationary combustion (including combustion of natural gas and biogas from the nearby landfill) GHG emissions were approximately 4,200 metric tons of CO_2e emissions. This is well below the emissions thresholds set for both State and Federal mandatory reporting.

6.2.7.4.2 *State Cap-and-Trade Program*

In addition to mandatory reporting of GHGs, the ARB adopted a GHG cap-and-trade program becomes effective in January 2012. This program states that agencies emitting 25,000 metric tons or more of fossil fuel-based (i.e., natural gas and diesel) CO_2e emissions per year beginning in 2011 or any subsequent year will be capped and required to reduce their emissions over time. As long as the RWQCP maximizes its use of renewable fuels and stays below this threshold, the current regulations may only require the RWQCP to report GHG emissions and will not subject it to being a capped entity.

6.2.7.4.3 *New Source Review Prevention of Significant Deterioration and Title V GHG Tailoring Rule*

On May 13, 2010, the U.S. EPA adopted the final rule, which sets thresholds for GHG emissions that define when permits under the New Source Review (NSR) Prevention of Significant Deterioration (PSD) and Title V Operating Permit programs are required for new and existing industrial facilities. The rule “tailors” the permit programs to limit which facilities are required to obtain PSD and Title V permits.

Defining GHG emission sources at wastewater treatment plants that are covered in this final rule is open to air district interpretation (e.g., whether combustion and/or process emissions are included); however, the Bay Area Air Quality Management District (BAAQMD) is only considering stationary combustion emission sources. In addition, this Rule only looks at fossil fuel related emissions at this time – as of January 12, 2011, EPA deferred GHG permitting requirements for non-fossil fuel (i.e., biogas) and biomass emission sources (including process emissions) for three years.

The RWQCP currently does not trigger reporting under this rule.

6.2.8 Cross-Media Impacts

The interconnection of regulations between various areas related to wastewater is an important consideration. Recently representatives from various air districts, Regional Water Quality Control Boards (Regional Water Boards), Caltrans, and the EPA came to an agreement to develop a cross-media checklist for use during the development of regulations. To discuss cross-media issues and solutions, the California Association of Sanitation Agencies (CASA) along with other Clean Water Summit Partners organized a Biosolids Cross-Media Roundtable for a wide range of state and federal officials on May 16, 2008. As a result of the roundtable, CASA has coordinated efforts to develop the cross-media checklist. Components of the cross-media checklist include biosolids, compost processing, recycled water, California's AB 32 (regulating GHG emissions), California Environmental Quality Act (CEQA), regulatory processes, development of Water Quality Control Plans (Basin Plans) and water quality standards/regulations, and impact assessments to air, water, and land media. The process of getting the checklist implemented by the various California air, water, and waste control boards is still underway.

Figure 6.2 shows the key wastewater components and their corresponding regulatory issues.

6.2.9 Hazardous Materials and Wastes

The RWQCP manages onsite hazardous wastes. Regulations for hazardous wastes are overseen by state disposal rules, the Palo Alto Fire Department, and Santa Clara County's Department of Environmental Health. Hazardous wastes onsite include laboratory materials, waste oil, Household Hazardous Waste (HHW) items, fluorescent lamps, and paints.

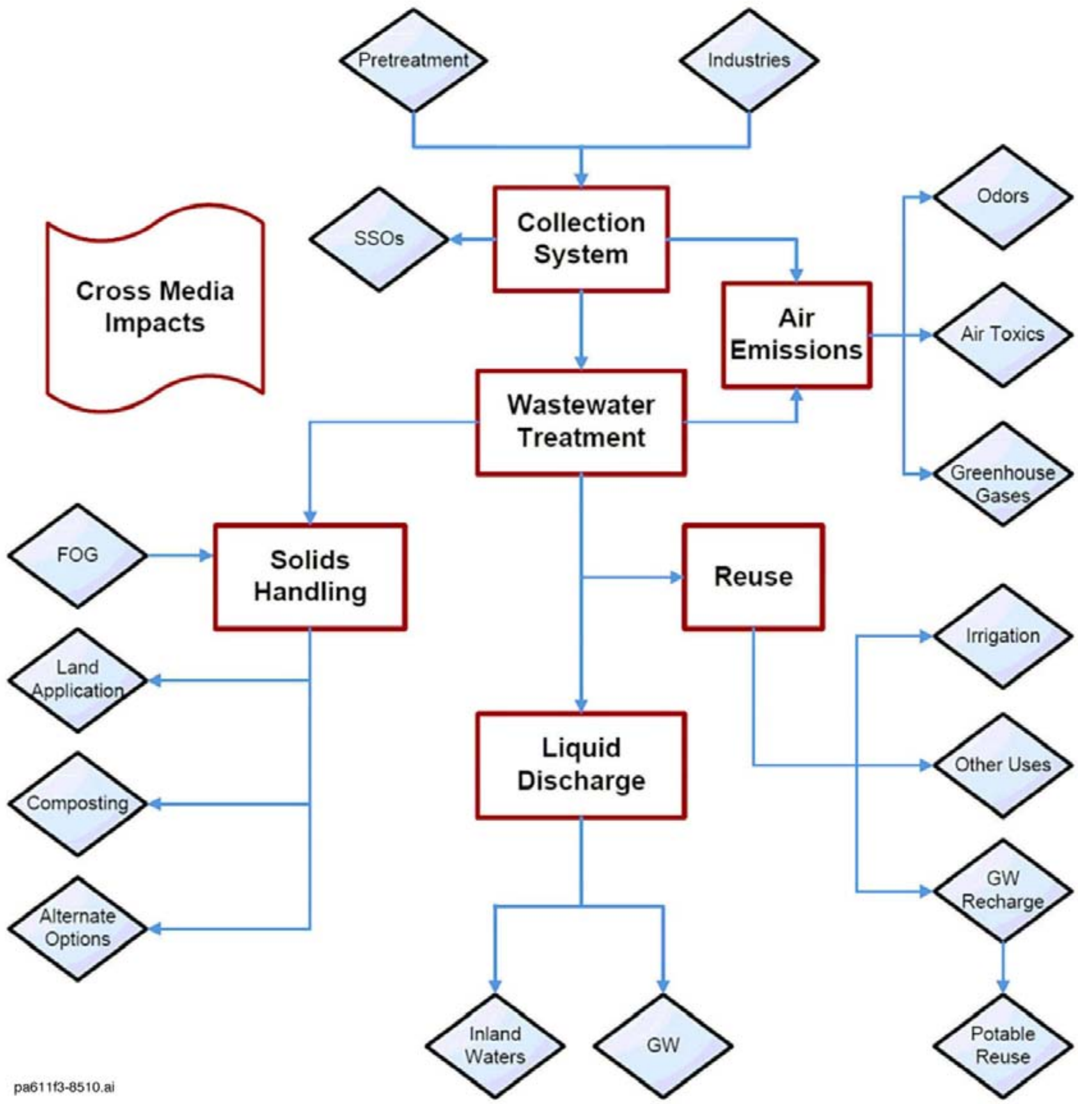


Figure 6.2 Cross-Media Impacts: Key Wastewater Regulatory Issues

6.3 FUTURE REGULATORY SCENARIOS

6.3.1 Approach to Development of Regulatory Scenarios

The development of regulatory scenarios for the LRFP is based on several factors, including:

- Other waste discharge requirements (WDRs) issued to dischargers in the San Francisco Bay area and California.
- Pending regulations.
- Discussions with regulators.
- Examination of growth and other non-regulatory developments that may affect areas where the RWQCP is currently in compliance.

These factors provide a basis for decision-making on regulatory issues to meet the needs of the RWQCP through the planning horizon in 2062.

6.3.2 Long Term Regulatory Scenario Through 2062

Through the planning horizon of 2062, the RWQCP will consider many strategies to deal with emerging regulations. At this level of planning, it makes sense to review groups of similar contaminants, rather than individual constituents, to determine ways to control their discharge. In general, the future regulations that have the greatest impact on the RWQCP long range planning and facility layout are those requiring major process changes, namely increased nutrient removal standards and incineration regulations that may drive the RWQCP to using different solids treatment processes.

Figure 6.3 summarizes the primary regulatory scenarios that will affect the LRFP alternative development. Ranges of permit cycles during which future regulations are likely to be implemented are shown for each regulatory scenario. Actual implementation dates for future regulations are projected and not certain.

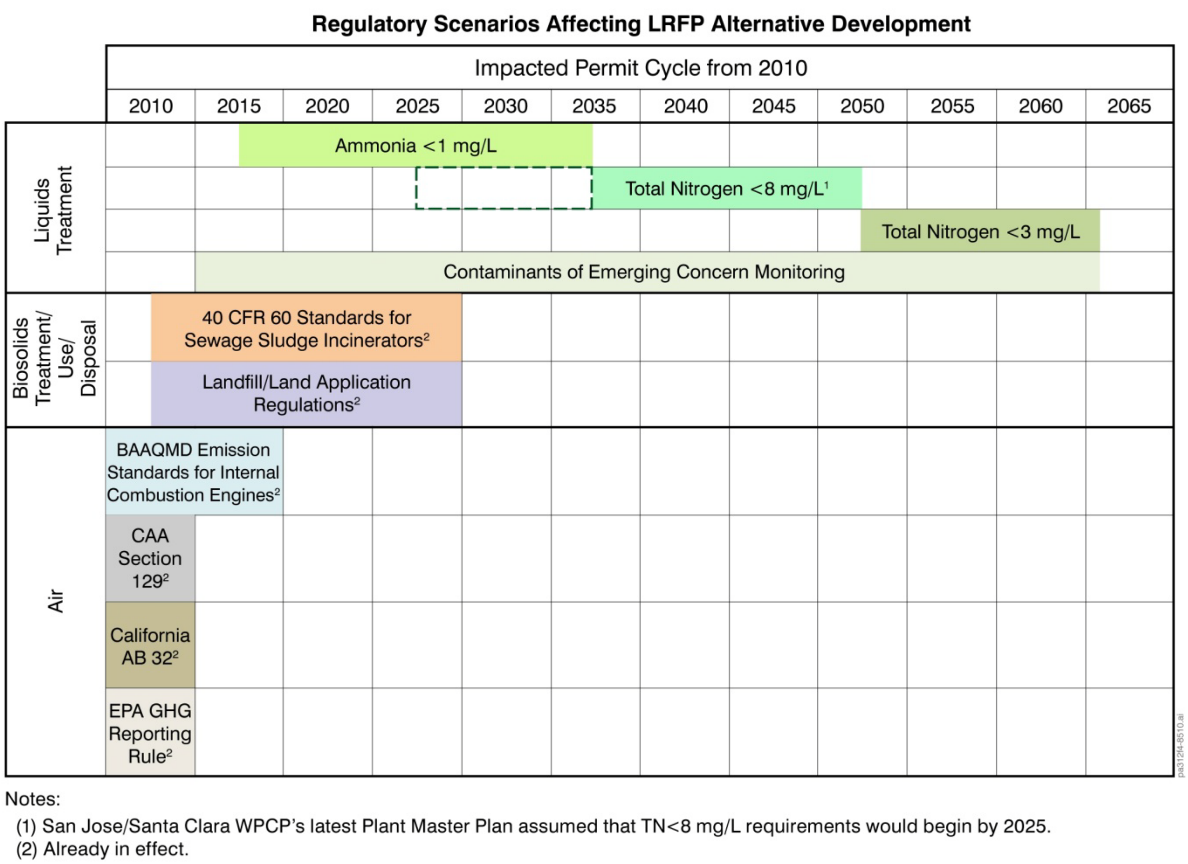


Figure 6.3 Regional Water Board Future Regulatory Scenarios

6.3.3 Summary

Table 6.11 summarizes solutions that can be implemented at the RWQCP to comply with current and future potential regulatory issues.

Table 6.11 Summary of Potential Regulatory Issues and Solutions

Topic	Issue	Potential Solution
Nutrient Removal	Federal and State consideration of nutrient removal regulations. Data collection and studies are ongoing to evaluate eutrophication of the Bay that may result in effluent limits.	Add processes and/or capacity to remove nutrients and maximize source control.
Microconstituents and Bioaccumulative Constituents	There is a trend of increasing regulation and it is anticipated that new effluent limits will be added to permits in the distant future.	Maximize removal through increased source control and pollution prevention programs. Consider advanced oxidation.
Recycled Water	State of California goal to increase water reuse to offset potable use.	Expand use of recycled water.
Biosolids	Landfilling of ash and land application of biosolids is becoming increasingly restricted and fewer landfills are accepting biosolids.	Consider diversifying biosolids management alternatives.
Incineration	EPA's new regulations impose strict requirements for new and modified incineration units. Based on this permitting cycle, these will only become more stringent.	Begin to diversify incrementally as opportunities arise and phase out the use of the current incinerators.
Air Emissions	New sewage sludge incineration (SSI) standards require RWQCP to apply for a Title V permit. Air emissions regulations increasing for standby engines.	Plan for increasingly stringent emissions requirements and need for emissions control equipment for stationary combustion facilities/engines.
Greenhouse Gases (GHG)	POTWs are not directly required to report GHG emissions but may need to report general stationary combustion emissions.	Monitor GHG emissions regulations and comply. Implement energy efficiency and green energy projects.

Chapter 7

SOLIDS TREATMENT ALTERNATIVES DEVELOPMENT AND SCREENING

7.1 PURPOSE AND OVERVIEW

As a critical function of treating wastewater at the RWQCP, solids removed from the liquid treatment processes must undergo additional treatment before they leave the site for beneficial use or disposal. The current solids treatment and handling system at the RWQCP includes gravity thickening, dewatering with belt filter presses, and multiple hearth furnace (MHF) incineration. The ash from the MHF is disposed of in a landfill. Due to the age of the MHFs and the increasing regulatory and community pressure on incineration, evaluating solids alternatives was a primary focus of this LRFP. As discussed in Chapter 5, long term operation of the MHF is not recommended due to the age, deteriorating condition and future regulatory compliance issues.

This chapter describes the solids alternative screening process, the alternatives considered, and the alternative solids treatment processes that will be considered for further evaluation. The solids treatment alternatives development and screening process began with considering available solids disposition options. Solids treatment alternatives that could achieve the required solids stabilization for a particular disposition option were evaluated using a set of initial screening criteria. Alternatives that best satisfied the initial screening criteria were selected for further evaluation.

7.2 BASIS FOR EVALUATION/PLANNING CONSIDERATIONS

The solids alternatives were evaluated for several key considerations: to meet the projected solids loading to the RWQCP, to meet regulatory requirements and to fit on the RWQCP existing plant site. Each of these considerations is discussed briefly below along with the overview of the alternatives development process.

7.2.1 Projected Flow and Loads

Influent flows and loads have been projected through the year 2062, as presented in Chapter 3. Based on population projections and current per capita flow rates, the projected average dry weather flow for 2062 is 34 mgd and the maximum month flow is 41 mgd. An alternate flow projection was developed using anticipated flow reductions from conservation and building code changes provided by member agencies. This alternate projection is 28.6 mgd for average dry weather and 34.6 mgd for maximum month. Influent loadings are not anticipated to change with conservation and are projected at maximum month as 72,874 ppd for TSS and 78,870 ppd for

BOD. These projections were used (along with estimates of additional solids from liquid treatment processes) for sizing the biosolids alternatives discussed herein.

7.2.2 Regulatory Requirements

Existing and future regulatory requirements for the RWQCP are presented in Chapter 6. Relevant requirements for solids treatment facilities include EPA's 2011 Sewage Sludge Incineration Rule, EPA's 40 CFR 503 regulations for contaminant limitations, and pathogen and vector control for biosolids, State and local use and disposal requirements, and the Bay Area Air Quality Management District's requirements for air emissions. All alternatives discussed were developed to meet anticipated regulatory requirements.

7.2.3 Site Considerations

The RWQCP has a very compact site that is already filled with treatment processes. Due to adjacent neighbors (such as the nearby parkland, business parks, and airport), odors, noise, emissions, truck traffic, and visual impacts are a concern. As a result, during a meeting with the LRFP project team (including City staff and Carollo) it was determined that siting all new solids treatment facilities near the center of the plant rather than the periphery was preferable. Figure 7.1 shows the existing facilities and the area identified for future solids facilities.

7.2.4 Solids Treatment Alternatives Development Process

In developing the solids alternatives, the LRFP project team presented the alternatives to the stakeholders on several occasions. In February 2011, the biosolids disposition options and solids treatment alternatives were presented to the stakeholders in a public meeting. At this meeting, each alternative was briefly presented along with its general benefits and disadvantages. At the November 2011 public meeting, the biosolids alternatives were presented in greater detail with descriptions of costs and greenhouse gas emissions for each. A summary of the recommendations for solids was presented at the March 1, 2012 final public meeting. Input was taken at each of these public meetings and used to develop the overall recommendations presented herein.

7.3 SOLIDS DISPOSITION OPTIONS

Solids can be disposed of or beneficially used depending on their material content and the extent they have been stabilized. The solids disposition options considered for this study are described below and include direct landfill of solids, use of biosolids as an alternative daily cover, ash disposal resulting from thermal conversion of solids, land application of biosolids, producing marketable products from biosolids, and regional opportunities that would require exportation of solids to an off-site solids processing facility.

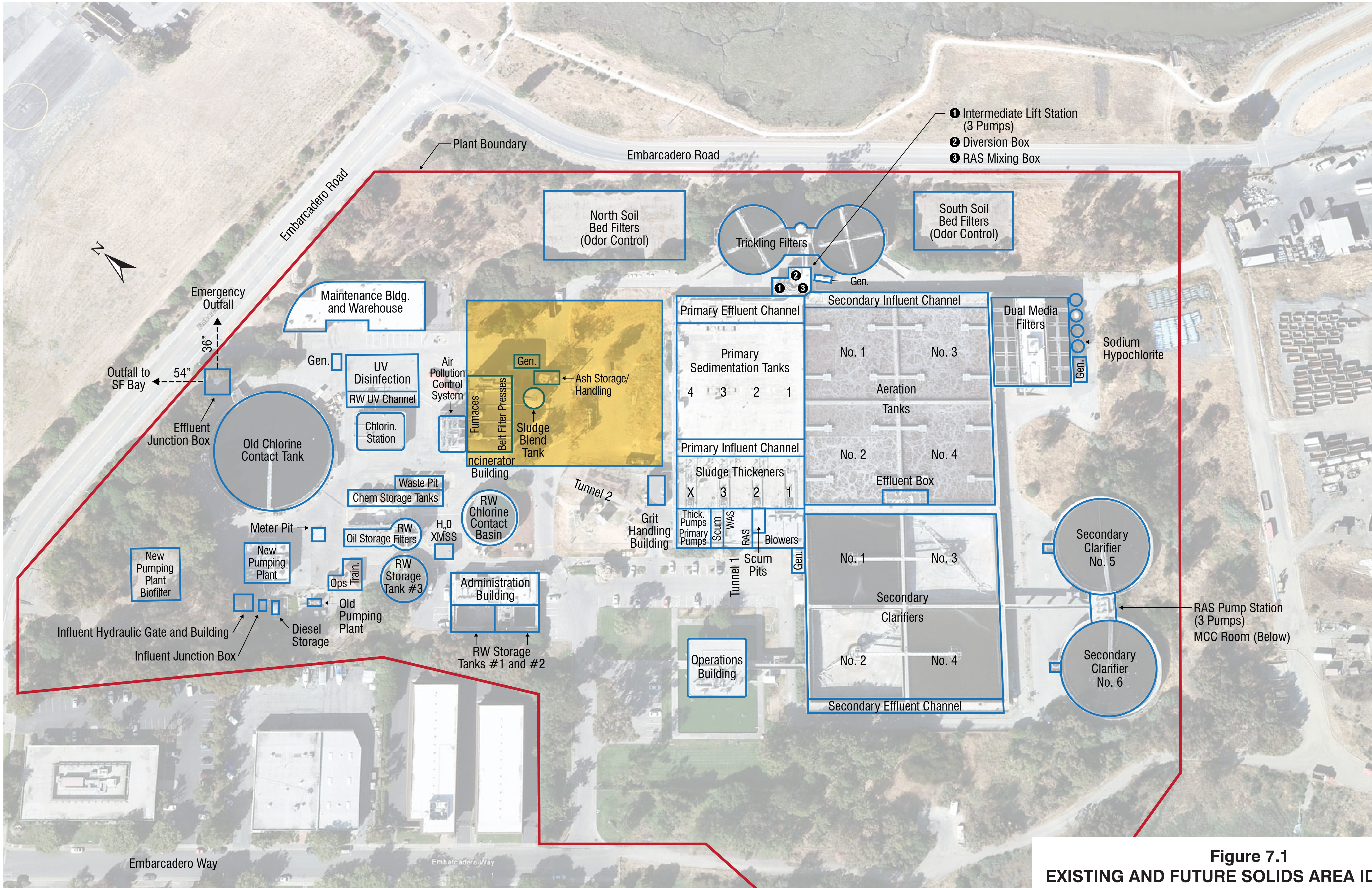


Figure 7.1
EXISTING AND FUTURE SOLIDS AREA IDENTIFIED
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f7-8510.ai

7.3.1 Landfill Disposal

7.3.1.1 Direct Landfill of Solids

Some landfills allow disposal of untreated solids or biosolids. Each landfill has its own requirements for disposal of these materials with respect to solids content and specific chemical constituent concentrations. Generally, dewatered cake is an acceptable form of material that can be landfilled. Biosolids cake is typically anaerobically digested and then mechanically dewatered to between 18 and 30 percent solids.

However, the trend in California is to move towards the prohibition of organics sent to landfills. In addition, capacity is becoming an issue with many landfills, including the City's landfill, which was not considered because of its closure July 28, 2011.

Treatment processes that can produce acceptable materials for landfill disposal include anaerobic digestion and solids dewatering.

7.3.1.2 Alternative Daily Cover

Soil is typically used as daily cover for the solid waste placed in a landfill. Biosolids can be mixed with other materials to serve as an alternative daily cover (ADC) for the solid waste, reducing the use of 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 CalRecycle, and is limited to 25 percent of the total landfill cover requirements. Treatment processes that can produce acceptable materials for ADC include anaerobic digestion and solids dewatering.

7.3.1.3 Ash Disposal

Ash is the end product of combusted sewage sludge and can be classified as either non-hazardous or hazardous based on its pollutant concentrations. The ash is typically landfilled; however, it can be beneficially used in the production of brick or cement products if (a) a nearby facility can be identified, (b) price is right, and (c) the quality of ash is consistent so that it meets manufacturer's and end user expectations. Multiple hearth and fluidized bed incineration produce ash. Plasma arc oxidation, pyrolysis, and gasification produce a biochar that may be used as soil amendment or disposed in a landfill, similar to ash.

7.3.2 Land Application

Land application refers to the agricultural use of biosolids in bulk as a soil amendment or fertilizer to grow crops. The biosolids add organic matter to the soil, which is a valuable addition to many California soils that lack this material. Biosolids are applied at or below the agronomic rates, required by the Federal Regulations 40 CFR 503, to ensure that the nitrogen in the biosolids are used up by the crop rather than accumulating in the soil and leaching to groundwater.

Biosolids are classified as Class A or Class B, which correspond to the level of treatment to reduce pathogens. Class A biosolids that meet more stringent requirements for pollutant concentrations required by the 40 CFR 503 regulations are called Exceptional Quality (EQ).

Class B biosolids can be applied only at sites where the general public could not come into contact with the material (e.g., agriculture, landfills). Class A biosolids can be applied where the general public may come in contact with the biosolids (e.g., nurseries, gardens, golf courses). EQ biosolids can be used in bulk form or distributed in bags.

As discussed in Chapter 6, there has been increasing pressure to ban land application, especially of Class B biosolids. Twenty-two counties in California have implemented either a complete or a partial ban on biosolids land application through either a direct ban or impracticable requirement. Only three counties specifically allow Class B biosolids land application: Sonoma, Solano and Merced Counties as shown in Figure 7.2. Dewatered cake represents the most basic and most common form of land-applied biosolids.

7.3.3 Marketable Products

7.3.3.1 Biosolids Compost

Dewatered cake can be mixed with various other materials (e.g., soil) and processed to create soil amendments (i.e., compost) or topsoil replacement products. In general, compost products are considered the most acceptable beneficial use products available to the public. This is because compost products are associated with food, yard, and agricultural wastes that the public is more familiar with and so are more likely to accept biosolids compost.

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.

7.3.3.2 Dried Biosolids

Dewatered cake can be dried to form fertilizer products. Thermally dried biosolids products generally contain less than 10 percent moisture. The product appearance can range from uniform spherical pellets to less uniform granules. The overall appearance of thermally dried products is generally acceptable to the public.

Figure 7.2
STATUS OF BIOSOLIDS LAND APPLICATION ORDINANCES BY COUNTY
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa911f4-8510.ai

Dried biosolids can be used as a soil amendment or fertilizer for agricultural purposes as a Class A product. Conventional spreading equipment is used to apply the product. The pellets are similar in size and shape to, and can be blended with, conventional synthetic fertilizer materials.

pa811f17-8510.ai

Figure 7.3 Dried Biosolids Pellets and Marketable Products

Dried biosolids can also be used as an alternative fuel source, which can offset fossil fuel usage. Dried biosolids have an energy content that ranges between approximately 7,000 to 10,000 Btu per pound depending on the stabilization process used. Potential future markets for dried biosolids pellets include electrical power plants and cement kilns. The cement industry has recently become interested in biosolids as a renewable fuel source not only because of the biogenic fuel value, but because the combustion ash adds needed chemicals that can be integrated into the cement. User requirements are specific to each cement kiln.

There is a large operating cement kiln located approximately 13 miles from the RWQCP. A Lehigh Hanson Cement Plant representative was contacted. The representative explained that the facility is currently upgrading their air pollution control system and they have no interest in using dried biosolids granules as a fuel at this time.

7.3.3.3 <u>Pyrolysis Char/Oil</u>

Pyrolysis is a thermal conversion technology that can convert sludge into a char or oil having an energy content ranging from 4,500 to 9,000 Btu per pound. The process also produces a syngas that can be used as a fuel. These materials can be used in waste-to-energy facilities and cement kilns. Since there are no currently operating pyrolysis facilities in the U.S. that take in sludge or biosolids, evaluation of uses of pyrolysis char or oil will be tracked for future consideration, but not considered further in the LRFP process.

7.3.4 Regional Opportunities

Two regional opportunities to process the City's sewage sludge have been considered in this LRFP: 1) Bay Area Biosolids-to–Energy (BAB2E) Project and 2) the San Jose/Santa Clara Water Pollution Control Plant (SJ/SC WPCP). For each of these, solids would be hauled from the RWQCP to the facility. The BAB2E facility could utilize the solids as a fuel to produce energy. This could be implemented either with or without digestion at the RWQCP. Alternatively, the solids could be anaerobically digested at the SJ/SC WPCP. Each of these alternatives would require upgrading the RWQCP's dewatering capabilities, as well as providing solids storage and loading facilities.

Other opportunities with adjacent wastewater treatment facilities were considered (e.g. Sunnyvale and South Bayside System Authority), but none other than the SJ/SC WPCP have adequate capacity in their solids treatment facilities.

7.3.5 Comparison of Disposition Implementation and Longevity

As discussed in the sections above, the different disposition options have differing regulatory and policy pressures that affect whether they are viable long-term alternatives. Based on our current understanding of these pressures we anticipate the approximate remaining life (and rationale) for each of the options to be as shown in Table 7.1.

In general, the future appears to hold limited options for landfill disposal and land application of biosolids in California, unless public perception is changed. Continued landfill disposal of ash is less problematic due to the small volume and lack of organics. Long term, reliable options for biosolids include developing marketable products and collaborating on regional solutions.

7.4 SOLIDS TREATMENT PROCESS ALTERNATIVES

This section identifies and evaluates alternative treatment schemes to satisfy potential future biosolids beneficial use/disposal requirements and to comply with air emission requirements. These alternatives include solids thickening and dewatering processes, thermal conversion technologies (i.e., multiple hearth furnace incineration, fluidized bed incineration, plasma arc assisted oxidation, gasification, and pyrolysis), anaerobic digestion, solids drying, and regional opportunities. These solids treatment alternatives and associated energy recovery opportunities are described in this section.

Table 7.1 Comparison of Disposition Options

	Estimated Remaining Life	Reason	Issue/Driver
Landfill Disposal			
• Direct Disposal • Ash • Alternative Daily Cover	• 5 years • Indefinite • 10-15 years	• Organics & GHGs • Small volume • Organics & GHGs	CalRecycle is pushing to reduce/eliminate organics from landfills
Land Application			
• Class B • Class A	• 5-10 years • 10-15 years	• Perception of poor quality for Class B, Less so for Class A	Counties are implementing bans, Limited close sites
Marketable Products			
• Compost • Dried Biosolids	• Indefinite with marketing	• Growing demand for local compost & fertilizer	Local, sustainable, phosphorous need
Regional Opportunities			
• BAB2E • SJ/SC WPCP	• Indefinite • >20 years	• Planned as long term • Current Master Plan	• Diversification • Excess capacity

7.4.1 Summary of Existing Solids Treatment Facilities

The current solids treatment and handling system at the RWQCP includes gravity thickening, dewatering with belt filter presses, and multiple hearth furnace (MHF) incineration. The ash from the MHF is disposed of in a landfill.

7.4.2 Sludge Thickening and Dewatering

All of the disposition options discussed in Section 7.3 will require solids thickening and dewatering. The RWQCP currently utilizes gravity thickening followed by belt filter presses for dewatering. These processes are working well for the RWQCP and require a relatively low energy input as opposed to other options such as dissolved air flotation thickening or centrifuge dewatering. As discussed in Chapter 5, based on the age and condition of the existing thickening and dewatering facilities, the RWQCP will need to plan for rehabilitation and/or replacement of these processes during the 50-year LRFP implementation period. However, at this time the RWQCP staff decided to assume continuation of gravity thickening and belt filter press dewatering. It is recommended that each time the equipment is replaced and when significant changes are made to the sludge being dewatered that this decision be reevaluated.

7.4.3 Thermal Conversion

The following section describes the thermal conversion technologies considered for the initial qualitative screening evaluation. Thermal conversion technologies would be utilized following thickening and dewatering of the solids. Thermal conversion options considered include multiple hearth furnaces (the existing process), fluidized bed incineration, plasma arc assisted oxidation, gasification, and pyrolysis. A process schematic of how existing and future thermal processing would be configured is shown in Figure 7.4. Opportunities for energy and/or heat recovery are discussed for each process alternative.

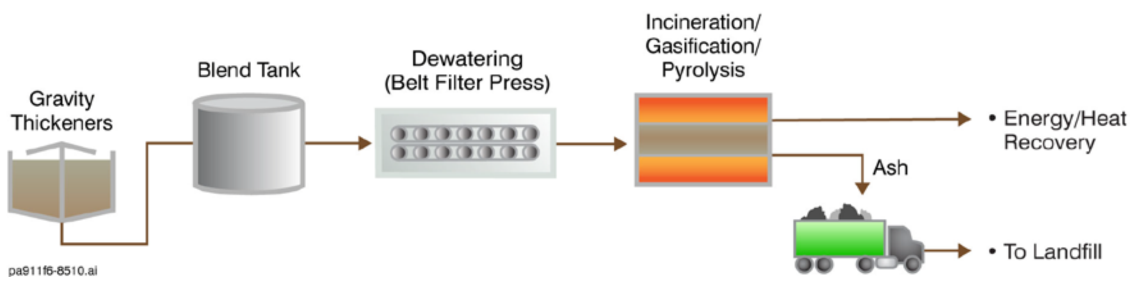


Figure 7.4 Existing and Future Thermal Solids Processing

7.4.3.1 <u>Multiple Hearth Furnace Incineration</u>

Multiple hearth furnace (MHF) incineration is the current solids processing technology employed at the City's RWQCP. The system is composed of two MHFs and air pollution control systems. Each MHF is a cylindrical tower consisting of six evenly stacked hearths. Solids are fed through the top of the furnace and they pass downward through each hearth. The MHF operates with three primary zones: 1) drying zone, 2) combustion zone, and 3) cooling zone. Dewatered cake is fed into the drying zone located at the top of the furnace. Dried solids enter the combustion zone located in the middle. The solids are combusted and reduced to ash, which is cooled in the lower part of the MHF.

Combustion air and fuel can be introduced into hearths 1, 2, 4, and 5. Combustion air is added to these hearths to provide adequate oxygen for the combustion process. Fuel in the form of natural gas is introduced to control combustion temperatures. The operating temperature range for the MHFs is 760 to 930 degrees Celsius.

Cooling air is blown through the center shaft to protect rotating steel equipment from warping within the MHFs. The cooling air does not come into contact with the solids. As the cooling air reaches the top of the shaft, it is used for mist suppression and exhausted to atmosphere.

Two streams of air are discharged from the MHF. Combustion air and any air that comes in contact with solids are treated to remove pollutants. The flue gas is treated in an afterburner maintained over 1,300°F to complete combustion on flue gases not completely combusted within the furnace. The exiting afterburner air is pulled into a wet scrubber where heat, moisture, and particulate matter are removed. Exhaust gases are sent to a stack where the stack gas is continuously monitored for total hydrocarbon levels.

A condition assessment and seismic stability analysis were performed on the both the MHF incinerators and the incinerator building, as discussed in Chapter 5. While the facilities have been well maintained , based on the age the MHFs are estimated to have approximately 10 years of remaining useful life. The earthquake used for the seismic evaluations were consistent with the ground motion at the site that has a 10 percent probability of being exceeded in a 50-year period. Results of these evaluations concluded that the MHFs at RWQCP are not anticipated to collapse or suffer extensive structural failure that would affect the safety or long-term operation of the incinerators. However, there could be some localized interior damage to the refractory bricks due to seismic force. The seismic review of the incinerator and dewatering building found that the building piles lacked the shear strength required to resist the seismic loading. During a large earthquake, the piles are likely to shear off below the top of the pile and the building could then experience unpredictable movement potentially resulting in significant lateral displacement and/or rotation. Construction costs to rehabilitate the building with new piles and connections were estimated at $0.55 million.

There is limited opportunity to recover heat from the existing MHF system.

7.4.3.2 **Fluidized Bed Incineration**

Fluidized bed incineration is a well-established sludge treatment technology in the U.S. It is the preferred technology for new incineration systems because they are more energy efficient, easier to control, and produce less air emissions than MHFs. Fluidized bed incinerators are refractory-lined steel cylinders with three distinct zones: 1) a windbox, 2) the bed section typically composed of sand, and 3) the freeboard. Combustion air is preheated and introduced into the windbox, which distributes air to an orifice plate. The plate separates the windbox from the fluidized bed, provides structural support for the sand bed, and is comprised of air distribution tubes. Fluidizing air is passed through the tubes to the bed section, which fluidizes the sand. Dewatered cake is fed into the fluidized sand bed, the water in the solids is evaporated, and the combustible matter is oxidized in seconds. Oxidation gas and water from this process flow upward into the freeboard where the gas combusts and completes the process.

The operating temperature range for the freeboard is 650 to 850 degrees Celsius. A high-pressure spray system is located in the freeboard zone to control process temperatures. This is more efficient and less costly than the existing MHF process that uses auxiliary fuel to control process temperatures.

Air from the incineration process is recycled to preheat the combustion air. Prior to discharging the air to the atmosphere, it is treated to remove pollutants. Carbon is injected upstream of a baghouse filter to remove mercury from the air stream. The air is conveyed to the baghouse filter where the mercury-containing carbon is removed as it passes through the filter. These steps are followed by a tray scrubber and wet electrostatic precipitator to remove the particulate matter (ash). Then the air is condensed to remove moisture and clean air is discharged to the atmosphere.

Energy and heat recovery from a FBI system would typically consist of a waste heat recovery boiler to generate steam, which is used to turn either process equipment (such as pumps or blowers) or a generator. Based on discussions with vendors, for a facility the size of the Palo Alto RWQCP, it is not cost effective to incorporate energy generation. Inherent to the FBI system is recirculation of the heated air to reduce energy input required for operation. This reduction in energy is included in the overall energy required for operation of the FBI system.

7.4.3.3 Plasma Arc Assisted Oxidation

Plasma arc assisted oxidation is an emerging technology with no commercially operating installations for wastewater solids. This technology uses a plasma torch that could heat, dry, and oxidize sludge. The torch is created in an electrode with an electrical current and combustion gas. The electrical current is passed through the combustion gas. The current ionizes the gas until an arc of light called plasma is created, similar to lightning. Combustion gas is projected through the end of the electrode creating the plasma torch. The torch creates enough energy to preheat the incoming sludge and combustion air, which makes the process more energy efficient. The plasma torch is located at the end of a rotary kiln.

Dewatered sludge and oxidation air are fed into the rotary kiln after being preheated. Drying and oxidation occur inside the kiln with the presence of the plasma torch located at the opposite end. Ash accumulates in the kiln and acts as a heating media for the incoming material. As it builds up, ash is extracted and could be trucked to a landfill or beneficially used. Process air is exhausted through an air pollution control system and ultimately discharged to the atmosphere.

Plasma arc assisted oxidation is similar to incineration except that no auxiliary fuel is needed to start or sustain the operation, required additional energy is provided as electricity through the electrodes. Other differences include the operating temperature and feed solids concentration. The operating temperature (600 to 700 degrees Celsius) is lower than either of the other incineration processes considered – multiple hearth (760 to 930 degrees Celsius) and fluidized bed (650 to 850 degrees Celsius). Feed solids must have a minimum 9,500 Btu heating value and 20 percent solids concentration. The air pollution control system for a plasma arc assisted oxidation process would be similar to FBI.

Fabgroups Technologies Inc./Hydro Quebec have a demonstration unit in operation that can process up to 48 wet tons per day. The facility is expected to be commercially ready for operation in the near future. Due to the lack of operating systems, it is unknown whether a plasma arc system could be configured to recover heat for potential energy generation, although because of the high electrical usage to provide the plasma arc, it is doubtful that it could produce more energy than it consumes.

7.4.3.4 Gasification

Gasification of sludge/biosolids is a technology that has been widely used for the last twenty years on coal, wood, and municipal solid waste. However, it is an emerging technology for processing wastewater sludge, with only one installation in the U.S. (in Sanford, Florida). The Sanford installation has been intermittently operated since 2010, during which they tested and optimized the gasification process. MaxWest began officially reporting biosolids processing data to the EPA in early 2011, upon which they considered the installation to be a commercial operation. However, the facility has operated intermittently throughout the year, much like the pattern prior to this year. The process involves applying a controlled amount of air to supply a small amount of oxygen to control the heat to a fuel rich sludge providing a temperature-controlled environment (greater than 800 degrees Celsius). Most of the volatile portion of the sludge is converted into synthesis gas, also called “syngas.” However, complete combustion is not realized in the gasifier because gasification operates in an oxygen-starved environment. An estimated 80 percent of the solids are converted to syngas. The remaining ash has little value and is usually disposed of similar to incinerator ash, though there are ongoing studies evaluating its use as a fertilizer.

Dewatered sludge is fed into a dryer to reduce the moisture content to approximately 10 percent. Dried solids are conveyed into the gasifier at a controlled rate to optimize syngas production. The majority of the volatile content of the solids is converted to syngas and conveyed to a thermal oxidizer where it is blended with air and burned. The heated flue gas from the thermal oxidizer is used to heat the solids dryer. Flue gas is conveyed through a bag house filter and scrubber prior to atmospheric discharge. In addition, flue gas from the solids dryer is conveyed to an odor control system prior to atmospheric discharge.

As currently implemented, while the syngas produced in a wastewater solids gasification process has a high fuel value, it is all utilized to dry the solids prior to the gasification unit. Because of this, there is little recoverable energy, and it is actually a net user of power since electrical power is used for dewatering, conveyance, and odor control, even though this is a relatively small power use.

7.4.3.5 Pyrolysis

Pyrolysis is an emerging technology with no commercially operating installations in the U.S. The process is similar to gasification in that it involves applying a controlled amount of heat to sludge except that it operates in an oxygen free environment. Because it operates in this type of environment, there is little or no combustion. The incomplete combustion of the sludge produces a char with an energy content ranging from 4,500 to 9,000 Btu per pound and a gas similar to syngas created with gasification. In comparison, the energy content of coal is in the 8,000 to 12,000 Btu per pound range. The char and gas from pyrolysis can be used to fuel a waste-to-energy facility or as a fuel alternative for cement kilns.

Similar to the gasification process, dewatered cake is dried to 90 percent solids and fed into the pyrolysis system. The cake is subjected to high temperatures (less than 700 degrees Celsius) in the absence of oxygen. Char and gas are created from this process and can be used as a fuel. The air pollution control system for pyrolysis would consist of equipment similar to a gasification process.

Due to the lack of operating systems, it is unknown whether a pyrolysis system could be configured to recover heat for potential energy generation. Based on discussions with a German company that has two operating pyrolysis facilities for solid waste, these system are not net energy producers.

7.4.4 Anaerobic Digestion

Anaerobic digestion is a widely used sludge stabilization process in the U.S. Thickened sludge is heated and fed into a digester where it is degraded in the absence of oxygen. The sludge is heated and mixed in the digester for at least 15 days as it is decomposed by anaerobic bacteria. Anaerobic digestion can meet Class A or B pathogen reduction requirements based on temperature and time requirements as described in the 40 CFR 503 regulations. Digestion is a suitable process for a variety of disposition options. Typically, solids are thickened prior to digestion and dewatered after digestion and before any other processing or disposition, as shown in Figure 7.5.

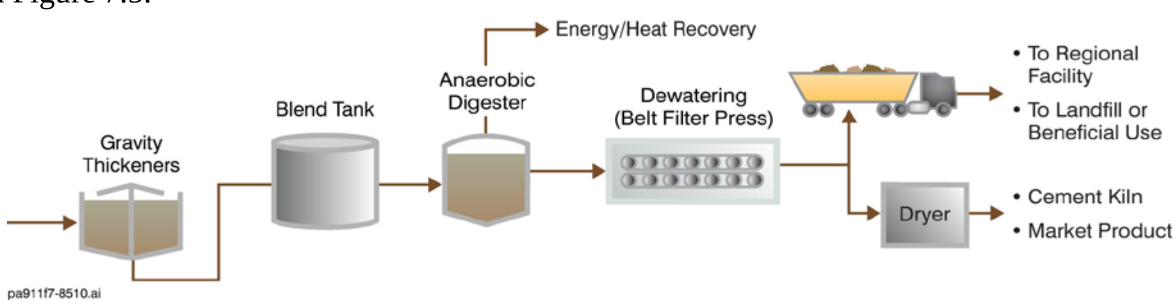


Figure 7.5 Digestion Solids Process

The anaerobic digestion process can be divided into three stages: 1) hydrolysis – the solubilization of particulate matter, 2) acidification – production of volatile acids, and 3) methane formation. During hydrolysis, the proteins, cellulose, lipids, and other complex organics are made soluble. During acidification, acetogens convert the biodegradable organics into low molecular weight volatile fatty acids (VFAs). In the last stage, methanogens convert the VFAs into methane and carbon dioxide. In conventional anaerobic digestion, all of these processes occur within one reactor even though both groups of bacteria have considerably different optimal conditions for growth.

Conventional mesophilic anaerobic digestion involves insulated digesters, operated at increased temperatures from 95 to 105 degrees Fahrenheit, with a hydraulic residence time (HRT) of 15 days or more. Waste heat from a cogeneration system or boilers and heat exchangers are required to attain mesophilic temperatures. Mesophilic digestion is typically used to produce Class B biosolids.

Odor control has been a concern with the anaerobic digestion process. Methane and carbon dioxide are the primary end products of an anaerobic digestion process, but hydrogen sulfide and ammonia are also produced under anaerobic conditions.

The anaerobic conditions in digesters also release ammonia from the solids back into liquid, which stays with the liquid recycle stream during dewatering and is usually returned to the liquid treatment processes. This ammonia recycle stream adds load to the secondary treatment process, requiring an additional input of energy for treatment. The additional liquid treatment required due to digestion is discussed further in Chapter 8, Liquid Treatment Alternatives Development and Screening.

The anaerobic digestion process can be modified to operate at higher temperatures or to incorporate additional phases to produce Class A biosolids. Anaerobic digestion in general was considered for this screening evaluation. Variations on anaerobic digestion processes will be evaluated further during a preliminary design phase if anaerobic digestion is selected for implementation. The anaerobic digestion processes that should be included in this type of evaluation would be: mesophilic, thermophilic, temperature-phased, acid-phased, and a combination of thermal hydrolysis and anaerobic digestion. Descriptions of these alternative anaerobic digestion processes are included in Appendix K.

Anaerobic digestion presents an opportunity to produce energy at the RWQCP. Energy recovery from an anaerobic digestion process consists of using the digester gas in a co-generation process and using waste heat to heat the digesters. For most wastewater facilities, cogeneration consists of reciprocating engines, which have an overall efficiency (as a percent of fuel input energy) of 30 to 38 percent conversion to electrical energy and 40 to 45 percent efficiency to recoverable heat. Emissions from engines are limited by the Bay Area Air Quality Management District, with limits continuing to get more restrictive. It is assumed that, in the future, a digester gas scrubbing system and exhaust gas scrubbing equipment will be required for cogeneration.

An alternative to engines is the use of fuel cells, which are electrochemical devices that combine hydrogen from the digester gas and oxygen from the air to produce electricity and recoverable heat with little emissions. Fuel cells have an overall efficiency of 45 to 47 percent conversion to electrical energy and 20 to 25 percent efficiency to recoverable heat. Fuel cells require gas conditioning systems to remove contaminants from the gas and to convert the methane to hydrogen. The gas conditioning systems are fairly complex and require regular maintenance. There are several fuel cell systems that have been installed in California with significant grant funding from the state. Some of these installations have experienced difficulty with the fuel conditioning systems. It is also unknown how long grant funding will remain available for fuel cells. Due to the limited installations of fuel cells, we recommend keeping this technology on the promising technology list, but we are including reciprocating engines for the alternatives evaluation.

7.4.5 Composting On-site

Composting is a stabilization process normally performed after biosolids are dewatered and after subsequent mixing with a bulking agent. The bulking agent raises the initial solids content of the mixture and provides a carbon source for the organisms and bulk porosity important for maintaining aerobic conditions. High temperatures achieved during the microbial decomposition reduce pathogenic organisms in the solids. When composting is complete, the compost material is typically screened to retrieve a portion of the bulking agent. The product is then allowed to cure for several days and the resulting humus-like material can be used as a soil amendment. As identified in the 40 CFR 503 regulations, composting operations can meet either Class A or Class B pathogen reduction requirements dependent upon time and temperatures met during the process.

In general, compost products are considered the most acceptable beneficial use products available to the public. This is because compost products are associated with food, yard, and agricultural wastes that the public is more familiar with and so are more likely to accept biosolids compost. In addition, biosolids compost does not have an objectionable odor or sludge-like appearance. The two most common types of composting processes are windrow composting and aerated static piles.

In windrow composting, the biosolids and bulking agent mixture is formed into long, open-air piles. The biosolids are turned frequently to ensure an adequate supply of oxygen throughout the compost pile and to guarantee high, uniform temperatures throughout the pile for optimal pathogen reduction. Windrows are the lowest-cost composting process. However, this technique can have high odor emissions and composting the plant's sludge would take significantly more land than is available on the site. Therefore, windrow composting will not be considered for further evaluation.

Aerated static piles rely on forced air to supply air for both decomposition and moisture removal. Air is supplied by blowers connected to perforated pipes running under the piles. The blowers draw or blow air into the piles, assuring even distribution of air throughout the composting biosolids mixture. A layer of previously composted biosolids is often placed over the surface of the pile to help to insulate the pile and assure that sufficient temperatures are achieved throughout the pile. Positive pressure aerated static pile composting is often conducted within an enclosed building in order to collect and scrub the gases emitted from the process. An aerated static pile composting facility would require a large parcel of land and as such will not fit on the RWQCP site and as such, aerated static pile composting will not be further evaluated.

There is no opportunity for energy and/or heat recovery from a composting operation. Due to the limited land available on-site, composting options will only be considered for an off-site location.

7.4.6 Composting Off-site

Another option to produce biosolids compost is to haul dewatered cake to a private composting facility. Synagro operates a composting facility in Merced County that could accept solids from the City.

Also, the City of Palo Alto is considering processing its green waste and food waste in a dry digestion/composting facility that might be located at the parklands (former landfill site) adjacent to the RWQCP. Co-mixing the green waste and food waste with biosolids is being considered as one of the options.

There is no opportunity for energy and/or heat recovery from a composting operation whether onsite or offsite.

7.4.7 Thermal Drying

Thermal drying is a well-established solids treatment technology. Drying technologies use thermal energy to evaporate almost all moisture from biosolids to create a Class A product. There are wide varieties of dryer technologies available; for master planning purposes, the technologies can be divided into direct and indirect heat transfer technologies. The process flow schematic for a dry operation at RWQCP is shown in Figure 7.6, although either digested or undigested biosolids could be dried. Although drying of undigested solids leaves more of the fuel and fertilizer value in the dried product (pellet), there are greater public perception and odor issues as a result of the drying process and final product rewetting.

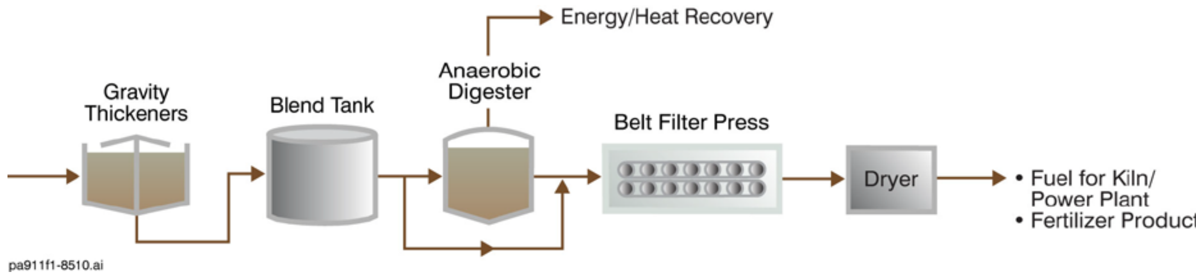


Figure 7.6 Drying Solids Process

There is no opportunity for energy production using heat recovery from a dryer. In fact, dryers require considerable input of fuel, which could be supplied by natural, digester or landfill gas. On the other hand, the dried solids can be used as a biogenic fuel source for use in coal or coke fired power plants or cement kilns.

7.4.7.1 Direct Drying

Direct drying of solids typically takes place in a rotary kiln or a fluidized bed dryer. For a facility the size of the RWQCP, a fluidized bed dryer is probably the equipment of choice and is discussed here, although both should be evaluated during final design if drying technology is to be implemented.

In fluidized bed dryers, moisture removal is achieved predominantly by convective heat transfer. A natural gas or biogas fired furnace heats oil or other heating media. The oil is pumped into a heat exchanger where the heat is transferred to the fluidizing air. The heated fluidizing air comes into direct contact with the cake solids, causing the water to evaporate. Fluidized bed dryers are equipped to produce a high-quality biosolids product consisting of uniform, hard, spherical pellets similar in appearance (with the exception of color and odor) to commercial inorganic fertilizer products.

Dewatered biosolids are pumped directly into the dryer. An extrusion and cutting system is used to form pellets for the drying process. Heated, fluidized air is blown through the bed of the dryer. Once the pellets are dried, they are discharged from the fluidized bed. The pellets are separated from the air stream and conveyed to storage.

Air from the dryer is conveyed to a bag house to remove particulate matter. The solids from the baghouse are collected and mixed with a stream of cake solids fed to the dryer. The remaining air is condensed and recycled to heat the fluidization air. Exhaust air is treated in a regenerative thermal oxidizer to remove volatile organic compounds prior to atmospheric discharge.

7.4.7.2 Indirect Drying

Indirect dryers achieve moisture removal predominantly by conductive heat transfer, and the biosolids are kept separate from the primary heated drying medium (typically oil or steam). The drying medium is heated in a boiler or heat exchanger by the hot combustion gases from a fuel-burning furnace. Dewatered biosolids are introduced to the drying chamber, which is heated with hot oil or steam. Moisture evaporates from the biosolids as they move through the machine. Dried biosolids exit the dryer and are cooled prior to being put into temporary storage.

Vapor from the dryer passes through a condenser prior to treatment in a biofilter or other odor control process and discharged to the atmosphere. The volume of air that must be treated is significantly smaller than the direct drying systems because the furnace air does not come into contact with the drying biosolids.

Indirect dryers can be equipped to produce pellets, similar to the direct dryers. However, pelletizing would require recycling 50 to 70 percent of the dried material to initiate the pellet forming process.

7.4.7.3 Storage of Dried Biosolids

Heat dried biosolids products must be stored properly or they can ignite. If a pile of heat-dried biosolids absorbs moisture, it can autoheat and combust. Therefore, proper design of product storage facilities is vital. Product storage silos are generally equipped with temperature sensors and inert gas blanketing to reduce fire potential.

7.4.8 Regional Opportunities for Solids Handling and Disposal

Regional solutions for biosolids handling and disposal would entail taking either digested or undigested solids produced at the RWQCP and transporting them to an offsite regional facility. Depending on the distance, solids could either be pumped and piped or trucked to a regional facility location. For this evaluation, we have assumed dewatered solids would be trucked to the regional facilities as shown in Figure 7.7. Regional opportunities considered for the LRFP include the Bay Area Biosolids-to-Energy (BAB2E) Project and the SJ/SC WPCP. It should be noted that at the time of this report's publication, the BAB2E site had not been determined.

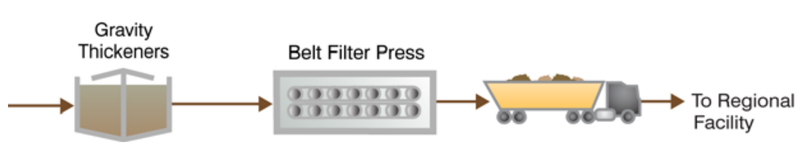


Figure 7.7 Regional Opportunities Solids Process

Regional opportunities have some implications to the existing landfill gas used at the plant. The RWQCP will no longer be able to utilize landfill gas if a regional solids handling options is implemented; instead, the landfill will need to use its flare continuously. Use of fuel cells or generator engines is not recommended since the volume of landfill gas is expected to steadily decline once the landfill is closed.

7.4.8.1 Bay Area Biosolids-to-Energy Project

Sixteen bay area agencies have formed a coalition to implement a regional biosolids-to-energy facility that will be located within the nine-county bay area. Following a request for qualifications process completed in 2010, the coalition has selected the following teams to participate in a subsequent request for proposals process:

- Synagro – for a dryer that would use waste heat from engines in Solano County to dry biosolids then use the dried biosolids as a fuel in a biomass plant in Woodland.
- MaxWest – for a gasification facility that would recycle heat from the gasifier but would not produce energy at a site or sites yet to be determined.
- Intellergy – for a steam reformation plant that would use the steam reformation process to produce hydrogen fuel at a site or sites yet to be determined.

Selection criteria for the request for proposals (RFP) will require that a technology can effectively and efficiently process biosolids. Prior to issuing the RFP, the coalition has elected to pilot Intellergy's steam reformation technology. The pilot will be used to demonstrate that the technology can effectively and efficiently process biosolids. Based on the results of this pilot, the coalition will issue an RFP for a regional biosolids to energy facility. The RFP is expected to be released in 2012.

The solids going to the BAB2E facility could either be digested or undigested sludge. The cost for this alternative will not be finalized until a technology is selected and the amount of grant funding is determined.

7.4.8.2 San Jose/Santa Clara Water Pollution Control Plant

The SJ/SC WPCP solids treatment process is currently comprised of anaerobic digestion, solids storage lagoons, and drying beds. As part of their 2010 WPCP master plan (www.rebuildtheplant.org), the solids treatment process will be upgraded. Nine of their sixteen digesters will be upgraded, mainly to provide better mixing to match the biosolids needs. The existing solids stabilization lagoons will be replaced with smaller covered lagoons that will store digested solids for up to six months. Sludge from the lagoons will be extracted and mechanically dewatered. A new centrifuge dewatering facility will be provided to dewater all biosolids. The solids will then be dried either mechanically or via greenhouses.

The SJ/SC WPCP would consider accepting sludge from the RWQCP; however, capacity would need to be added to the SJ/SC WPCP solids treatment process. In addition, a receiving and storage facility would need to be constructed to accept the sludge. The raw biosolids (over 90,000 lbs TSS/day at build out in 2062) 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/ft3 loading, between one and two digesters would be needed to handle the RWQCP solids. The RWQCP partner agencies would be responsible to finance these upgrades.

Various disposition alternatives will be available for biosolids from the SJ/SC WPCP. These include landfill and agricultural uses, which require biosolids that are dewatered or dried. Dewatered biosolids cake can be used as ADC at landfills. Composting processes typically require dewatered cake. Composting facilities can be provided on-site or dewatered biosolids can be sent to an off-site facility. Biosolids can also be dried and used for agricultural purposes. Drying can be accomplished on-site with greenhouses or thermal dryers. Finally, the SJ/SC WPCP Master Plan includes the option that the dewatered biosolids could go to the BAB2E facility when it is constructed.

The two plants are located about 11 miles by freeway from each other. For this evaluation, it was assumed that a solids loading facility would be constructed at the RWQCP site and the dewatered solids would be trucked to the SJ/SC WPCP site where an unloading facility would be constructed and additional solids handling facilities would be upgraded to handle the additional capacity.

7.5 INITIAL SCREENING OF SOLIDS TREATMENT ALTERNATIVES

A qualitative screening evaluation was performed on the alternative solids treatment processes. The alternatives were evaluated against a set of criteria that included: treatment, environment, community/neighbors, and cost.

Treatment criteria considered included: the process footprint, flexibility, and whether the primary technology is proven. The RWQCP has limited area in which a solids treatment process can be constructed. As a result, the overall footprint requirement of each alternative was evaluated. Flexibility considered the ability for a technology to adapt to anticipated changes in regulations or future regulations. A technology was considered proven if (a) it is commercially installed and processing wastewater sludge successfully at full scale at one or more facilities and (b) it has been in operation for 2 to 3 years.

Environment criteria considered the amount of energy required to operate the system. This included electrical and fuel demands. In addition, air quality effects of each technology were evaluated.

Community/neighbors considered the visual and odor impacts from each alternative. Visual impacts were based on how the technology and associated equipment and buildings fit the landscape of the RWQCP. Odor impacts were based on emissions from the process or related activities (e.g., hauling).

Table 7.2 summarizes the initial qualitative screening results based on the above criteria (detailed results are provided in Appendix L).

Based on the results of the screening, plasma arc assisted oxidation, pyrolysis, dried pellets as cement kiln fuel, and composting on-site will not be considered for further. Some of the reasons for the decisions on whether to eliminate or further consider a process are listed below:

- There are no existing plasma arc assisted oxidation or pyrolysis installations that commercially process wastewater sludge. However, these processes should be watched as emerging technologies that could potentially be implemented in the future.
- The local cement kiln is not interested in using dried sludge pellets as fuel. There is not a developed market for pellets and drying is an expensive process to implement.
- There is not enough room at the RWQCP for on-site composting.
- Gasification appears to be a promising process for wastewater solids. At the May 2012 IFAT Conference in Munich Germany (16th International Symposium on Water, Wastewater, Solid Waste and Energy), there were 15 vendors advertising gasification processes and there is a lot of interest in the wastewater field in furthering the application of this technology on wastewater solids. Understanding gasification’s emerging level of development and proper application represents both an opportunity and a challenge as this technology improves for sewage sludge treatment.

Therefore, the viable alternatives remaining are the baseline (MHF) and Alternatives 1, 3, 5, 8, 9, and 10, that is:

- Thermal Conversion: MHF (Baseline), FBI (Alternative 1), and Gasification (Alternative 3)
- Anaerobic Digestion (Alternative 5)
- Regional Options: Composting Off-site (Alternative 8), SJ/SC WPCP (Alternative 9) and BAB2E Facility (Alternative 10)

Table 7.2 Summary of the Initial Qualitative Screening Evaluation

	Treatment Process	Treatment	Environment	Community/ Neighbors	Cost
Thermal					
Baseline	MHF	●	○	●	◒
Alternative 1	FBI	●	◒	●	◒
Alternative 2	Plasma Arc Assisted Oxidation	○	○	●	○
Alternative 3	Gasification	○	○	●	○
Alternative 4	Pyrolysis	○	○	●	○
Digestion					
Alternative 5	**Anaerobic Digestion**	◒	●	◒	◒
Drying					
Alternative 6	Pellets for Fertilizer	◒	◒	◒	○
Alternative 7	Pellets as Fuel	◒	○	◒	○
Regional Options					
Alternative 8	Composting Off-site	●	◒	○	◒
Alternative 9	SJ/SC WPCP	●	◒	○	◒
Alternative 10	BAB2E Facility	●	◒	○	◒

Notes:
(1) Treatment criteria include footprint, flexibility to meet future regulations and proven technology.
(2) Environment criteria include energy and air quality.
(3) Community/Neighbor criteria include visual and odor impacts.
(4) Cost criteria include capital and O&M costs.

Legend:
● - Best meets the critieria
◒ - Meets some of the criteria but has some adverse impacts
○ - Worst at meeting the criteria, there are many adverse impacts.

However, several of these alternatives are not discrete, mutually exclusive alternatives. Namely, composting off-site would require digestion prior to hauling off-site to a composting facility.

Similarly, anaerobic digestion alone is not a full alternative as a final disposition option must be included. Based on the discussion in section 7.3 and the longevity of the disposition options shown in Table 7.1, we have combined off-site composting with the anaerobic digestion alternative.

The alternatives eliminated from further consideration could be evaluated in the future when more information is available and more interest develops (i.e., market develops for biosolids pellets).

7.6 COMPARISON OF VIABLE ALTERNATIVES

This section presents a comparison of the viable biosolids alternatives for the RWQCP and the assumptions used in their development.

7.6.1 Assumptions for Evaluating the Viable Biosolids Alternatives

The following assumptions were used in developing and analyzing the plant-wide biosolids alternatives:

- The baseline of using the existing MHF facilities is not a viable long-term option, as the facility is near or at the end of its useful life. The baseline option assumes continuing with the required maintenance (including a seismic retrofit to the building) to keep the facility operational until a new solids facility can be constructed (before or by 2025).
- All solids alternatives are sized for projected influent flows in year 2062 assuming secondary solids production from an activated sludge process with nitrification and denitrification – a worst case scenario of 94,000 ppd of thickened solids for digestion alternatives and 91,000 ppd of thickened solids for all other alternatives.
- All solids facilities are sized using reliability/redundancy criteria similar to the existing MHF operation, such that the processes can operate with one unit out of service during annual average conditions to allow for routine maintenance and cleaning.
- Continued use of gravity thickeners and belt filter presses for thickening and dewatering, respectively. Costs are included for replacement of dewatering equipment.
- Costs basis as established in the Basis of Cost Technical Memorandum.
- While many digestion options are available, this evaluation considers mesophilic digestion in a standard-shaped configuration, as representative of footprint and cost required. Other digestion options would be considered during the preliminary design phase if digestion were to be implemented.
- Cogeneration is included for the digestion alternative assuming use of reciprocating engines with a gas scrubbing and gas exhaust system to comply with future emission requirements.

- Gasification costs are based on quotes from MaxWest, the company running the Sanford, Florida installation. MaxWest does not sell the gasification units, but instead sells a service of solids processing for an annual fee. The City would be responsible for providing a location, utilities, and piping of dewatered sludge to the gasification process. Capital costs included dewatering facilities, a building, and utility connections for the vendor supplied gasification system.
- Demolition costs were assumed for the existing MHFs and incinerator building for the alternatives that include digestion, gasification, and FBI as the new facilities would be sited in the same location.
- Operation and maintenance (O&M) costs are based on 2015 dollars. Assumed annual replacement costs of equipment based on 5 percent of the original capital costs. Electricity based on 50 percent City of Palo Alto Utility (CPAU) green power mix ($0.017/kWh) and 50 percent CPAU standard power mix ($0.14421/kWh).

7.6.2 Alternatives Evaluation

The alternatives evaluation was narrowed to a baseline and five alternatives based on the results in Section 7.5. For alternatives costing, the final disposition must be incorporated into the alternative. The alternatives include thermal conversion with landfilling of the ash; anaerobic digestion with beneficial use to an off-site composting facility or the BAB2E facility; and sending solids to SJ/SC WPCP. Thus the alternatives to be evaluated further are:

- Baseline – Continued use of the MHF until the useful life is exceeded, with landfill disposal of the ash.
- Alternative A – Convert to FBI with landfill disposal of the ash.
- Alternative B – Convert to gasification with landfill disposal of the ash.
- Alternative C – Anaerobic Digestion with off-site beneficial use (either land application or composting).
- Alternative D – Send dewatered solids to SJ/SC WPCP for digestion and disposition.
- Alternative E – Send dewatered solids to BAB2E.

Table 7.3 presents the solids production, gas production, and energy consumption for each of the alternatives based on annual average conditions in year 2045. In addition, Table 7.4 presents the gas production, and energy consumption for each of the alternatives based on annual average conditions in year 2019 when the solids alternative is anticipated to be on-line.

The following sections present additional information on the alternatives.

Table 7.3 Comparison of Energy Use for Biosolids Treatment Alternatives (2045)[(1)(2)]

Alternative[(1)]	Number of Units Needed	Ash or Biosolids Hauled Offsite (dry tons per day)[(2)]	Electrical Power (Therms)	Natural Gas Usage (Therms)	Landfill Gas (Therms)	Excess Digester Gas[(4)] (Therms)	Digester Gas Required for Heating (Therms)	Contracted/Off-site Energy Usage (Therms)
Baseline. Existing MHFs	2	2	135,491	317,509	255,135	-	-	-
A. FBI	2	4	104,339	-	-	-	-	-
B. Gasification	2	4	28,314	-	-	-	-	72,903
C. Anaerobic Digestion[(3)]	3	22	109,021	-	-	(199,907)	114662	-
D. SJ/SC WPCP	NA	22	14, 492	-	-	-	-	52,838
E. BAB2E	NA	22	14,714	-	-	-	-	72,903

Notes:

NA = not applicable

(1) All alternatives assume continuation of gravity thickening and belt filter press dewatering.

(2) Based on liquid alternatives with the maximum amount of solids generation.

(3) Not including any FOG and food waste addition. Expected heat recovered for gas production with anaerobic digestion is 36,700 MMBTU/yr.

(4) Based on a 0.73 MW cogeneration power available and without food waste. A 1.0 MW engine generator is required in 2062.

Table 7.4 Comparison of Energy Use for Biosolids Treatment Alternatives (2019)[1][2]						
Alternative[1]	**Electrical Power (Therms)**	**Natural Gas Usage (Therms)**	**Landfill Gas (Therms)**	**Excess Digester Gas**[4] **(Therms)**	**Digester Gas Required for Heating (Therms)**	**Contracted/Off-site Energy Usage (Therms)**
Baseline. Existing MHFs	135,491	317,509	255,135	-	-	-
A. FBI	80,380	-	-	-	-	-
B. Gasification	21,938	-	-	-	-	72,903
C. Anaerobic Digestion[3]	84,289	-	-	(168,565)	68,644	-
D. SJ/SC WPCP	11,400	-	-	-	-	40,665
E. BAB2E	11,237	-	-	-	-	72,903

Notes:

NA = not applicable

(1) All alternatives assume continuation of gravity thickening and belt filter press dewatering.

(2) Based on liquid alternatives with the maximum amount of solids generation.

(3) Not including any FOG and food waste addition. Expected heat recovered for gas production with anaerobic digestion is 36,700 MMBTU/yr.

(4) Based on a 0.73 MW cogeneration power available and without food waste. A 1.0 MW engine generator is required in 2062.

7.6.3 Net Present Value

Table 7.5 shows the net present value analysis for the baseline and each of the five alternatives evaluated, respectively. The evaluation includes O&M costs, capital costs (based on millions of 2015 dollars), net present value, annualized cost, and cost per dry ton for treatment and disposition. All capital and O&M costs were developed based on the procedures and guidelines presented in the Basis of Cost Technical Memorandum shown in Appendix M. The details of these costs are provided in Appendix N.

Table 7.5 Biosolids Treatment and Disposition Alternatives Cost Estimates(1)

Treatment Alternative(2)	O&M Costs(3) ($/yr)	Capital Costs(4) ($)	Net Present Value(1) ($)	Annualized Cost(5) ($)	$/Dry Ton(6)
Baseline. Existing MHFs	2.3	1.8	36.5	2.4	362
A. FBI	5.0	130.5	240.3	13.5	1112
B. Gasification	4.5	49.8	138.5	7.8	641
C. Anaerobic Digestion	4.4	89.0	182.0	10.2	841
D. SJ/SC WPCP	4.0	39.5	115.4	6.6	542
E. BAB2E	6.1	12.8	124.2	6.9	572

Notes:
(1) Present value cost represents the value in millions of 2015 dollars of the total cash flow occurring over the life of a project (30 years and 5% interest)
(2) All alternatives sized for 2062 solids production with the exception of the Baseline (existing MHFs), which assumes costs for maintenance until new solids facilities constructed (by 2025).
(3) O&M costs are in 2015 dollars and based on sludge production in 2045 except for the baseline (existing MHFs).
(4) Capital costs are for the 2062 facilities amortized over a 30-year period using an interest rate of 5 percent.
(5) Annualized costs are based on a 30-year period using an interest rate of 5 percent.
(6) Includes treatment and disposition costs.

7.6.4 Greenhouse Gas Emissions Analysis

A greenhouse gas (GHG) emissions analysis of each alternative operating in 2045 was completed and compared to baseline (existing MHFs) conditions using Carollo's GHG emissions estimating tool. A summary of the detailed analysis is provided in this section. Details of the GHG analysis is provided in Appendix O.

The following assumptions were used in developing the GHG emissions analysis for the alternatives:

- GHG emissions included in the analysis are a result of electricity or natural gas consumption for necessary operations onsite. Operations emissions at an off-site location (i.e., SJ/SC WPCP and BAB2E) were not included in this evaluation.
- GHG emissions estimated for this evaluation include the direct (fuel combustion at the RWQCP, as well as sewage sludge incineration) and indirect (electricity use at the plant, energy use to produce polymer and natural gas consumed on-site, and fuel combustion for biosolids and chemical hauling) emissions generated by RWQCP operations.
- Electricity related emissions are estimated using an emission factor of 400 lbs per megawatt-hour (MWh) of fossil fuel based electricity per the City's request. This emission factor was determined by the City of Palo Alto Utilities (CPAU) Department. CPAU's existing electricity is generated from a mix of 81 percent renewable energy sources and 19 percent fossil fuel sources. In 2045, it is assumed that only 9 percent of annual electricity consumption is fossil fuel based. Therefore, only 9 percent of the entire demand is evaluated at 400 lbs per MWh for the alternatives comparison.
- Emissions resulting from incineration of sewage sludge are estimated per the methods and emission factors provided in the 2006 *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. Since there are no data available for methane and nitrous oxide emissions from U.S. incinerators, default values for methane and nitrous oxide emission factors are used. The uncertainty ranges are estimated to be ±100 percent or more.
- Trucks hauling biosolids and chemicals are assumed to achieve 5.65 miles per gallon on average consuming California Diesel fuel.

Table 7.6 and Figure 7.8 show the results of the GHG emissions analysis for the biosolids treatment alternatives in terms of carbon dioxide equivalent (CO_2e) emissions. The ranking of alternatives based on estimates of the GHG emissions are largely affected by the incineration of sewage sludge estimates. FBI incineration is shown in Table 7.5 as having a higher annual GHG emission than MHF due to the evaluation of the baseline (MHF) at current solids loading rates and the other alternatives at the 2045 solids loading rates. The last column in Table 7.5 attempts to normalize the alternatives by showing the emissions per dry ton. Even without the emissions estimates from incineration, the use of natural gas in the existing MHF causes the GHG emission estimates to be higher than the other alternatives per dry ton.

Table 7.6 Solids Treatment Alternatives Annual On-site CO_2e Emissions in Metric Tons

Alternative	Electricity[(1)]	Biogas and Natural Gas[(2)]	Process and Fugitive Emissions [(3)]	Solids Hauling[(4)]	Chemical Production and Handling[(5)]	Annual GHG Emissions	Annual GHG Emissions/Dry Ton[(6)]
Baseline. Existing MHFs	143	4,524	15,156	29	7	19,540	3.050
A. FBI	132	7	31,267	54	55	31,515	2.585
B. Gasification	101	10	20,165	54	55	20,386	1.672
C. Anaerobic Digestion	-131	5,916	4,390	469	111	10,753	0.882
D. SJ/SC WPCP (regional digestion)[(5)]	-130	5,916	4,390	480	165	10,821	0.888
E. BAB2E (regional gasification)	84	10	20,165	251	55	20,565	1.687

Notes:

(1) Emissions from electricity used or offset assuming emissions factor of 400 lbs of CO_2/MWh is applied to only 9 percent of annual CPAU electricity consumption.

(2) Emissions from production of natural gas and the combustion of natural gas and biogas.

(3) Emissions from solids incineration, composting, and fugitive emissions. Emissions from incineration of sewage sludge per 2006 *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*.

(4) Emissions from hauling ash or dewatered solids to final destination for disposition or additional treatment.

(5) Emissions from the production and hauling of chemicals used for solids treatment at RWQCP.

(6) Annual emissions per annual tons of solids handled. The baseline uses annual solids handled based on existing conditions while all other alternatives consider annual solids handled based on conditions in 2045.

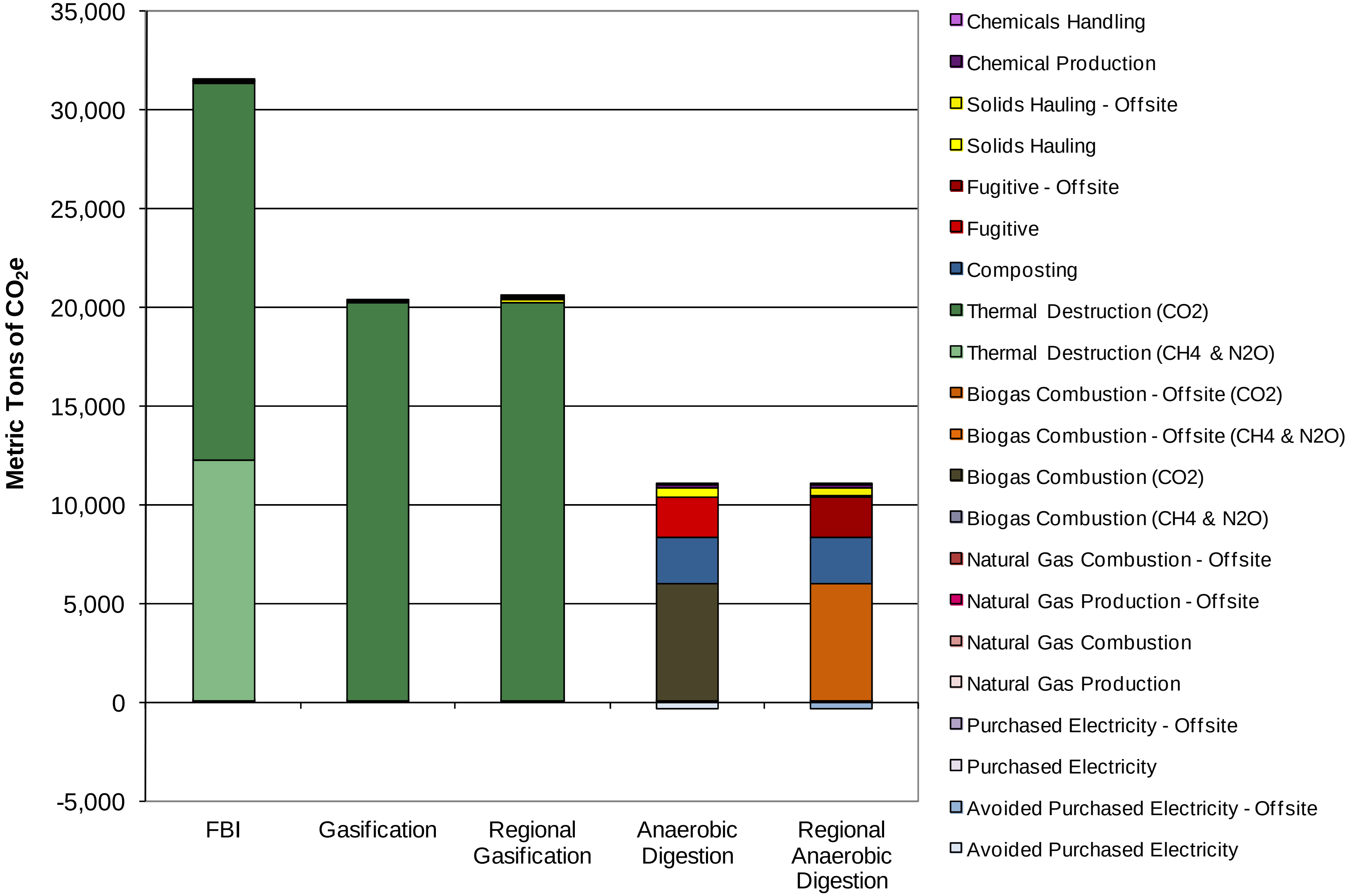


Figure 7.8 Annual On-site Greenhouse Gas Emissions for Each Biosolids Treatment Alternative in 2045

7.6.5 Sensitivity of Biosolids Alternatives to Changes in Assumptions

The solids alternatives have been compared using the high end of solids production from the various liquid treatment alternatives being considered. There are several things that could change the amount of solids to be treated and the composition of those solids, namely the use of chemically enhanced primary treatment, different liquid treatment alternatives and the addition of FOG, Food Waste, and Other Import Material. In addition, the ranking of alternatives based on costs may change with a different assumption of energy costs in the future. Each of these items is discussed below in terms of the sensitivity of the solids alternatives sizing and costs presented.

7.6.5.1 <u>Enhanced Primary</u>

For the alternatives compared above, an estimate of 94,000 ppd (for digestion) and 91,000 ppd (for thermal processing) of solids generated from the primary and secondary systems was used for sizing and developing costs for digestion and non-digestion alternatives, respectively. These estimates were based on 2062 flows and assuming that a TN<3 mg/L was required. One idea presented by the City's Technical Advisory Committee of Perry McCarty and Craig Criddle (professors at Stanford University) was to use chemical addition in the primary sedimentation tanks to maximize the solids sent to a digestion facility that could produce methane gas. While chemically enhanced primary treatment (CEPT) would increase removal rates in the primary treatment process, it is anticipated that the overall solids sent to the digesters would remain about the same. The composition of the sludge would change slightly as it would contain more primary sludge, which has a higher volatile solids content. Based on a sensitivity analysis, it is estimated that the addition of chemicals to the primaries would only increase gas in an anaerobic digester by approximately 5 percent. Additional testing of the primary and secondary solids streams and a pilot of CEPT would be required to confirm this potential benefit. The impacts of CEPT are potentially more significant to the secondary treatment process as the activated sludge system becomes less loaded. However, if the RWQCP is required to reach a TN<3 mg/L, adding chemicals to the primaries would reduce a necessary source of carbon to the secondary process. The impact of CEPT on the liquid treatment processes are discussed in Chapter 8.

7.6.5.2 <u>Liquid Treatment Alternatives</u>

Depending on the liquid treatment process utilized at the RWQCP in the future, different amounts of solids will be produced. For the biosolids treatment alternatives compared in this chapter, we used a solids generation rate from the primary and secondary processes that was on the upper end of the future liquid treatment alternatives for sizing and developing costs. The range of anticipated solids from the primary and secondary processes for all the liquid treatment alternatives (discussed in Chapter 8) are 94,000 ppd (for digestion) and 91,000 ppd (for thermal processing) TS. Implementation of a liquid treatment alternative with lower solids production would mean that the solids facilities could potentially be downsized. Alternatively, the RWQCP may wish to conservatively size solids facilities to be able to handle a variety of potential future liquid treatment options. For example, if digesters were implemented as sized in this chapter, the effect of using one of the liquid treatment alternatives with a lower projected solids generation rate is that the HRT in the digestion process would be longer by up to 4 days and the final disposal tonnage of either ash or biosolids would be reduced by 20 to 25 percent. Gas production and energy generation would also be reduced by 20 to 25 percent.

7.6.5.3 FOG, Food Waste, and Other Import Materials

Food waste such as food scraps from the restaurant industry, produce or fish markets, school cafeterias, etc., is an attractive high-energy feedstock for anaerobic digestion systems. However, scraps from residential communities are currently not a viable source due to limitations in collection and separation.

With proper training and participation, food scrap collection from sources outside the residential community is viable. Typical sources include restaurants. The material would be hauled to a pre-processing facility located outside of the wastewater treatment plant. The waste would be screened to remove packaging materials, utensils, or other inorganic objects. After grinding the scraps to a uniform mixture, they would be hauled to the wastewater facility.

At the wastewater facility, processed food waste would be pumped from the delivery truck to storage tanks. The food waste would need to be conditioned to 10 percent solids content prior to being fed to the anaerobic digesters, which would increase methane gas production. Based on testing at the East Bay Municipal Utilities District, the methane potential of food waste is about 367 cubic meters/ton (13,000 cubic feet/ton).

7.6.5.3.1 *Impacts on Addition of FOG and Food Wastes at RWQCP*

Food waste streams (including FOG) were included in this evaluation to determine the effect on digester sizing, ability to achieve the required HRT, and digester loading rates. The City currently accepts 46,167 gallons per month of FOG that is added at the head of the plant. If digesters are selected as the preferred solids treatment alternative, FOG can be added directly to the digesters. On average, this could provide 770 lbs of total solids per day and 740 lbs volatile solids per day. In 2062, the FOG to be sent to the RWQCP is estimated at 130,000 gallons per month. On average, this would provide 2,200 lbs of total solids per day and 2,100 lbs volatile solids per day.

The potential for food and food processing waste is even greater. The City-Wide Waste Stream Review projected that 18,000 tons per year of compostable waste could be diverted to the RWQCP. Of the 18,000 tons per year of compostable waste identified, 13,000 tons is generated from commercial sources and 5,000 are generated from residential sources. Of the 13,000 tons per year only 7,758 tons are food waste, the remainder consists of leaves and grass, compostable organics, compostable paper, prunings and trimmings and branches and stumps.

As previously mentioned, only food waste from commercial sources are viable for collection. For the purposes of this LRFP, it was assumed that 7,758 tons per year of food waste could be currently sent to the RWQCP and this would increase proportionally to the flow increase to the plant. On average, this would provide 42,500 lbs of total solids per day and 36,100 lbs volatile solids per day. In 2062, the food waste to be sent to the RWQCP is estimated at 13,094 tons/year. On average, this would provide 71,800 lbs of total solids per day and 61,000 lbs volatile solids per day.

The impacts of adding FOG and food waste to the RWQCP solids processes is that for a given digester size, HRT is reduced, the volatile solids loading is increased and the gas production and energy generation is also increased. Table 7.7 shows the impacts of FOG and food waste on the digesters at 2035 and 2062 wastewater influent flows. The HRT shown in Table 7.7 is based on building three digesters, with typical operation of two in service. To meet Class B biosolids designation a 15-day HRT is required. Class A biosolids are created by post digestion treatment usually involving composting or heat drying. This sensitivity analysis showed that the addition of FOG and food waste would require that all digesters be in service in 2062 to allow for receiving the maximum estimated quantities of FOG and food waste. If a digester needed to be taken out of service during this build-out condition, the RWQCP would have to stop accepting FOG and food waste to prevent the HRT from dropping too low or build additional or larger digesters.

Table 7.7 Sensitivity Analysis of FOG and Food Waste Addition

Treatment Alternative	Wastewater Volatile Solids (ppd)	FOG Volatile Solids (ppd)	Food Waste Volatile Solids (ppd)	HRT (days)	VSS Loading Rate (lbs VSS/ ft^3-day)	Gas Production (SCFM)
2035 AAF Base	45,900	0	0	28.8(1)	0.08	199
2035 AAF Enhanced	45,900	2,100	50,500	19.7(1)	0.16	389
2035 ADMM Base	52,500	0	0	25.2(1)	0.09	228
2035 ADMM Enhanced	52,500	2,100	50,500	17.4(1)	0.19	437
2062 AAF Base	71,800	0	0	18.6(1)	0.13	343
2062 AAF Enhanced	71,800	2,100	61,000	20.7(2)	0.15	613
2062 ADMM Base	81,600	0	0	16.4(1)	0.14	415
2062 ADMM Enhanced	81,600	2,100	61,000	18.2(2)	0.17	685

Notes:
(1) 2 digesters in service, 1 standby.
(2) All digesters in service.

7.7 PROMISING TECHNOLOGIES

As discussed in earlier sections, there are several technologies that look promising, but are not sufficiently developed for confidently sizing and costing alternatives. The approach for the LRFP is to develop a list of promising technologies to watch and potentially include when preliminary design efforts are underway to finalize technology and design concepts. The City should also seek to pilot test these new technologies to determine whether they would be suitable for the RWQCP or participate in pilot testing that is scheduled to take place at neighboring facilities such as SJ/SC WPCP and the BAB2E regional facility.

7.7.1 Thermal Conversion Processes

There are several thermal conversion processes that look promising for future application in biosolids treatment but that have no real experience in this field to date. These include pyrolysis and plasma arc assisted oxidation. Even gasification is a newer process for wastewater solids that is just starting to get installations in wastewater applications in the U.S. All of these processes should continue to be watched and evaluated further when they have been proven at other wastewater treatment plant locations. Alternatively, the RWQCP can participate in the regional efforts to examine these types of processes, such as BAB2E. The City of San Jose Solid Waste Division is also investigating the feasibility of doing a gasification pilot with both solid waste and sewage sludge.

Installation lists for gasification and pyrolysis thermal conversion processes are included in Appendix R. As discussed above, as more data becomes available, these processes should be considered further.

7.7.2 Microscreen-Gasification Process

M2 Renewables (M2R) is developing a system that comprises a belt screen filter coupled with a gasification process. Raw wastewater flows into the belt screen filter, which removes the solids from the water. Approximately 55 to 70 percent of the total suspended solids (TSS) and biological oxygen demand (BOD) are removed by the screen. The solids are dewatered to between 30 and 35 percent and conveyed to the gasification process. Effluent is discharged to the downstream secondary treatment process. Due to the projected high BOD removal rates across the microscreens, downstream secondary treatment systems would be less loaded and could potentially either be downsized, or run at lower energy demands due to less air required for BOD removal.

The dewatered solids and secondary solids are combined, pretreated, and mixed. Pretreatment consists of sorting, sizing, and optimizing the moisture content of the combined stream. The pretreated mixture is conveyed to the gasifier by an auger in an oxygen-free environment. The gasifier uses electricity to induce a thermal energy capable of generating reaction temperatures of

1200 to 1700 degrees Celsius. Oxygen is controlled within the reactor for efficient syngas production. A scrubbing system is used to clean the syngas prior to use.

M2R has one microscreen operating system at the City of Adelanto, CA wastewater treatment plant (a 1.5 mgd plant), but no commercially operating gasification system. A M2R demonstration test was conducted at the City of Palo Alto between February 13th and 15th, 2012. The demonstration unit was a MS-28 Microscreen with 160 and 105 micron meshes/28 inches wide belt. During the test period, the average TSS and BOD removal rates were 82% and 55% respectively and a fresh solids production of up to 56% was achieved. This test data indicates that installation of the M2R Microscreen system could have benefits to the City's RWQCP such as increasing the plant TSS and BOD removal rates, reducing primary sludge disposal costs, reduction of aeration requirements, reduce operational costs and lower odor generation. However, the requirement of a nitrogen limit in the future would require that BOD removal be minimized since the BOD is required downstream in the liquid treatment process for a denitrification step.

M2R has a batch test gasification unit operating in Munich, Germany, which processes a variety of wastes, including sewage sludge. In addition, they have plans to construct a five ton per day test unit at their manufacturing facility in Carson, Nevada. The purpose of this testing facility is to demonstrate the gasification process capabilities, determine the power generation potential, and design optimization based on client provided sludge samples.

Because the microscreen has limited operating experience, and the gasifier has no operating installations, development of these technologies will be closely tracked but not included as a solids alternative for this study location.

7.7.3 Fuel Cells

Fuel Cells are gaining interest in California for facilities with digester gas as a way to produce energy with low emissions. Fuel cells are electrochemical devices that combine hydrogen from the digester gas and oxygen from the air to produce electricity and recoverable heat with little emissions. Recent installations have had difficulty with the required fuel conditioning systems. If the RWQCP decides to implement digestion, fuel cells should be considered, particularly if additional FOG or food waste will be fed to the digester.

7.8 SUMMARY AND RECOMMENDATIONS

A summary of the major considerations and the impact on the overall strategic plan for the LRFP are presented in Table 7.8.

Table 7.8 Biosolids Treatment Alternatives Summary of Considerations	
Future Considerations	**Impact on Strategic Plan**
Aging solids handling facilities	While the current incinerators should have a remaining useful life of 10 years, there is no guarantee that this will be the case. Corrosion of the steel shell is a dramatic demonstration of the extremely harsh operating conditions and suggests that it is prudent to begin planning immediately for incinerator replacement.
More stringent regulations on incineration and air quality	EPA's sewage sludge incineration final rule adopted in 2011 implemented Hg emission standards that were less stringent that originally proposed. EPA has indicated the intention to revisit this rule every 5 years. More stringent rules may make compliance with the existing MHF or their upgrading infeasible.
For neighbor impact concerns, site solids facilities away from outer edges of the RWQCP.	Solids treatment processes have a high risk for odors. To reduce the potential impact to neighbors, the solids facilities are to be sited near the center of the RWQCP. Odor Control: Install fixed covers on digesters, provide odor control on future dewatering, loading, and drying facilities, and other potential odor sources. Noise and Visual: Contain equipment, pumps, motors, etc., where practical.
Reliability for disposal in event of facilities being off-line	Develop emergency contract for hauling and disposing of undigested sludge in event of an earthquake or other circumstances where processing of solids is interrupted.
Multiple and diversified disposition options will enhance flexibility	If digestion is implemented, increase disposition flexibility by entering into long term contracts with multiple disposition facilities that provide the multiple disposition options. Multiple products and markets will further enhance flexibility and will require additional staff 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.

Table 7.8 Biosolids Treatment Alternatives Summary of Considerations	
Future Considerations	**Impact on Strategic Plan**
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.
More stringent regulations for landfilling and ADC for biosolids	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. Trends could be against biosolids as ADC in the near and long term.
Participation in Regional Biosolids Facility	As the BAB2E project develops, there may be opportunities for the City to participate in the facility.
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 City should consider developing a market for dried products in the future.
Need to consider sustainability, carbon footprint, and greenhouse gases	California Assembly Bill AB 32 on global climate regulation will favor certain biosolids management practices. Consider GHG emissions in process selection.
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.
Future technologies	When the RWQCP decides to move forward with a new solids treatment process design, promising technologies should be reviewed to determine if there are additional installations and if operating experience shows promise.

7.8.1 Recommendations

Based on the information presented in the sections above, the following is recommended for the LRFP:

1. Continue to use the existing incinerators until they can be retired and a new solids handling facility and disposal option implemented. Retire incinerators based on following conclusions:

    a. Units are difficult to maintain as they age; the steel structure holding the refractory bricks together is stressed and rusting from within. The steel skin of the furnace will need to be completely replaced to ensure heat remains within the furnace. Existing efforts have focused on patching and rewelding problem areas that have stressed due to decades of thermal stress.

    b. Incinerators may experience damage from an earthquake (per Chapter 5) rendering the incinerators nonfunctional. A backup ash hauling contract needs to be in place. The complex logistics and costs to implement a backup contract while trying to repair a 40-year old furnace after a major earthquake are problematic.

    c. EPA air regulations are becoming stricter for older incinerator units. The existing incinerator units cannot be upgraded more than 50 percent of their original construction cost (i.e., planned obsolescence in regulations). Regular 5-year EPA reviews of emission limits and the threat of lawsuits to force stricter emission limits remain a potential issue. Reacting to such regulatory changes or lawsuits on a compressed regulatory compliance timeline will greatly increase the capital costs and may result in sunk assets (e.g., expensive air pollution control equipment that will be used only for a few years until a new solids handling system is implemented).

    d. The existing incinerators produce ash that is hazardous waste due to the soluble copper levels exceeding a state of California limit at 25 ppm. While ash hauling costs and state and local hazardous waste fees for the RWQCP’s hazardous waste ash are relatively low compared to operating costs and the debt service on a new project, moving away from production of a hazardous waste is consistent with the City’s goals of minimizing production of hazardous waste.

    e. The existing furnaces are not good candidates for energy recovery potential on the exhaust flue gas stream; this is inconsistent with the plant’s long term goal of energy reduction. Upgrade potential for the existing units is limited to minor optimization projects.

    f. The Solids Incineration Building’s foundation piles are not expected to perform well in a design earthquake (see Chapter 5). Approximately $0.55 million is needed to upgrade this building’s foundation piles. Retiring the incinerators will make maintenance and capital re-investment decisions on the incinerator clear and remove outdated infrastructure from the RWQCP systems.

2. Initiate a Solids Facility Plan

    a. Develop the scope of a Solids Facility Plan to choose a technology and onsite or offsite option for the replacement technology for the RWQCP's solids handling systems

    b. Given the issues foreseen regarding disposition of solids with a limited future for landfilling and land applying biosolids, beneficial uses locally would provide the ability to control the RWQCP's destiny. However, the lack of a local market and space on-site limit options to off-site beneficial use or privatization. For the purposes of the LRFP, proceed with detailed evaluation (including layouts) for the following solids alternatives:

        a) Alternative B – Onsite gasification

        b) Alternative C – Anaerobic Digestion with off-site beneficial use (either land application or composting).

        c) Alternative D – Send dewatered solids to SJ/SC WPCP.

        d) Alternative E – Send dewatered solids to BAB2E.

    c. Enter into further discussions with the SJ/SC WPCP to determine conditions of an agreement to send solids to their facility. In addition, participate in San Jose's piloting of gasification, if that project proceeds.

    d. Consider joining the BAB2E consortium and participate in their ongoing evaluation of promising technologies.

    e. If the City and Partner decision makers have a strong preference to keeping solids treatment within the control of the RWQCP, begin a preliminary design study for anaerobic digestion facilities to evaluate in more detail the advantages and disadvantages of different anaerobic digestion configurations.

    f. If an anaerobic digestion process is implemented on-site, consider efforts to develop a marketable product and local users through either drying or composting.

    g. Investigate in greater detail the installations and operating history of gasification systems, including performance, reliability and operational challenges. While the United States has very limited experience with gasification of biosolids, there are existing gasification systems in the US utilizing other feedstocks including wood wastes and municipal solid wastes. Abroad, especially in Europe and Japan, numerous entities have gasification systems utilizing various feedstocks, including wastewater solids.

3. Develop backup plans for raw sludge disposal with a local waste hauler should the furnace systems fail to operate.

Chapter 8

LIQUIDS TREATMENT ALTERNATIVES DEVELOPMENT AND SCREENING

8.1 PURPOSE AND OVERVIEW

The purpose of this chapter is to discuss the liquid treatment alternatives that can provide reliable treatment at the RWQCP and meet current and potential future regulatory requirements. More specifically, the RWQCP must accommodate the projected flows over the 50-year planning horizon (through 2062) as well as meet regulatory requirements for effluent discharge, reuse, air and biosolids. This chapter shows the results of the qualitative and quantitative screening of the liquid treatment alternatives.

8.2 BASIS FOR EVALUATION/PLANNING CONSIDERATIONS

8.2.1 Projected Flow and Loads

Influent flows and loads have been projected through the year 2062, as presented in Chapter 3. Based on population projections and current per capita flow rates, the projected average dry weather flow (ADWF) for 2062 is 34.0 million gallons per day (mgd) and the maximum month flow (MMF) is 41.1 mgd. An alternate flow projection was developed using anticipated flow reductions from conservation and building code changes provided by member agencies and resulted in a projection of 28.6 mgd ADWF and 34.6 mgd for MMF. Influent loadings are not anticipated to change with the alternative flow condition and are projected to be 78,870 pounds per day (ppd) for TSS and 72,874 ppd for BOD at maximum month flow.

The alternatives being evaluated in this chapter to meet future regulations are sized primarily based on loading, and therefore, the alternate flow projection does not influence the alternatives. For the purposes of this study, the peak wet weather flows were assumed to be 80 mgd. For a more detailed analysis of the peak wet weather flow, a comprehensive estimate of wet weather flows (e.g. collection system model) should be developed for all the contributing areas to determine the projected flows during wet weather events. On going and planned efforts to reduce infiltration and inflow (I&I) need to be incorporated into this wet weather estimate.

Additionally, as conservation measures will not reduce the peak wet weather flow that drives the hydraulic capacity sizing of the plant, the alternate projections will also not reduce the need for other common facilities.

8.2.2 Regulatory Requirements

The regulatory scenarios for future treatment compliance were developed in Chapter 6. The future regulatory scenarios that would affect liquid treatment processes are the potential regulations for nutrient reduction (in the form of total nitrogen limits) and emerging contaminants, including pharmaceuticals, personal care products and endocrine disruptors. Table 8.1 shows the current and future potential regulatory requirements that would require additional liquids treatment facilities along with estimated dates for when the regulations would be required.

Table 8.1 Existing and Potential Future Regulatory Requirements

Parameters	Units	Current Monthly Limits	Potential 2035 Limit	Potential 2050 Limit
$CBOD_5$	mg/L	10	10	10
TSS	mg/L	10	10	10
Total Ammonia as Nitrogen	mg/L	2.7	<1	<1
Total Nitrogen	mg/L	None	8	3
Emerging Constituents	Unknown	None	Unknown	Unknown

Nutrient limitations are considered the most likely regulation to be imposed in the near future. Current research efforts are focusing on nutrient impacts to the Bay, which will inform policy makers. The Regional Water Quality Control Board recently issued a technical report order requiring submittal of information on nutrients in wastewater discharges. This order is to aid in the development of nutrient water quality objectives for the San Francisco Bay estuary. It is unknown exactly how nutrients may be regulated in future. The U.S. Environmental Protection Agency (EPA) has indicated in general, that requiring monthly nutrient limits would be impracticable though the recent federal and state framework is built around annual nutrient limits (e.g. the Chesapeake Bay, Wisconsin, Colorado). However, current NPDES discharge permits issued by the State of California through permit authority by Regional Water Quality Control Boards, typically structure effluent limitations with monthly, weekly, and daily limits. Therefore, all alternatives discussed in this chapter are sized based on facilities needed to meet effluent limits during the maximum month flow. If annual limitations are anticipated instead of monthly limitations, there would be a good opportunity to plan for reduced capital costs.

8.2.3 Site Considerations

The RWQCP has a very compact site that is already filled with existing treatment processes and underground piping that makes placement of new treatment facilities challenging. As discussed in Chapter 7, space for new solids facilities has been reserved near the center of the plant. Due to adjacent neighbors (such as the nearby business parks and Palo Alto airport), odors, noise, emissions, truck traffic, and visual impacts are a concern. However, any new facilities need to be constructed while existing processes are operating. Therefore, new liquid treatment facilities are primarily located at the periphery of the plant in areas where few existing facilities are located. Figure 8.1 shows the existing facilities layout.

8.2.4 Alternatives Development Process

The evaluation criteria and process for comparison of alternatives were developed in Chapter 2. The evaluation process consists of two levels of evaluation: an initial qualitative screening and a more detailed quantitative evaluation.

In developing the liquid treatment alternatives, the LRFP project team met on several occasions and presented the alternatives to the stakeholders twice. In May 2011, the liquids treatment alternatives were presented to the stakeholders for the first time in a public meeting. At this meeting, each alternative was briefly presented along with its general benefits and disadvantages. During a March 2012 public meeting, the liquid treatment alternatives were presented in greater detail with descriptions of costs and greenhouse gas emissions for each. Input was taken at each of these public meetings and used to develop the overall recommendations presented herein.

8.3 SUMMARY OF EXISTING LIQUIDS TREATMENT FACILITIES AND FUTURE NEEDS

As described in Chapter 4, the existing liquid treatment processes include screening, settling in primary clarifiers, biological treatment through fixed film reactors and aeration basins, settling in secondary clarifiers, filtration in dual media filters and disinfection with ultraviolet light (see Figure 8.2). Each process performs key steps in the wastewater treatment process:

- **Preliminary Treatment (Headworks):** Remove debris, rags, and grit that clog or cause wear on downstream equipment and processes.
- **Primary Clarifiers:** Remove readily settled and floatable solids.
- **Fixed Film Reactors (Trickling Filters):** Remove a large portion of the carbonaceous BOD.
- **Aeration Basins:** Remove additional carbonaceous BOD, inorganic compounds, and ammonia.
- **Secondary Clarifiers:** Remove additional carbonaceous BOD in the form of colloidal solids and ammonia-nitrogen in the form of settable biomass.
- **Dual Media Filters:** Remove residual solids and BOD to meet final effluent limits.
- **Disinfection:** Destroy or inactivate pathogens.

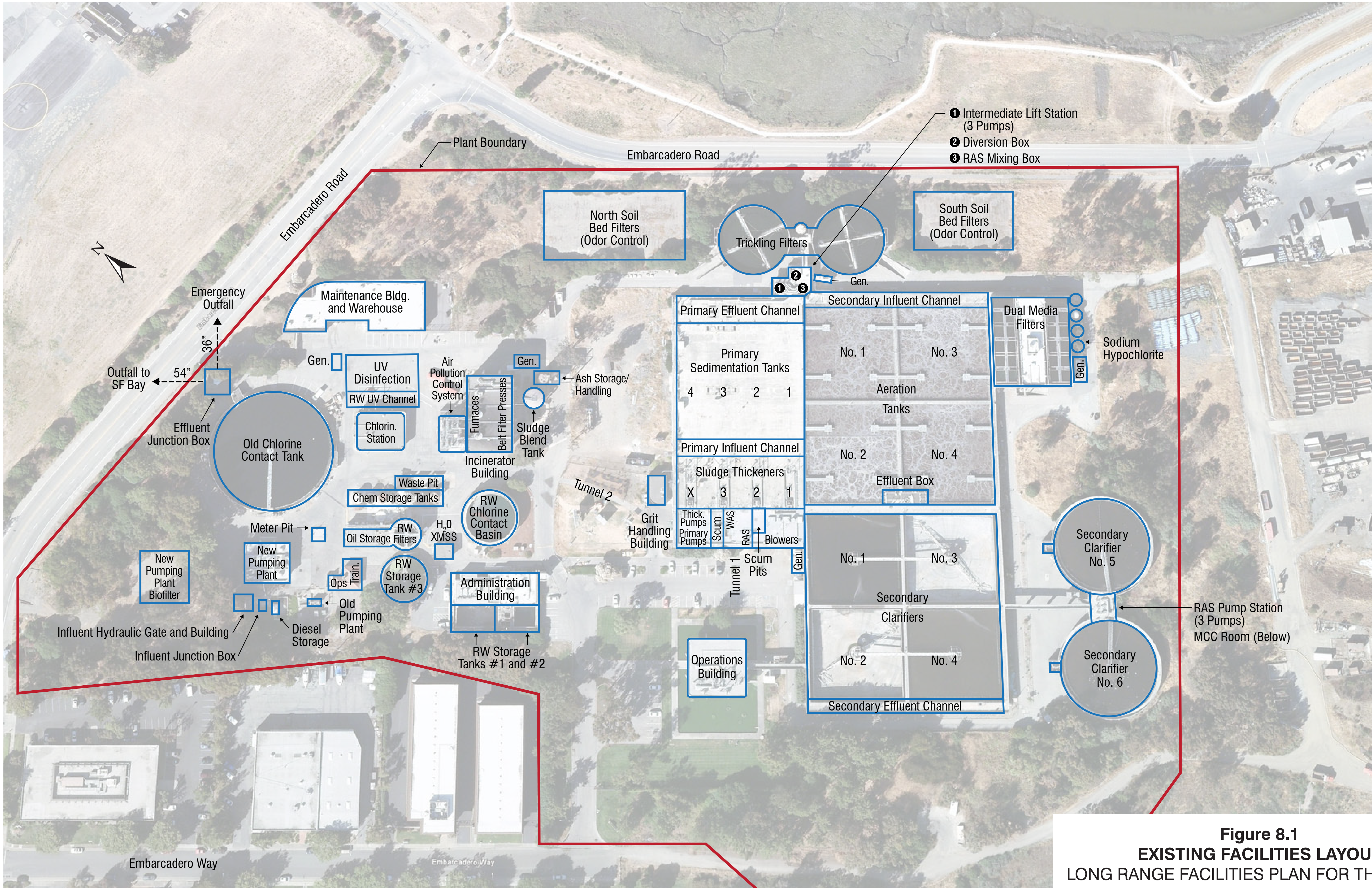


Figure 8.1
EXISTING FACILITIES LAYOUT
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f8-8510.ai

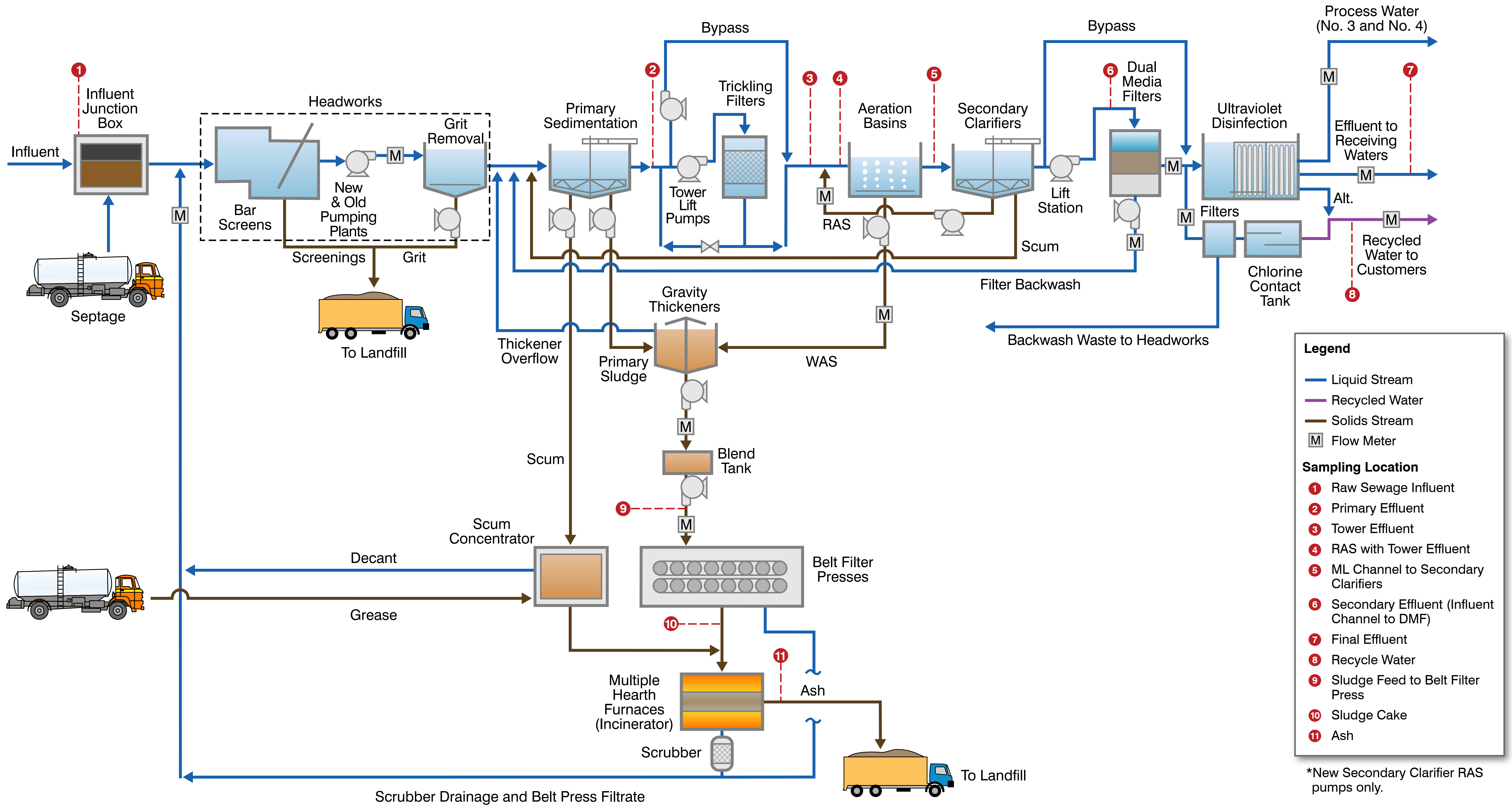


Figure 8.2
EXISTING FACILITIES PROCESS FLOW DIAGRAM
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa412f5-8510.ai

The current biological treatment process is one method of meeting the current discharge permit requirements, particularly for BOD and ammonia. However, as described in Chapter 5, there are certain recommended improvements necessary for the RWQCP to continue to reliably meet the current discharge requirements in the near and intermediate future. Additionally, in the future, more stringent discharge permit requirements for total nitrogen and/or ammonia may require further modifications and/or new treatment processes.

8.3.1 Preliminary Treatment

As discussed in Chapter 5, the useful life of the headworks facilities will be exceeded during the 50-year planning horizon. For the purposes of the LRFP, construction of new headworks is recommended that would include influent pumping, grit removal and screening to remove rags that clog downstream equipment. A preliminary design is required for a more detailed evaluation of the grit and screening options. For the purposes of estimating costs, a vortex grit removal system and 3/4 inch screening was assumed.

8.3.2 Primary Treatment

While the primary sedimentation tanks need rehabilitation, they are sufficiently sized to meet future treatment needs. Options that could be considered are use of Chemically Enhanced Primary Treatment (CEPT) or use of microscreens.

CEPT requires the use of chemical coagulants to improve settling of solids in the primary process. While use of CEPT could decrease loading to the downstream secondary processes, when and if future regulations require total nitrogen removal, CEPT would remove too much carbon (as carbon is needed for total nitrogen removal) and not be a good choice for liquid treatment. If the secondary processes were capacity limited, CEPT would be a good interim solution, but at this time, there is no need to take on the additional operation and maintenance costs for CEPT.

The use of microscreens in place of primary treatment is a newer technology that is showing promise for providing an equal level of treatment. However, due to the large peak wet weather flows experienced at the plant (up to 80 mgd), a large number of screens would be required. At this time, since primary sedimentation tanks already exist at the RWQCP, it does not make sense to switch to microscreens. However, this technology should be watched for potential future implementation, particularly if found to have an advantage for certain solids alternatives.

8.3.3 Secondary/Tertiary Treatment

The existing secondary and tertiary treatment system is adequately treating the wastewater to meet the existing discharge requirements. Chapter 5 identified rehabilitation needs for the fixed film reactors, aeration basins, secondary clarifiers and the dual media filters. In general, these facilities have adequate capacity and can continue to provide sufficient treatment. The existing fixed film reactors are only required for one of the liquid alternatives, but have a rated capacity that is slightly less that the estimated build-out flow. Although bypassing is an option, for continued use through 2062, the fixed film reactor units will need to have all the media replaced as part of the rehabilitation effort, to ensure that these units reliably operate at their maximum efficiency. Therefore, the costs for the fixed film reactor rehabilitation as part of the liquid treatment alternatives includes a total media replacement.

The existing ultraviolet light disinfection facilities were constructed in 2010 and therefore are in excellent condition and have adequate capacity in the near future. Where improvements to the secondary and tertiary processes would be required is in meeting new regulatory requirements. The existing facilities were not designed to remove total nitrogen or emerging contaminants. Alternatives to meet new regulatory requirements are discussed in section 8.4 of this chapter.

8.3.4 Recycled Water Facilities

As discussed in Chapter 3, the City of Palo Alto has been producing and supplying recycled water since the 1980s. A Water Reclamation Master Plan was developed in 1992 that identified potential users and a Recycled Water Facilities Plan was developed in 2008 that established a phased implementation program. The Phase 2 system was developed in 2009 to provide water to Mountain View. The Phase 3 expansion to Palo Alto is being considered but is on hold at the moment due to concerns over salinity levels. If the City were to implement all the recommended projects as outlined in the 1992 Master Plan, the annual average and maximum month recycled water demands would be 4.2 mgd and 9.8 mgd respectively, as shown in Table 8.2.

Based on the capacity of the existing recycled water facilities (approximately 10.8 mgd); both average and peak month project flows are achievable for the Phase 1-3 and Recommended project from the 1992 plan. However, as discussed in Chapter 5, some of these facilities (recycle water filters, chlorine contact basins and recycle water storage tanks) are aging and will need to be replaced in the next 10-20 years. In addition, the recycled water storage and pumping facilities are inadequate for the peak hour flow rates anticipated for the Phase 1-3 and the 1992 MP Recommended Projects. Therefore, the storage and pumping facilities will require an increased capacity to handle peak hour demands. For the purposes of this LRFP, new recycled water facilities are sited and costs are estimated to be able to serve a peak month flow of 9.8 mgd.

Table 8.2 Recycled Water Demands in the Near and Long Term

	Annual Average Flow Rate (mgd)	Peak Month Flow Rate (mgd)	Peak Hour Flow Rate (mgd)
Near Term: Demand for Phases 1-3	2.5	5.6	15.9
Recommended Project – 1992 WRMP	4.2	9.8	21.9

In addition to the need to replace aging facilities and provide adequate capacity, the recycled water treatment system may need to be improved in the future to meet more stringent water quality requirements. Some of the identified recycle water customers have landscaping and/or facilities that require lower salinity levels than the recycled water currently provides. The City of Palo Alto and its partner agencies have set a policy goal to meet salinity levels of 600 mg/L total dissolved solids (TDS) in its recycled water. The RWQCP currently produces recycled water with TDS levels ranging from 800 mg/L to 1000 mg/L and averaging 917 mg/L. In the first step towards achieving this objective, the City is implementing source control and is working with the RWQCP partner agencies to line sewers in an attempt to reduce infiltration of bay water. If source control proves to be unsuccessful in lowering the salinity to the desired salinity limits, a reverse osmosis (RO) system may be required. To protect the RO membrane and improve flux rates, RO processes are always preceded by an ultra-filter or micro-filter membrane process.

For the purposes of this LRFP, four scenarios were used to size an RO system as shown in Table 8.3. Costs presented in Section 8.3.6 are based on assuming that source control to 800 mg/L TDS will be effective. Details of the cost for just the RO system with and without pre-treatment are shown in Table 8.4. An alternative to putting in RO at the RWQCP would be to either serve users requiring lower salts with a satellite treatment facility located at the point of use, or with service from other providers (e.g., South Bay Water Recycling, Santa Clara Valley Water District, etc.) who have already made the investment in RO for their recycled water.

Table 8.3 Summary of Iterations to Meet Effluent Goal of 600 mg/L TDS			
	Influent TDS Assumptions		
RW flow, peak month, mgd	**TDS, mg/L**	**Basis**	**RO size, mgd**
Phase 1-3 peak month flow = 5.6 mgd	917	Existing average influent	1.98
Phase 1-3 peak month flow = 5.6 mgd	800	If do source control	1.44
Recommended projects from 1992 MP peak month flow = 9.8 mgd	917	Existing average influent	3.46
Recommended projects from 1992 MP peak month flow = 9.8 mgd	800	If do source control	2.51

Table 8.4 Summary of RO System Capital Costs in Millions of 2015 Dollars		
RO System Design Basis, mgd	**With Ultrafiltration Pretreatment, $M**	**Without Ultrafiltration Pretreatment, $M**
1.5	**43**	**27**
2.5	**62**	**39**

8.3.5 Advanced Treatment

Removal of emerging contaminants including endocrine disruptors and pharmaceuticals requires either a fine membrane process such as RO that eliminates constituents through size exclusion or an oxidation process such as ozonation. If regulatory requirements in the future require removal of emerging contaminants for Bay discharge, then adding ozone ahead of the existing UV disinfection process would provide removal of most constituents and would increase the efficiency of the UV system by improving UV transmittance. A technical memorandum describing the recommended ozone process for the RWQCP is included in Appendix P.

Facilities required would include liquid oxygen tanks, an ozone generator, and an ozone contact chamber. The ozone would be injected into the water after tertiary filtration and prior to the UV disinfection.

8.3.6 Support Facilities

As identified in Chapter 5, the existing administration, laboratory and maintenance buildings are inadequate for the number of staff and space needs for laboratory, and storage needs for equipment for normal operations and maintenance. Therefore, new buildings have been identified for the site including a new Laboratory and Environmental Services Building, which will house the administration, engineering, watershed protection, IT, and solid waste staff as well as provide a new laboratory. For the purposes of site planning, it is assumed that the new Laboratory and Environmental Services Building would be located on the RWQCP site adjacent to Embarcadero Road. One alternative to a new building on site is to acquire a neighboring commercial property for the new Laboratory and Environmental Services Building. This would preserve the limited space on site for future processes. Another option is to expand the operations building to house the new Lab and Environmental Services. Once the laboratory has been moved out of the operations building, the operations building will be renovated to provide additional locker space, operations office space, and a lunchroom/conference room. In addition, the maintenance building will be expanded to accommodate the need for additional warehouse space. Preliminary layouts of the new Laboratory and Environmental Services Building, remodeled Operations Building, and expanded Warehouse developed by Michael Willis Architects are shown in Figures 8.3, 8.4, and 8.5, respectively.

Based on the condition and lack of space available in the existing blower building, for each of the liquid alternatives, a new blower building is required. A different sized building is needed for each of the different alternatives, depending on required blower capacity. Costs and layouts for these blower buildings are included in each alternative discussed in Section 8.4.

Figure 8.3 Preliminary Layout for the New Laboratory and Environmental Services Building

PROGRAM AREA IN ADMINISTRATION BUILDING			
ADMINISTRATION	679 sf	WATERSHED PROTECTION	1740 sf
ENGINEERING	743 sf	SOLID WASTE	970 sf
SERVER ROOM/ I.T	692 sf	MISC.	1794 sf
LABORATORY (Includes Internal circulation)	7450sf	CIRCULATION, WALLS, COMMON AREAS	6621 sf
PURCHASE	135 sf	TOTAL (gsf)	20,824 sf

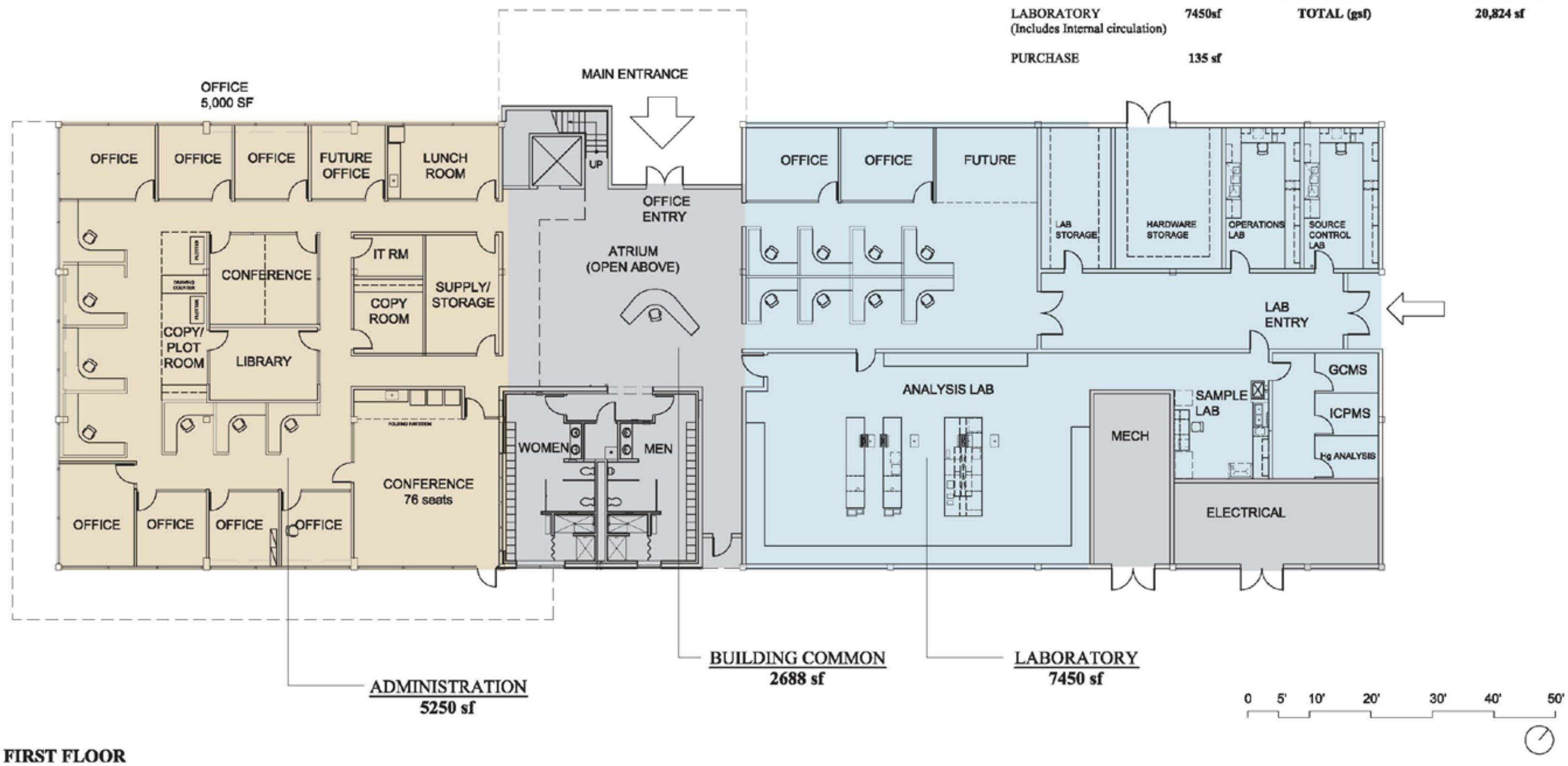


Figure 8.3 Preliminary Layout for the New Laboratory and Environmental Services Building (Continued)

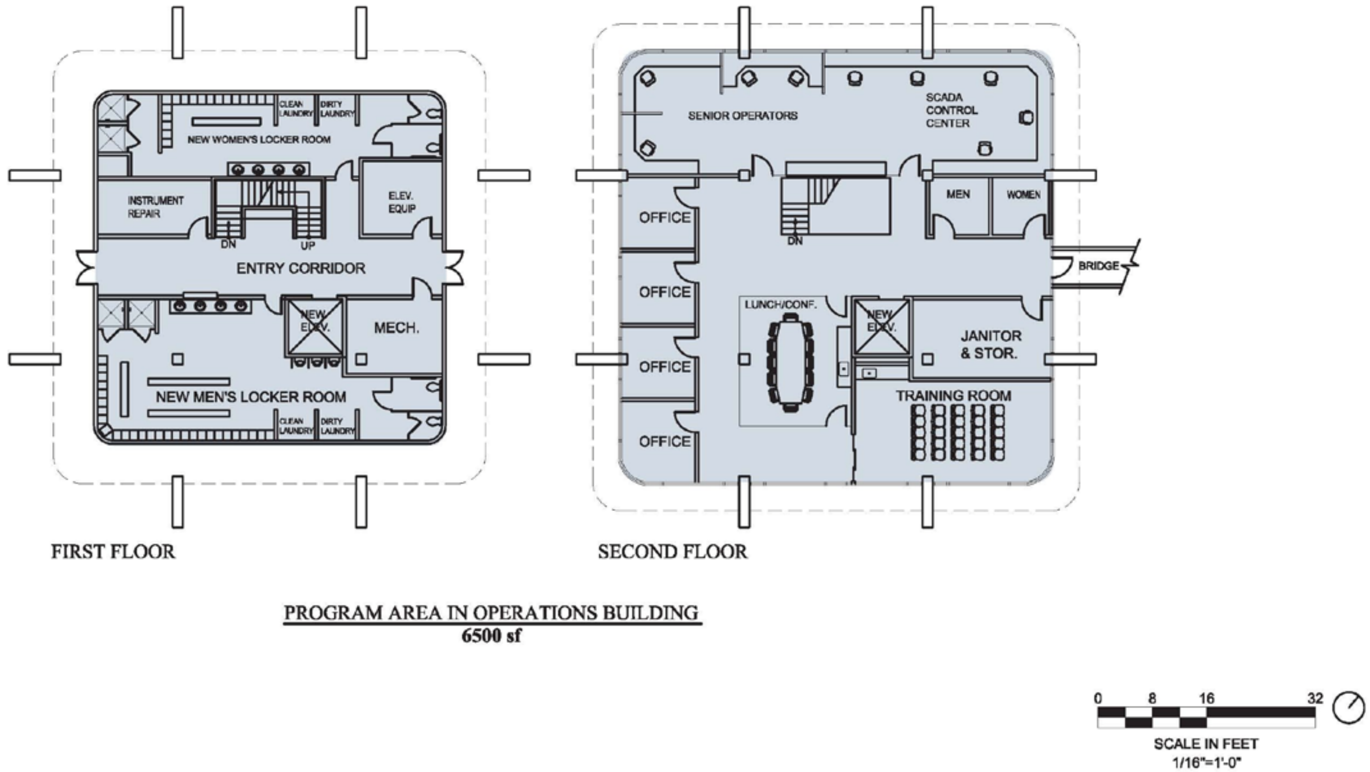


Figure 8.4 Preliminary Layout for the Remodeled Operations Building

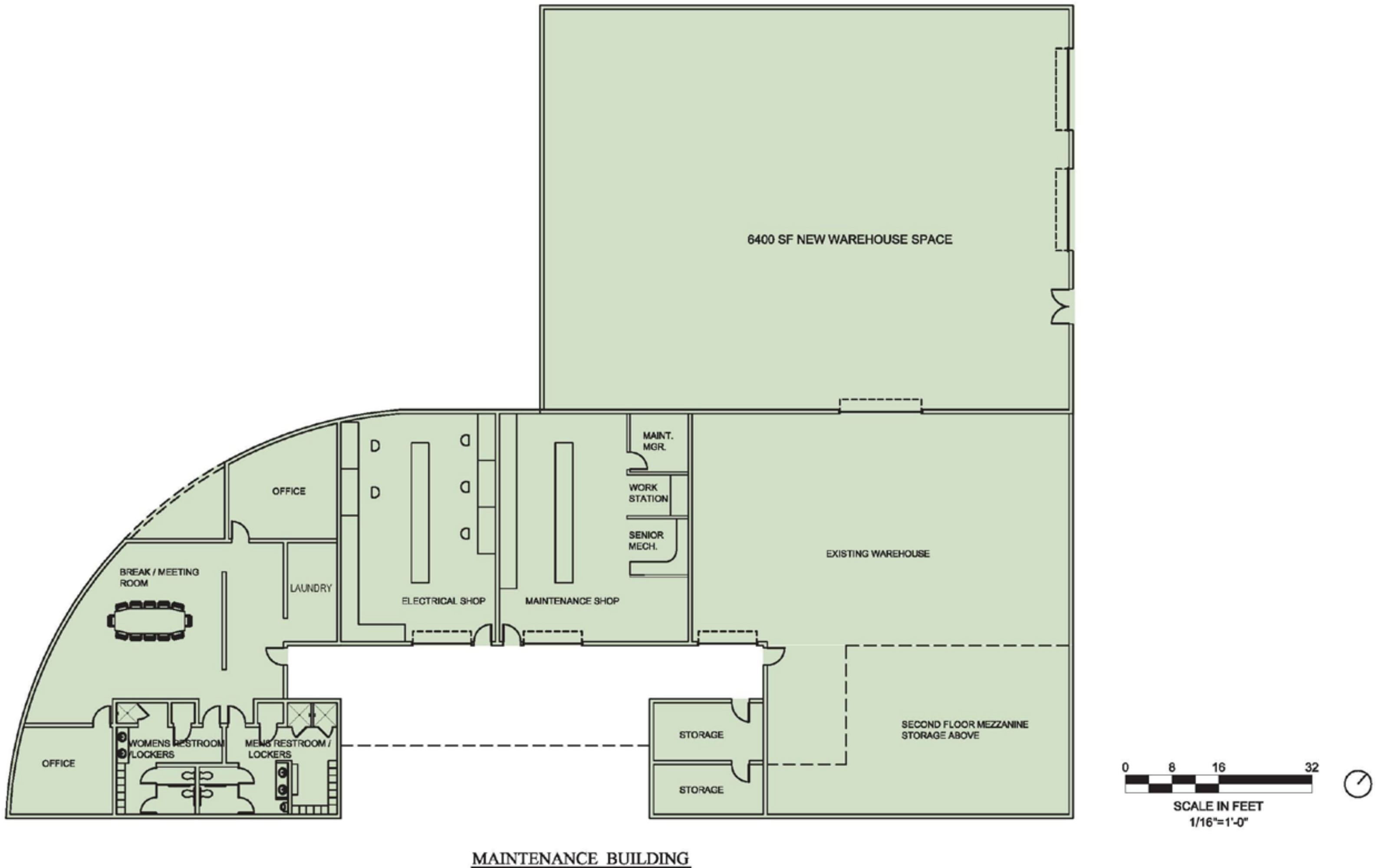


Figure 8.5 Preliminary Layout for the Expanded Warehouse Storage Space

8.3.7 Summary of Recommendations for Common Facilities

The recommended projects and costs for the common liquid treatment elements discussed in the earlier part of this section are presented below in Table 8.5 and in Appendix Q.

Table 8.5 Summary of Recommended Project Costs for Common Facilities(1)

Project	Elements Included	Reason/Driver	When needed	Project Costs(2)
New Headworks	New building, grit removal, screening, and influent pumping	Existing facility aging and near end of useful life	Before 2025	39
Administration Building/Laboratory	New laboratory and office space to accommodate 40-50 people	Need for additional space and updated laboratory	Before 2030	18
Operations Building	Remodel	Repurpose space from old laboratory		3
Maintenance Building Expansion	Warehouse	Need additional space		3
New Recycled Water Facilities	Filtration, disinfection, storage and pumping	Existing facility aging and near end of useful life. Need additional capacity.	Before 2030	29
Advanced Oxidation	Ozonation facilities	If need to remove emerging contaminants	Triggered by regulations	20
Reverse Osmosis(3)	Ultrafiltration and Reverse Osmosis	If need to reduce salts in recycled water	Policy decision	27 to 62

Notes:
(1) Cost estimates represent the values in millions of 2015 dollars.
(2) Project costs include estimated construction costs, engineering, design, administration, and construction management.
(3) Range of costs shown for a 1.5 to a 2.5 mgd RO facility with and without ultrafiltration pre-treatment.

8.4 LIQUIDS TREATMENT ALTERNATIVES

This section will evaluate alternatives for secondary/tertiary liquids treatment processes to meet the projected flows, loads, and regulatory scenarios discussed in Section 8.2. There are several processes that can be used to provide the required level of treatment either alone or in combination to achieve the desired effluent water quality. Table 8.6 below shows the list of secondary treatment processes that are commonly considered along with the constituents they most commonly remove.

Table 8.6 Secondary Processes to Meet Future Discharge Requirements

	Ability to remove		
Process	**Organics (BOD)**	**Ammonia**	**Total Nitrogen**
Suspended Growth			
Activated Sludge	X	X	X
Membrane Bioreactor	X	X	X
Attached Growth			
Trickling Filters	X		
Nitrifying Trickling Filters		X	
Denitrification Filters			X
Hybrid			
Integrated Fixed-Film Activated Sludge	X	X	X
Anaerobic Treatment			
Upflow Anaerobic Sludge Blanket	X		

8.4.1 Suspended Growth Processes

Suspended growth systems, whether they are activated sludge or membrane bioreactor (MBR), have been used and proven not just in California but also at municipal wastewater facilities worldwide. A list of MBR installations from two major vendors is presented in Appendix R. Suspended growth systems have also been in use for a number of decades at Palo Alto. The existing aeration basins are suspended growth technology that have been operating at the RWQCP since 1972 to provide BOD removal and ammonia removal since 1980.

8.4.2 Attached Growth Processes

Nitrifying trickling filters have been used at numerous locations in California such as the City of Sunnyvale, the City of Stockton and in the wider United States such as Cities of Reno and Sparks Truckee Meadows Water Reclamation Facility and the Cities of Englewood and Littleton Wastewater Treatment Plant. Attached growth systems have also been in use for a number of decades including at Palo Alto. The existing FFRs are an example of attached growth technology that has been operating at the RWQCP since 1980 as a set-up stage for the aeration basin nitrification system.

Denitrification filters are also being used more extensively to help reduce wastewater treatment plants' total nitrogen limits. Denitrification filters have been used by the Cities of Reno and Sparks Truckee Meadows Water Reclamation Facility for over 20 years to meet effluent total nitrogen limits of less than 2 mg/L. Lists of denitrification filters from several vendors are included in Appendix R.

8.4.3 Hybrid of Suspended and Attached Growth Processes

Hybrid systems that consist of both suspended and fixed film growth have been employed in situations where footprint is limited, as it provides biological treatment with a reduced footprint. The addition of a fixed film media into an aeration basin provides opportunities for both suspended and attached growth types of micro-organisms to inhabit the basin and remove BOD and nitrogen. One such system is the Integrated Fixed-Film Activated Sludge (IFAS) system. A list of IFAS installations is presented in Appendix R.

8.4.4 Anaerobic Liquid Treatment Processes

Anaerobic systems provide biological removal of organics (BOD) in the absence of oxygen. Due to the lack of oxygen, anaerobic systems have a lower energy requirement than aerobic suspended or attached growth processes. Anaerobic processes have the downside of requiring a longer detention time than aerobic processes, thereby requiring more space. Anaerobic processes also require a higher temperature and for this reason have been successfully utilized in warm countries like Brazil, but have not been utilized in the United States. Lastly, anaerobic bacteria are not able to remove or transform nitrogen in the water, and therefore must be paired with other processes for ammonia and total nitrogen removal.

8.5 INITIAL QUALITATIVE SCREENING OF ALTERNATIVES

This chapter identifies and evaluates alternative liquid treatment schemes to satisfy potential, future discharge requirements for ammonia and total nitrogen (TN < 3 mg/L). Six secondary and tertiary alternative treatment schemes were evaluated:

1. Alternative 1 – Aeration Basins

   This alternative will add more aeration basins and subsequently decommission the fixed film reactors as future total nitrogen limits are imposed. All the carbonaceous removal and nutrient removal will occur in the aeration basins. Up to ten aeration basins (six new basins approximately the size of the existing basins) would be required to provided treatment for the 2062 projections assuming an effluent TN < 3 mg/L. Because of the limited space available onsite, these basins cannot be located in the same area, but will need to be spread over the entire RWQCP site. This will make routing to and from the aeration basins difficult and a hydraulic challenge. Supplemental carbon would be required to meet the projected TN limits.

2. Alternative 2 – Membrane Bioreactors

   This alternative will use the existing aeration basins and add membranes to replace the existing secondary clarifiers and dual media filters. The existing aeration basins will be used for nitrification (conversion of ammonia to nitrate) and denitrification (conversion of nitrate to nitrogen gas) to meet projected future TN limits. The fixed film reactors would be decommissioned. Supplemental carbon will be required to meet the projected TN limits. Buildings will be required to house the new membrane support equipment and new tanks will be required for the membranes.

3. Alternative 3 – Trickling Filters/Aeration Basins/Denitrification Filters

   This alternative will use the existing fixed film reactors (trickling filters) and existing aeration basins for carbonaceous removal and nitrification. The existing 12 dual media filters would be converted to denitrification filters and 24 more denitrification filters would be added. Supplemental carbon will be required for the denitrification filters to meet the projected TN limits.

4. Alternative 4 – Aeration Basins/ Nitrifying Trickling Filters/Denitrification Filters

   This alternative will use the existing aeration basins for carbonaceous removal, the two existing fixed film reactors would be converted to nitrifying trickling filters (NTFs) and two new NTFs would be constructed. The existing 12 dual media filters would be converted to denitrification filters and 24 more denitrification filters would be added. Supplemental carbon will be required for the denitrification filters to meet the projected TN limits.

5. Alternative 5 – Integrated Fixed-Film Activated Sludge (IFAS)

   This alternative will convert the existing aeration basins to IFAS reactors by adding the appropriate equipment and media. The IFAS reactors will provide both carbonaceous and nutrient removal. One additional IFAS reactor will be required along with supplemental carbon to meet the projected TN limits. The existing fixed film reactors would be decommissioned.

6. Alternative 6 – Upflow Anaerobic Sludge Blanket (UASB) Reactor/Aeration Basin/ Denitrification Filters

   This alternative will use UASB reactors for carbonaceous and solids removal. The new UASB reactors would replace the primary sedimentation tanks, which would be decommissioned. Nitrification and residual carbonaceous removal would be provided in the existing aeration basins, the dual media filters would be converted to denitrification filters, and 24 more denitrification filters would be added. Supplemental carbon will be required for the denitrification filters to meet the projected TN limits. Initial estimates are that up to eight UASB reactors would be required that are approximately the same size as the existing aeration basins.

These six secondary and tertiary treatment alternatives developed to meet new regulatory requirements were initially compared on a qualitative basis for the four major categories of treatment, environment, community/neighbor impacts, and costs. Treatment criteria considered included: the process footprint, flexibility for future regulations, and whether the primary technology is proven. The RWQCP has limited area in which treatment processes can be constructed. As a result, the overall footprint requirement of each alternative was evaluated. Flexibility considered the ability for a technology to adapt to anticipated changes in regulations or future regulations. A technology was considered proven if it is commercially installed and processing wastewater successfully at full scale in the United States at one or more facilities and has been in operation for 2 to 3 years.

Environment criteria considered the amount of energy required to operate the system and chemical use required to meet the regulatory requirements. Community/neighbors considered the visual and odor impacts from each alternative. Visual impacts were based on how the technology and associated equipment and buildings fit the landscape of the RWQCP. Table 8.7 summarizes the initial qualitative screening results based on the above criteria.

Based on this qualitative screening and evaluation of layout considerations, Alternatives 1, 4, and 6 were not carried forward for further evaluation due to excessive land requirements (Alternatives 1 and 6), unproven processes (Alternatives 6) and no distinct advantage (Alternative 4). Therefore, the remaining viable alternatives for liquid treatment to meet future nutrient limits are Alternatives 2, 3, and 5.

8.6 COMPARISON OF VIABLE ALTERNATIVES

8.6.1 Assumptions for Evaluating the Viable Liquids Alternatives

All alternatives assume anaerobic digestion of solids, which requires the consideration of treating higher ammonia loads due to the recycle stream. As discussed under the common facilities, a new blower building will be required for each alternative. The costs and energy use for the new blowers are included in this comparison of the alternatives. All alternatives are sized for maximum monthly flows to meet total nitrogen limits of TN < 3 mg/l.

Table 8.7 Summary of the Initial Qualitative Screening Evaluation					
	Treatment Process	**Treatment**	**Environment**	**Community/ Neighbors**	**Cost**
Suspended Growth					
Alternative 1	Aeration Basins	◒	●	●	●
Alternative 2	Membrane Bioreactor	●	◒	●	◒
Combined Fixed Film Suspended Process					
Alternative 3	Trickling Filters/ Aeration Basins/ Denitrification Filters	●	◒	●	◒
Alternative 4	Aeration Basins/ Nitrifying Trickling Filters/ Denitrification Filters	◒	◒	◒	◒
Hybrid (Suspended and Fixed Film Processes)					
Alternative 5	IFAS/ Denitrification Filters	●	◒	●	○
Anaerobic Treatment					
Alternative 6	UASB/ Aeration Basins/ Denitrification Filters	○	●	●	◒

Notes:
(1) Treatment criteria include footprint, flexibility to meet future regulations and proven technology.
(2) Environment criteria include energy and chemical use.
(3) Community/Neighbor criteria include visual, odor impacts.
(4) Cost criteria include capital and O&M costs.

Legend:
● - Best meets the critieria
◒ - Meets some of the criteria but has some adverse impacts
○ - Worst at meeting the criteria, there are many adverse impacts.

8.6.2 Alternatives Evaluation and Site Layouts

8.6.2.1 Alternative 2 – Membrane Bioreactors

This alternative will add approximately 14 membrane bioreactor trains to replace the existing secondary clarifiers and dual media filters. The existing aeration basins will be used for nitrification and denitrification to meet projected future total nitrogen limits. The aeration basins will be operated at approximately a 5-day solids retention time and a mixed liquor concentration of between 8,000 to 9,500 mg/l. A supplemental carbon source, such as methanol, will be needed in the aeration basins to reach the projected low total nitrogen future requirements.

Although the secondary clarifiers will no longer be used for this alternative, these tanks can be used for equalization of wet weather flows. A new 10,700 square foot (sf) blower building would be required to house new blowers with 66,000 standard cubic feet per minute (scfm) capacity. A proposed plant process schematic and layout for the MBR alternative are shown in Figures 8.6 and 8.7, respectively.

The use of membranes for MBRs (shown in Figure 8.6) has the advantage of providing a high-quality water for the entire flow that would meet Title 22 unrestricted reuse requirements. If the RWQCP should have to implement RO to reduce salts in the recycled water, an additional membrane process before the RO units would not be needed with an MBR alternative.

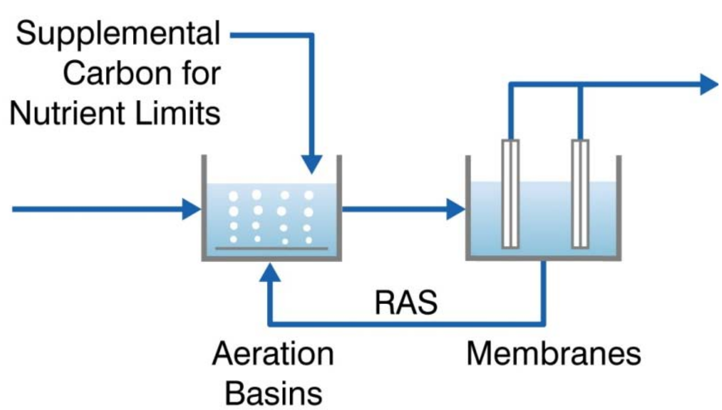


Figure 8.6 Membrane Bioreactor (Alternative 2) Process Flow Diagram

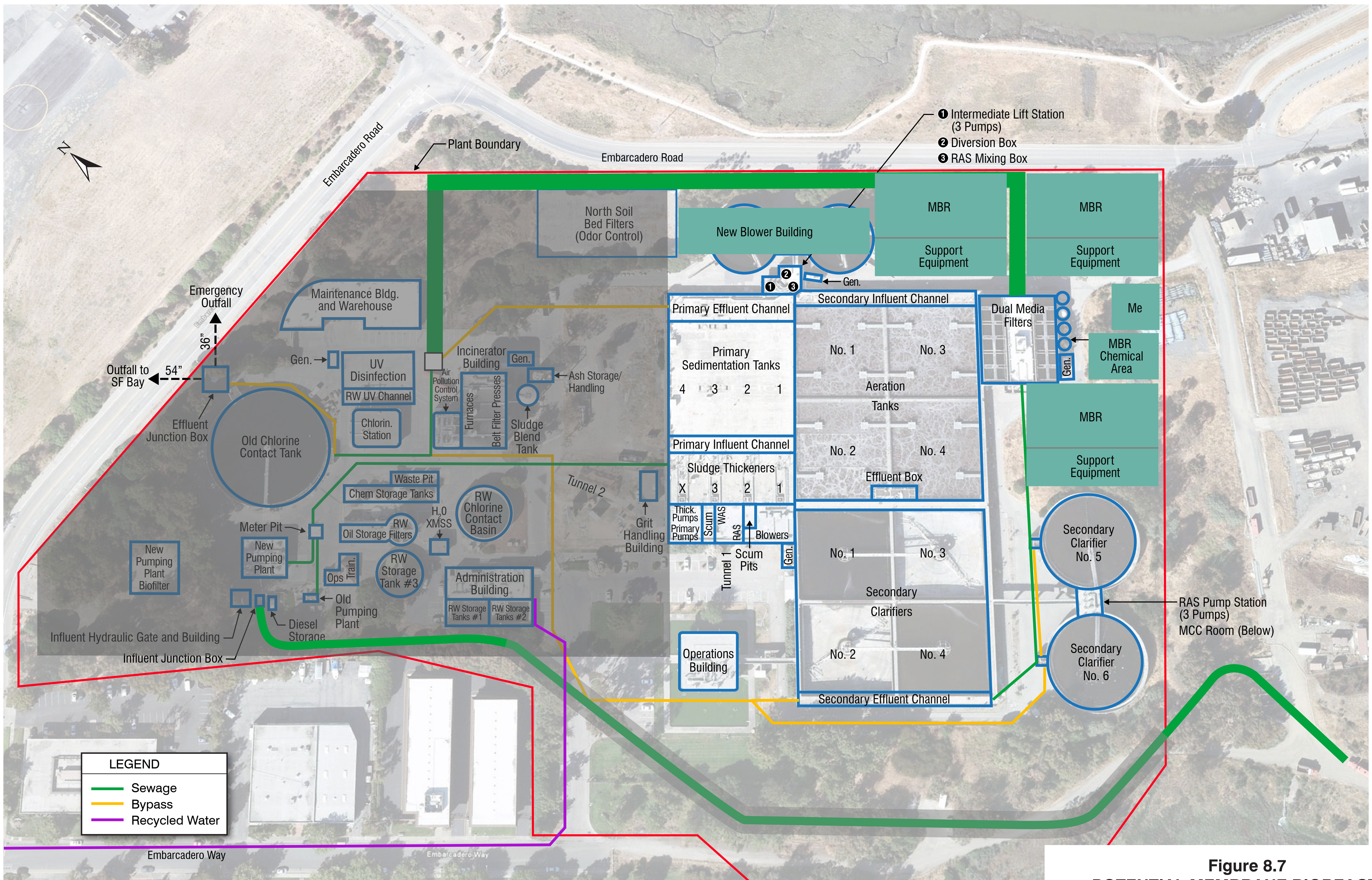


Figure 8.7
POTENTIAL MEMBRANE BIOREACTOR (ALTERNATIVE 2) LAYOUT
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f9-8510.ai

8.6.2.2 Alternative 3 – Trickling Filters/Aeration Basins/Denitrification Filters

This alternative will require rehabilitation of the existing fixed film reactors (trickling filters). The plant process model was reviewed to determine if the RWQCP could operate with only one reactor while the other was being rehabilitated; it was determined feasible if the rehabilitation occurred during the dry season. No new aeration basins are required for this alternative. The existing dual media filters will be converted to denitrification filters and twenty-four additional denitrification filters are required. A supplemental carbon source, such as methanol, will be needed in the filters to reach the projected low total nitrogen future requirements. A new 6,215 square foot (sf) blower building would be required to house new blowers with 60,000 scfm capacity.

This alternative will continue to operate the facilities similar to current operation where flows in excess of 40 mgd have to be bypassed around the fixed film reactors due to hydraulic limitation. The NPDES permit has provisions to allow this bypass during wet weather events with requirements for sampling to prove that effluent and receiving water limitations are still met.

The process schematic and the layout for this alternative are shown in Figure 8.8 and 8.9, respectively.

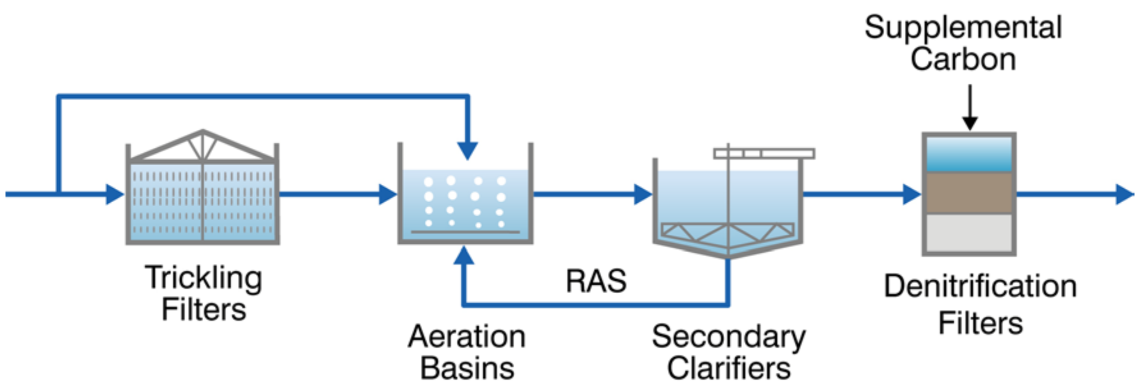


Figure 8.8 Trickling Filters/Activated Sludge/Denitrification Filters (Alternative 3) Process Flow Diagram

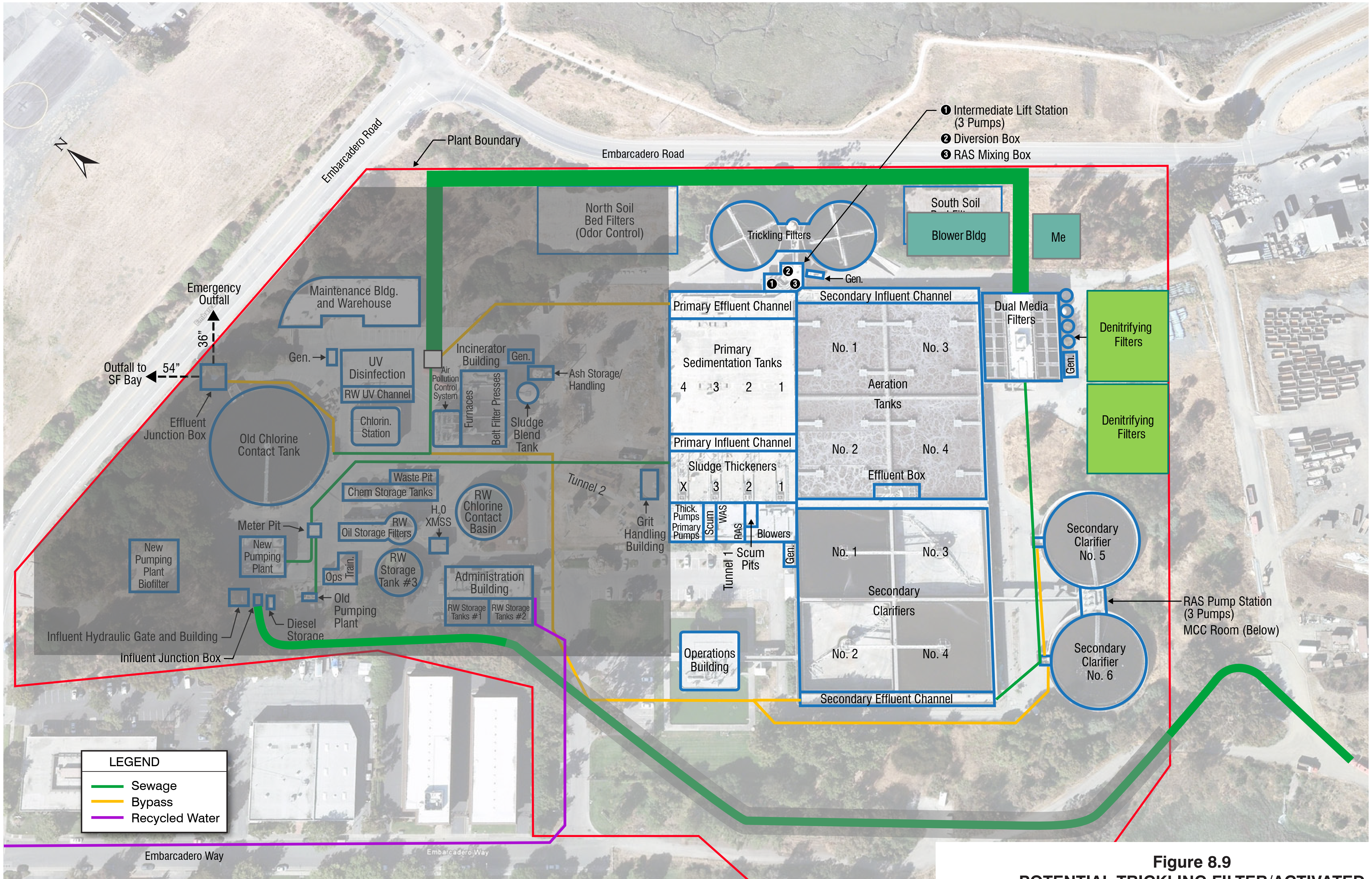


Figure 8.9
POTENTIAL TRICKLING FILTER/ACTIVATED SLUDGE/DENITRIFICATION FILTER (ALTERNATIVE 3) LAYOUT
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f10-8510.ai

8.6.2.3 Alternative 5 – Integrated Fixed-Film Activated Sludge (IFAS)

This alternative will require the existing aeration basins be converted to IFAS reactors (to accommodate the media and equipment) and construction of one additional aeration basin (IFAS reactor). A supplemental carbon source, such as methanol, will be needed in the IFAS reactors to reach the projected low total nitrogen future requirements. An additional secondary clarifier will be needed. A new 11,400 square foot (sf) blower building would be required to house new blowers with 120,000 scfm capacity. The process schematic and the layout for this alternative are shown in Figure 8.10 and 8.11, respectively.

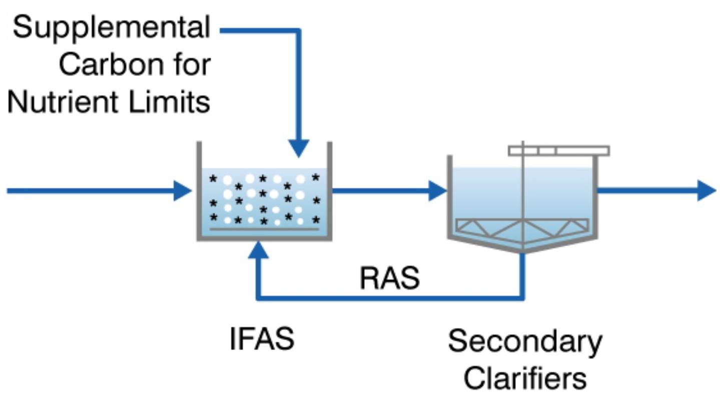


Figure 8.10 Integrated Fixed-Film Activated Sludge (Alternative 5) Process Flow Diagram

8.6.3 Alternative Cost Comparison

The viable liquid treatment alternatives were compared in 2015 dollars using capital costs, O&M costs and a calculated net present value. Table 8.8 is a summary of the capital and O&M costs for Alternatives 2, 3 and 5. Details of these costs are presented in Appendix Q. The O&M costs used in the Net Present Value evaluation consist of the process components associated with the alternatives and not the whole plant O&M. All capital, O&M, and repair and replacement costs were developed based on the procedures and guidelines presented in the Basis of Cost Technical Memorandum shown in Appendix M.

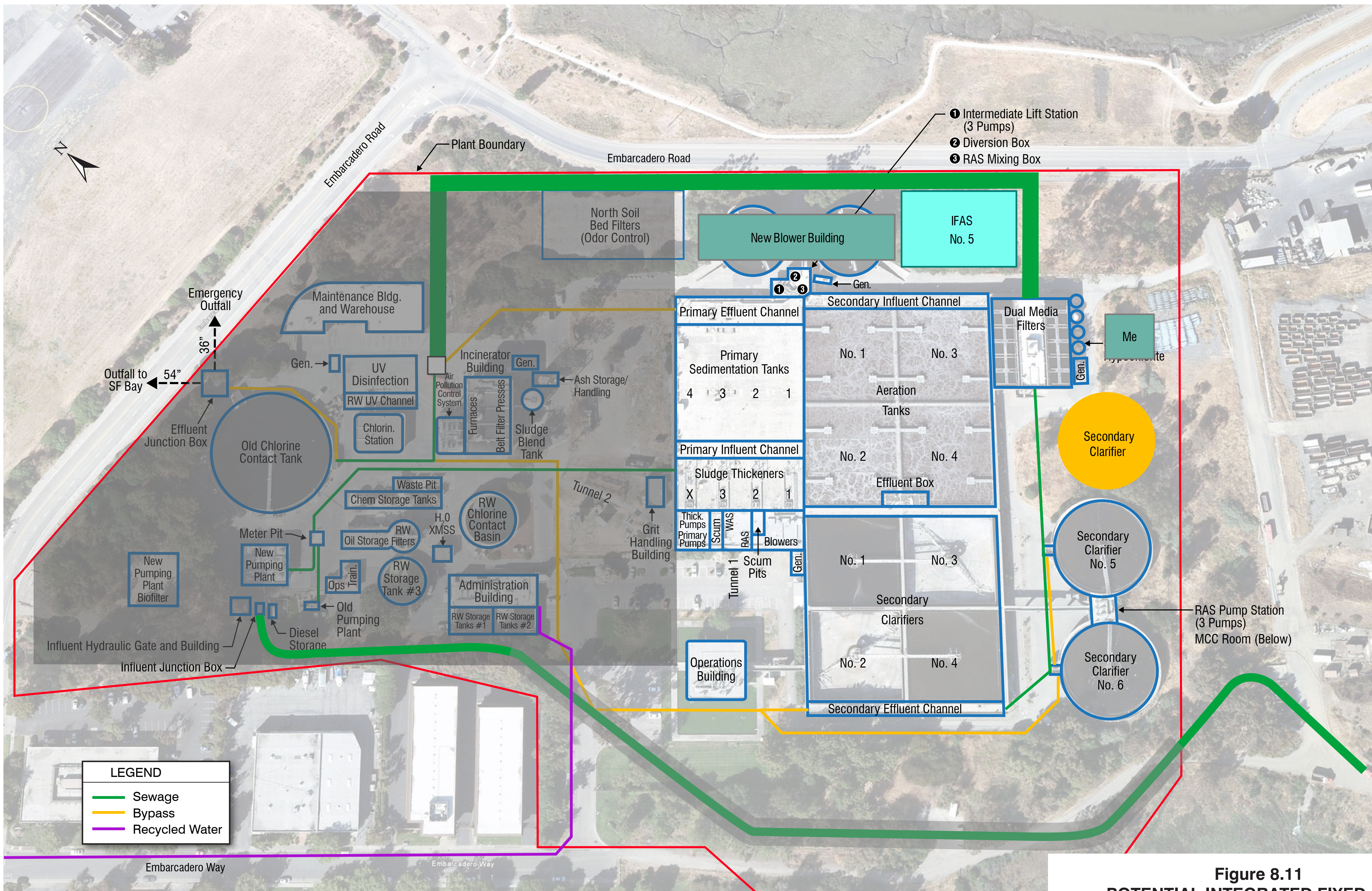


Figure 8.11
POTENTIAL INTEGRATED FIXED-FILM ACTIVATED SLUDGE (ALTERNATIVE 5) LAYOUT
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f11-8510.ai

Table 8.8 Liquid Treatment Alternatives Cost Estimates[1]				
Treatment Alternative	O&M Costs[2] ($/yr)	Capital Costs ($)	Net Present Value[3] ($)	Annualized Cost[3] ($)
Alternative 2 – MBR	10.4	135.9	296.4	19.3
Alternative 3 – TF/AS/Denitrification	8.3	68.5	195.5	12.7
Alternative 5 – IFAS	9.9	114.5	267.1	17.4

Notes:
(1) Present value cost represents the value in millions of 2015 dollars of the total cash flow occurring over the life of a project (30 years and 5 percent interest)
(2) O&M costs shown for liquid treatment alternative operations for year 2035, assuming a requirement of total nitrogen < 8 mg/l.
(3) Net Present Value and Annualized costs are based on 30-year period using an interest rate of 5 percent.

Based on these costs, Alternative 3 has the lowest capital and O&M costs, while Alternative 2 has the highest capital and O&M costs. Alternative 3 is therefore ranked as the most favorable option based on cost. There are, however, additional considerations that need to be taken into consideration and these are evaluated below.

8.6.4 Greenhouse Gas Emissions Analysis

A greenhouse gas (GHG) emissions analysis of each alternative was completed using Carollo's GHG emissions estimating tool. A summary of the detailed analysis is provided in this section.

The following assumptions were used in developing the GHG emissions analysis for the alternatives:

- GHG emissions included in the analysis are a result of electricity consumption for necessary operations onsite.
- GHG emissions estimated for this evaluation include the direct (process emissions) and indirect (electricity use at the plant, energy use to produce chemicals, and chemical hauling) emissions generated by RWQCP operations.
- Electricity related emissions are estimated using an emission factor of 400 lbs per megawatt-hour (MWh) of fossil fuel based electricity per the City's request. This emission factor was determined by the City of Palo Alto Utilities (CPAU) Department. CPAU's existing electricity is generated from a mix of 81 percent renewable energy sources and 19 percent fossil fuel sources. In 2035, it is assumed that only 9 percent of annual electricity consumption is fossil fuel based. Therefore, only 9 percent of the entire demand is evaluated at 400 lbs per MWh for the alternatives comparison.

- Process emissions are estimated per the methods and emission factors provided in the 2006 *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*.
- Trucks hauling chemicals are assumed to achieve 6 miles per gallon on average consuming California Diesel fuel.

Table 8.9 and Figure 8.12 show the results of the GHG emissions analysis for the liquid treatment alternatives in terms of carbon dioxide equivalent (CO_2e) emissions. The ranking of alternatives based on estimates of the GHG emissions are largely affected by the chemical production GHG estimates. The details of these GHG emissions estimates are provided in Appendix O.

Table 8.9 Liquids Treatment Alternatives Annual On-site CO_2e Emissions in Metric Tons for 2035

Alternative	Purchased Electricity(1)	Nitrification/ Denitrification(2)	Effluent Discharge(2)	Chemical Production and Handling(3)	Annual GHG Emissions
Alternative 2 - Membrane Bioreactors	58	606	494	3,121	4,279
Alternative 3 - TF/AS/ Denitrification	31	606	494	6,645	7,776
Alternative 5 - IFAS	48	606	494	3,127	4,275

Notes:
(1) Emissions from electricity used or offset assuming emissions factor of 400 lbs of CO_2/MWh is applied to only 9 percent of annual CPAU electricity consumption.
(2) Process emissions based on 2006 *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*.
(3) Emissions from the production and hauling of chemicals used for liquids treatment at RWQCP.

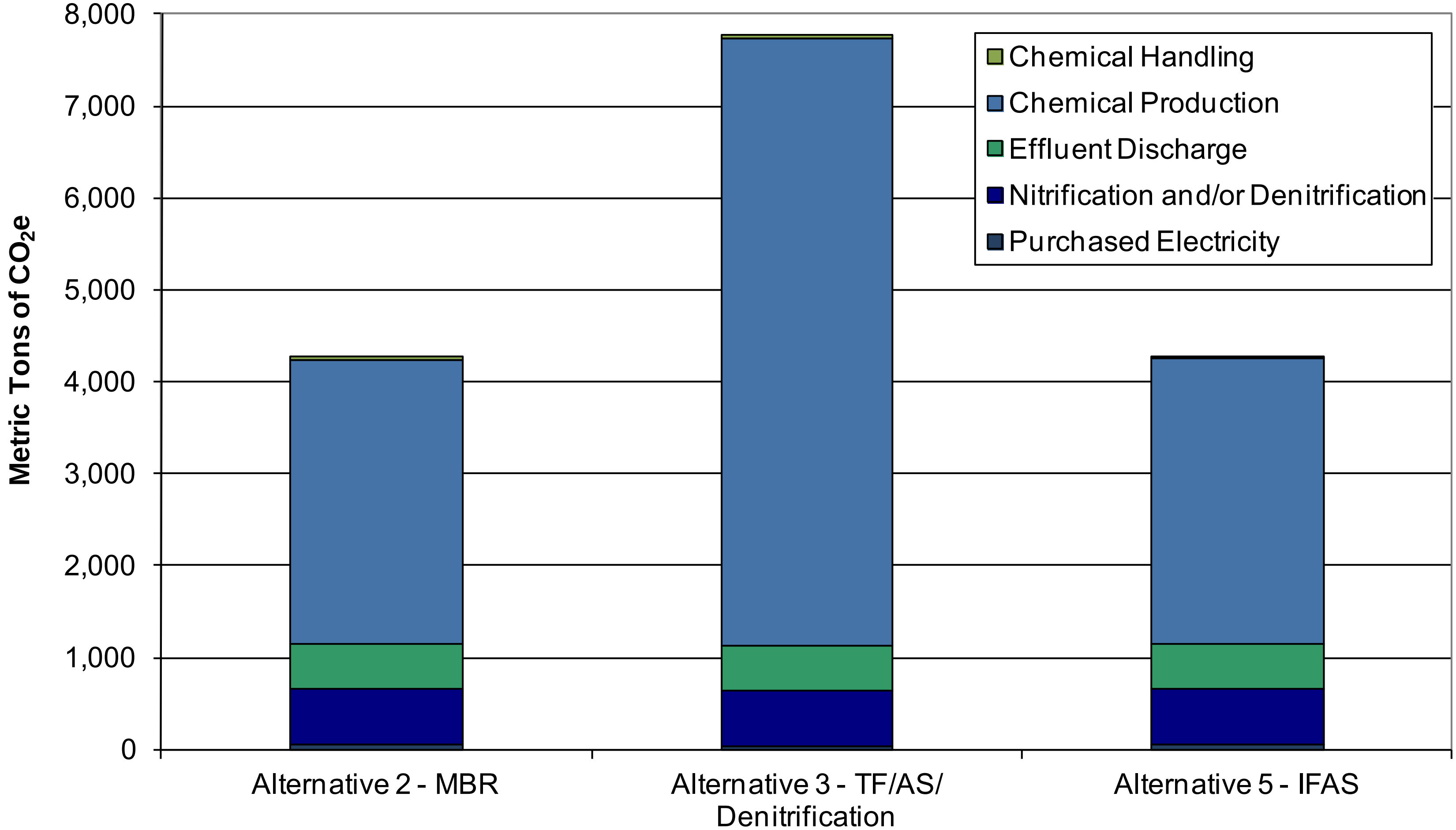


Figure 8.12 Liquids Treatment Alternatives 2035 Annual CO_2e Emissions in Metric Tons

8.6.4.1 Alternative Carbon Sources for Denitrification

Use of a supplemental carbon source is necessary for denitrification if there is not enough carbon in the wastewater. Meeting low TN limits, such as TN < 8 or 3 mg/l, typically requires a supplemental carbon source depending on the wastewater. The most commonly used source of carbon supplement is methanol. However, creation of methanol requires a significant amount of energy and therefore, methanol use has a relatively high GHG emission rate. Methanol vapors are also highly explosive and can pose a safety concern. Alternatives to methanol include ethanol, glycerin/glycerol, high fructose corn syrup, and MicroCg. While these options may have lower GHG emissions, they are less proven as a carbon supplement having different denitrification rates and kinetics, and have uncertain impacts to the emissions levels of nitrous oxide (a high global warming potential GHG) from treatment processes. It is recommended that when and if the RWQCP has to build facilities for low TN limits, a survey be performed to determine current use status and performance of other carbon sources.

8.6.5 Sensitivity of Liquids Alternatives to Changes in Assumptions

The potential impact of changes in assumptions on the liquid alternatives evaluation is discussed in this section.

8.6.5.1 Changes in Flow and Load Projections

The liquids alternatives have been compared using the baseline projections for flows and loads. The main condition that could change the amount of liquid to be treated is water conservation. While water conservation efforts could lead to reduction in flows, the loads are not expected to change. It is estimated that flow reductions could be as much as 16 percent. However, because the capital costs for the secondary treatment are more load based, a reduction in flows will not result in a reduction in the capital costs. The operating costs are impacted by both load and flows, however for a comparison of the liquid treatment alternatives focused on nutrient removal, the costs associated with the loads are controlling. Therefore, the reduction in liquids treatment operating costs due to conservation will be negligible.

In the event a residential garbage disposal ban were to be adopted, some organic loading to the RWQCP would be reduced (note that commercial garbage disposals are already banned in Palo Alto and Mountain View to avoid sanitary sewer overflows). This could lead to the potential reduction in sizing of future treatment process needs. Similarly, the implementation of an upstream satellite treatment facility could reduce BOD loading to the RWQCP. However, at this time the are no plans for any of the partners to adopt a garbage disposal ban or to implement an upstream treatment facility, therefore, no reduction in loadings were assumed as part of the alternative analysis.

8.6.5.2 Impact of Solids Treatment Alternatives

Depending on the solids treatment process utilized at the RWQCP in the future, different amounts of constituents will be recycled back to the liquid treatment process. For the liquids treatment alternatives compared in this chapter, we assumed that anaerobic digestion was the chosen solids treatment process since this generated higher ammonia recycle and therefore had a larger impact on the liquid treatment. Implementation of a solids treatment alternative that is not anaerobic digestion would mean that the liquids facilities could potentially be downsized and there could be some savings on capital costs for the future liquid treatment alternatives to meet low nitrogen limits. By the time regulatory requirements for nutrient reduction are adopted, the RWQCP should have a decision made on the solids process and either have the project implemented or well underway.

8.7 SUMMARY AND RECOMMENDATIONS

The major finding and recommendation from the liquid treatment alternatives analysis is that the existing treatment process (Alternative 3) is adequate for the near term and can be modified to incorporate future regulations. The RWQCP needs to invest in rehabilitating the existing liquid treatment facilities to keep them in good condition and operating well into the future. As regulatory limits are developed and promulgated that require reduction of total nitrogen, the City may want to consider re-evaluating the alternatives to see if new technologies have been implemented full scale and if costs for equipment (such as membranes) have decreased.

8.7.1 Summary of Recommended Projects

The recommendations for the liquid treatment at RWQCP are as follows:

- **Preliminary Treatment:** Replace the headworks (grit, screenings, and pumping).
- **Primary Treatment:** Rehabilitate existing primary clarifiers.
- **Secondary/Tertiary Treatment:** Continue with existing process until there is a regulatory trigger. Rehabilitate existing fixed film reactors, aeration basins, secondary clarifiers, and dual media filters.
- **Recycled Water:** Replace recycled water filters and chlorine contact tank. Provide storage and pumping to be able to meet peak-hour demands. Continue source control for salinity reduction and plan for reverse osmosis, if needed.
- **Advanced Treatment:** Leave space for ozonation facilities if a regulatory trigger should require higher quality effluent for emerging contaminants.
- **Buildings:** Replace the administration building with a new Laboratory and Environmental Services Building for all office staff and a new laboratory. Rehabilitate the operations

building and expand the maintenance building and warehouse to include additional warehouse space.

The recommended layout to reserve space for new facilities is shown in Figure 8.13. A summary of considerations for future liquid treatment at RWQCP is presented in Table 8.10.

Table 8.10 Liquid Treatment Alternatives Summary of Considerations

Future Considerations	Impact on Strategic Plan
Aging facilities	The RWQCP liquid treatment facilities have many aging facilities with limited remaining useful life. The RWQCP needs to systematically rehabilitate aging facilities to ensure continued performance. Some facilities are recommended to be replaced, such as the headworks and administration/laboratory facilities.
More stringent regulations anticipated for water quality.	All indications are that additional nutrient requirements will be imposed on Bay dischargers within the 50-year planning horizon. In addition, regulations on emerging contaminants may also be imposed. Leave room for identified additional facilities needed to meet future regulations.
Avoid noise, odor and visual impacts to neighbors.	Odors: Plan for odor control measures for potential odor sources, such as preliminary treatment and fixed film reactors. Noise and Visual: Contain equipment, pumps, motors, etc., where practical.
Consideration of recycled water needs	As the RWQCP expands recycled water uses, higher quality water may be required. Space and costs for reverse osmosis have been identified. However, further investment in source control is recommended.
Need to consider sustainability, carbon footprint, and greenhouse gases	California State Bill AB 32 on global climate regulation will favor certain biosolids management practices. Consider GHG emissions in future process selection.
Future technologies	Emerging future technologies should be monitored. In particular new liquid treatment processes to meet nutrient regulations, and chemicals for carbon sources for denitrification.

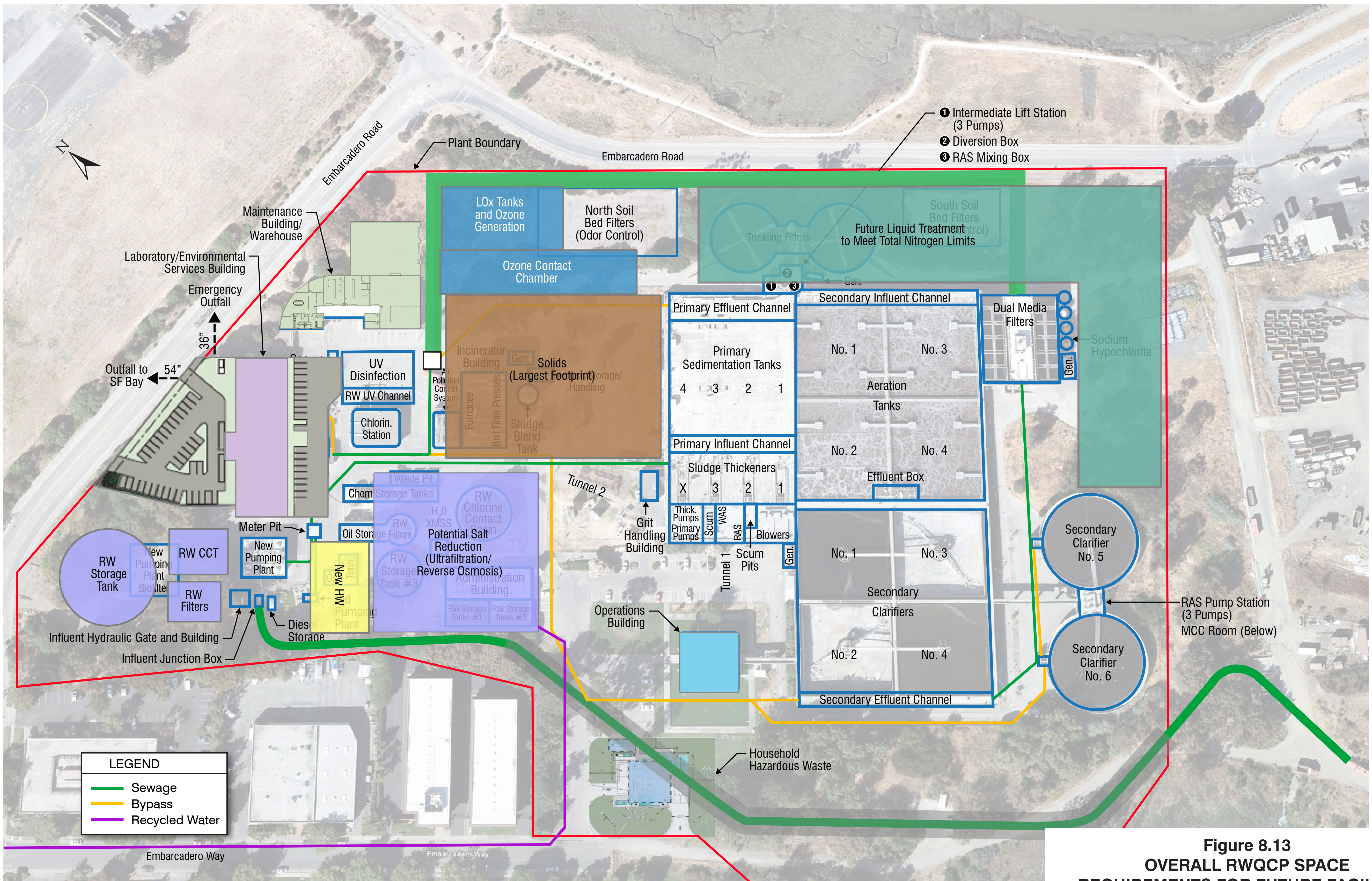


Figure 8.13
OVERALL RWQCP SPACE REQUIREMENTS FOR FUTURE FACILITIES
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f12-8510.ai

8.7.2 Promising Technologies

In addition to the alternatives considered, there are several promising types of technologies that should be tracked and evaluated as the technologies mature and are proven in similar types of applications. The City should also seek to pilot test these new technologies, as feasible, to determine whether they would be suitable for the RWQCP.

8.7.2.1 <u>Microscreens</u>

Microscreens have the potential to remove as much or more solids than a primary clarifier and then dewater those solids to a suitable dryness for direct incineration or gasification without additional thickening or dewatering. However, this technology is still emerging and has not been installed at any facilities near the size of the RWQCP, and pairing it with gasification has also not yet been proven full-scale. As mentioned previously in Chapter 7, the City had a microscreen demonstration unit on site between February 13th and 15th, 2012.

8.7.2.2 <u>Anaerobic Treatment</u>

Anaerobic treatment for liquid processes would provide biological treatment at a much lower power requirement than conventional aerobic processes, such as activated sludge. However, anaerobic liquid treatment has not been successfully applied at full scale in a climate similar to Palo Alto. Anaerobic treatment also has the disadvantage of providing only BOD treatment and thus needs to be followed by a process that can remove ammonia and total nitrogen.

Upflow Anaerobic Sludge Blanket – The UASB process was evaluated as Alternative 6 in the discussion in section 8.5 of this chapter. While it was eliminated for both a large footprint and being an unproven process, if this process becomes proven at cooler temperatures comparable to Palo Alto, consideration of the process may be warranted due to lower energy requirements of the anaerobic process.

Anaerobic MBR with Granular Activated Carbon (GAC) - Anaerobic fluidized bed membrane bioreactors for secondary treatment of domestic wastewater would replace the activated sludge process. In research studies, the fluidized GAC was found to efficiently prevent membrane fouling, providing highly efficient wastewater treatment (5 mg/L BOD and zero TSS). Power usage is estimated to be 50 percent less than conventional MBR processes and methane production is projected to increase by ~75 percent due to increased digestion of solids in the anaerobic secondary process.

8.7.2.3 <u>Alternative Nitrogen Reduction Processes</u>

Another promising technology class is use of other types of bacteria or organisms to remove nitrogen from the wastewater. There is ongoing research and development of several of these processes including use of ammonia oxidizing archea (AOA) and the anammox process for nitrogen reduction.

Ammonia oxidizing archea (AOA) is being used in MBR processes with a low oxygen environment to reduce energy use in MBR facilities by up to 40 percent while meeting low nutrient requirements. Anammox uses a select organism for the conversion of ammonia to nitrate and then to nitrogen gas, skipping the nitrite step. This process eliminates carbon needed for denitrification (such as methanol) but requires extensive SRTs of 30+ days. Estimates of energy use for Anammox are in the range of 40 – 60 percent less than conventional activated sludge. Anammox has been implemented full scale for side-stream treatment of high ammonia recycled streams.

While both of these processes show promise, additional research is underway and full-scale applications are still needed to demonstrate reliable treatment.

Chapter 9

RECOMMENDATIONS AND IMPLEMENTATION PLAN

9.1 INTRODUCTION

This section provides a summary of recommendations for the near, mid, and long term capital improvement of the Regional Water Quality Control Plant (RWQCP), as well as a phased implementation plan for the needed improvements over the 50-year planning horizon (2012 to 2062). The projects presented herein have been identified in previous chapters.

Major findings and recommendations of the Long Rang Facilities-Plan (LRFP) fall into four major categories that drive all facility planning efforts:

1. Capacity needs to accommodate the service area.
2. Replacement and rehabilitation of existing facilities due to aging and inadequate infrastructure.
3. Future regulations.
4. Policy directives.

9.2 SUMMARY OF NEEDS AND OPPORTUNITIES

The RWQCP is able to treat the existing wastewater flows to meet current effluent discharge limits and provide recycled water to users. With the exception of the interceptor and outfall during peak wet weather events, the plant capacity is adequate to meet the anticipated growth in the service area over the next 50 years provided that there are no regulatory changes. In Chapters 7 and 8, alternatives were developed for solids facilities in response to changing incinerator regulatory requirements and for complying with more restrictive effluent discharge limits (e.g., total nitrogen limits and the potential removal of emerging contaminants).

Findings from treatment evaluations show that continued investment in the incineration process is not warranted due to its age, condition, and lack of regulatory flexibility. The existing incinerators are rusting, requiring significant patching and maintenance, continued use of the building will require seismic improvement, and new regulations continue to be stricter and difficult to meet. Therefore, a new solids process needs to be selected and implemented for the RWQCP.

Continued investment in the existing liquid treatment processes is appropriate even in light of changing regulatory requirements. The existing liquid treatment process performs well and is flexible for modification to meet future regulatory requirements.

Therefore, the major recommendation of this LRFP is to rehabilitate and replace existing facilities that are nearing the end of their useful life, and not switch liquid treatment processes until there is a regulatory driver. Since a significant portion of the plant was built in 1972 (e.g., the Main Structure), many facilities are aging and are in need of significant investment in rehabilitation or replacement. In addition, increasing use of recycled water in the service area is a policy directive that will drive the need to provide adequate treatment, storage and distribution capacity and potentially to remove salts from the liquid stream to better meet the needs of the recycled water users.

A summary of the RWQCP needs and opportunities is presented in Table 9.1.

9.3 RECOMMENDED PROGRAMS AND PROJECTS

There are near term, mid-term, and long-term recommendations that have been provided throughout the course of the facilities plan project for maintaining reliable wastewater treatment for the RWQCP's customers. This section provides a summary of the recommended projects organized into the four major categories of capacity, replacement, regulatory and policy directive. In addition, solids handling was given its own category to reflect that it represents a significant cost and a detailed decision process. The recommended projects are summarized in Table 9.2 at the end of this section. The projects were prioritized based on condition and critical need. Timing assumptions for the recommended projects were developed in conjunction with RWQCP staff recognizing the need for minimizing multiple projects ongoing at the same time for ongoing plant operation and due to funding capacity.

9.3.1 Projected Flows/Loads and Capacity Projects

The dry weather flow and loads to the RWQCP were projected based on population projections from the Association of Bay Area Governments (ABAG) and historical influent characteristics. While growth may in fact occur at a slower rate than projected, it is prudent to plan for the population estimates identified for the long-term planning horizon. Similarly, upstream intervention measures may be implemented that could reduce flow and/or loadings to the RWQCP, but facilities were evaluated for the full projected flows and loads (especially since flow reduction measures would not reduce plant loadings).

In general, the RWQCP existing facilities provide adequate capacity for average dry weather flows anticipated over the planning period. The projection of wet flows was based on historical events and previous design criteria for peak hour wet flows of 80 mgd. While the RWQCP appears to have adequate hydraulic capacity to pass peak flows of 80 mgd, evaluation of the influent sewer (72-inch diameter Joint Interceptor Sewer) and the outfall indicate less than 80 mgd peak capacity. Before deciding to replace these pipelines, a comprehensive estimate of

Table 9.1 Summary of Needs and Opportunities

Driver	Process	Need/Opportunity	Reason
Capacity	Influent Sewer (72 inch Joint Interceptor)	Clean, CCTV, repair. Study to determine needed capacity	Corrosion and leakage. Appears to have inadequate capacity.
	Effluent Outfall	Inspect and perform study to determine needed capacity	Appears to have inadequate capacity and is aging.
Replacement	Headworks	New headworks	Near end of useful life.
	Support Facilities	Laboratory and Environmental Services Building	Inadequate space for lab and staff. Administration building at end of useful life.
	Solids Process	Replace incinerators	Incinerators are deteriorating and at the end of useful life. Ability to continue meeting regulations is questionable.
	Recycled Water Facilities	Need additional pumping, storage, and new RW filter and CCT	Limited capacity and aging infrastructure
Rehabilitation	Primary	Rehab tanks/channels	Concrete cracks and exposed rebar.
	Secondary	Rehab FFRs, aeration basins, and clarifiers	Structural and media damage to FFRs. Concrete and equipment corrosion.
	Tertiary	DMF filters and pumps	Pumps/piping near end of life.
	Sludge Pumps/ Thickeners	WAS, sludge, and scum pumps/ Thickener No. 4	Pumps at end of useful life. Need new equipment.
	Piping	In-plant piping	Near end of useful life.
	Misc. Buildings/ Power/Electrical	Storage buildings/tunnels, generators, MCCs	End of useful life.
	Support Facilities	Remodel Operations Building and Maintenance Building and expand Warehouse	Need for better utilization of and additional space for staff and equipment storage.
Potential Future Regulatory Limits	Additional Secondary Facilities	Blower building, denitrification filters, methanol facilities	Reduce effluent total nitrogen to 8 mg/l or 3 mg/l
	Advanced Oxidation	Ozone generator and chamber, liquid oxygen	Reduce concentration of emerging contaminants
Policy Directives	Salt Reduction	Ultrafiltration and reverse osmosis	Reduce salts for improved recycled water quality

wet weather flows (e.g. collection system model) should be developed for all the contributing areas to determine the projected flows during wet weather events. On going and planned efforts to reduce I&I need to be incorporated into this wet weather estimate.

Recommendations for the project flows and loads and capacity are based on Chapters 3 and 5 of this LRFP and include:

Model Influent Sewer Flows

- **Determine peak wet weather flow**: Work with RWQCP partner agencies to understand sewer flows. Develop a sewer system estimate of the key components of the wastewater collection system to determine the peak wet weather flows that will reach the RWQCP. Knowing peak flows will inform sewer rehabilitation options, inform plant capital improvement sizing for wet weather flows (note: not pollutant loads), and inform effluent outfall capacity evaluation. Understanding peak flows will also inform infiltration and inflow management needs, if necessary, to reduce capital sizing.

- **Inspect and clean influent sewer**: Following the development of the sewer system flow estimate to determine needed capacity, clean and inspect the 72-inch diameter interceptor sewer to decide the best option for rehabilitation.

- **Outfall**: Following the development of the collection system flow estimate, the capacity of the outfall should be reviewed. Additionally the outfall should be inspected to determine rehabilitation needs for the near future.

Continue Source Control and Flow Reduction Efforts

- Continue to evaluate options for source control and flow reduction measures for cost-effective options to reduce costs at the RWQCP for treatment of flow and loads.

- Continue traditional source control efforts; source control is more cost effective at removing some pollutants than traditional wastewater treatment technology (e.g., toxic heavy metals) and will reduce the potential need for more expensive capital facilities.

- Source control for emerging contaminants should be considered before advanced treatment.

- Continue support of water conservation efforts as well as infiltration and inflow reduction efforts, which reduce operating costs, preserve surplus wet-weather capacity, reduce energy consumption, and reduce the wear and tear on existing capital investments, thereby extending their life.

- Consider banning residential garbage disposals to reduce pollutant loads, as necessary, to reduce the sizing of potentially necessary capital facilities. Commercial garbage disposals are already banned in Palo Alto and Mountain View to reduce sanitary sewer overflows.

- Continue strategic analysis of salinity infiltration to reline and rehabilitate sewers with highly saline groundwater infiltration.

- Consider banning specific household products that pass through the treatment plant and have ecological impacts on the Bay to reduce the need for large capital improvements to reduce pollutants better reduced through source control.

9.3.2 Solids Handling Project

Based on the information presented in Chapters 5, 6, and 7, the existing incineration process needs to be retired due to deteriorating condition, limited remaining useful life, regulatory pressures, and available alternatives for future solids processing. The capital costs to implement alternative solids processes ranged from approximately $12 million (to send dewatered solids to the BAB2E facility, which is likely to be a gasification process) to $89 million (to provide anaerobic digestion on the RWQCP site). The annual operating costs for the solids treatment alternatives range from $4 million to $6 million in 2045 (based on a 30 year CIP planning horizon). The overall recommendations for solids processing facilities include:

1. Continue to use the existing incinerators until they can be retired and a new solids handling facility and disposal option implemented.
2. Initiate a Solids Facility Plan
   a. Develop the scope of a Solids Facility Plan to choose a technology and onsite or offsite option for the replacement technology for the RWQCP’s solids handling systems
   b. Given the issues foreseen regarding disposition of solids with a limited future for landfilling and land applying biosolids, beneficial uses locally would provide the ability to control the RWQCP’s destiny. However, the lack of a local market and space on-site limit options to off-site beneficial use or privatization. For the purposes of the LRFP, proceed with detailed evaluation including layouts for the following solids alternatives:

      (1) Alternative B – Onsite gasification.

      (2) Alternative C – Anaerobic Digestion with off-site beneficial use (either land application or composting).

      (3) Alternative D – Send dewatered solids to SJ/SC WPCP.

      (4) Alternative E – Send dewatered solids to BAB2E.

c. Enter into further discussions with the SJ/SC WPCP to determine conditions of an agreement to send solids to their facility. In addition, participate in San Jose's piloting of gasification, if that project proceeds.

d. Consider joining the BAB2E consortium and participate in their ongoing evaluation of promising technologies.

e. If the City and Partner decision makers have a strong preference to keeping solids treatment within the control of the RWQCP, begin a preliminary design study for anaerobic digestion facilities to evaluate in more detail the advantages and disadvantages of different anaerobic digestion configurations.

f. If an anaerobic digestion process is implemented on-site, consider efforts to develop a marketable product and local users through either drying or composting.

g. Investigate in greater detail the installations and operating history of gasification systems, including performance, reliability and operational challenges. While the United States has very limited experience with gasification of biosolids, there are existing gasification systems in the US utilizing other feedstocks including wood wastes and municipal solid wastes. Abroad, especially in Europe and Japan, numerous entities have gasification systems utilizing various feedstocks, including wastewater solids.

3. Develop a contingency plan for raw sludge disposal with a local waste hauler should the furnace systems fail to operate.

A summary of the recommended solids project costs is shown in Table 9.2.

Table 9.2 Summary of Recommended Solids Project Costs (only one to be selected)

Project	Project Start Date	Estimated Project Cost, millions
Anaerobic Digestion	2013	$89.0
Gasification	2013	$49.8
SJ/SC WPCP	2013	$39.5
BAB2E	2013	$12.8
Total Range		**$12.8 to 89**

9.3.2.1 Dry Digestion and Measure E

Another solids disposal option that is being considered independent of the LRFP is dry anaerobic digestion. With the closing of the Palo Alto landfill in 2011, the City wanted to look at options for their solid waste disposal, particularly for green wastes. The City hired consultants Alternative Resources, Inc. (ARI), to complete a dry anaerobic digestion study for solids generated by the RWQCP and for handling green and food wastes collected in the City. ARI concluded that a dry anaerobic digester could indeed be cheaper than the exporting options for green waste, but only if such factors as carbon adders, state and federal grants and contingency costs for exports are added into the mix. A citizen led initiative was placed on the ballot as Measure E, which was to undedicate ten (10) acres of Byxbee Park for a ten year period for the exclusive purpose of considering an Energy/Compost Facility to treat yard trimmings, food waste and/or other organic material, including solids from the RWQCP. In November 2011, a public vote resulted in a majority "yes" vote on Measure E, which means that the ten acres has been undedicated and the site is available if the City Council decides to proceed with an Energy/Compost Facility. City staff and Alternative Resources, Inc. (ARI) are developing an Action Plan to layout the process and timeline for considering the facility.

9.3.3 Replacement Projects

Major facility replacement needs were identified in Chapter 5 of this Report based on the condition of existing facilities and the alternatives considered in Chapters 7 and 8. Minor projects are included in the Rehabilitation Projects list. Recommended major replacement projects include:

- **Solids Treatment:** Replacement of the existing solids handling facilities (discussed in the previous section).
- **Headworks/Preliminary Treatment:** Replace the existing headworks facilities and add grit removal.
- **Recycled Water:** Replace recycled water filters and chlorine contact tank.
- **Support Facilities:** Replace the administration building with a new Laboratory and Environmental Services Building to house a new laboratory and staff office space. Remodel the operations building and maintenance building and expand the maintenance building to include additional warehouse space.

The existing headworks will reach the end of their useful life within the next 15 to 20 years. It is recommended to consolidate the facilities from two facilities into one and to add grit removal capabilities at the headworks. The replacement of the recycled water facilities is primarily driven by aging facilities and the need to better allocate space for treatment processes at the RWQCP site. The existing recycled water filters, chlorine contact tank, and storage tank should be replaced. Additional recycled water storage and pumping are required to meet the demands of future users but these projects are listed under Future Recycled Water projects.

A summary of the recommended replacement project costs is shown in Table 9.3. A table showing all the recommended projects is listed in Appendix S.

Table 9.3 Summary of Recommended Replacement Project Costs		
Project	**Project Start Date**	**Estimated Project Cost, millions**
Headworks Facility (including Grit Removal System)	2020	$38.9
Recycled Water Filters and Chlorine Contact Tank	2022	$14.2
Recycled Water Piping	2022	$1.3
Total		**$54.4**

The existing Administration Building and Laboratory spaces are not adequate. The existing Administration Building was originally built as an industrial concrete structure for recycled water processing, including pumping (still exists in the basement). The industrial environment is not suitable for offices. The existing laboratory in the operations building is inadequate for the number of staff that needs to be housed and for the types of laboratory testing that is conducted.

It is recommended to build a new Laboratory and Environmental Services Building that includes a laboratory and sufficient space to house all the administrative, purchasing, IT, engineering, solid waste, and watershed protection staff in one location. Alternatives for the Environmental Services Building include siting it onsite along Embarcadero Road, siting it offsite at a building adjacent to the RWQCP, or expanding the Operations Building around the building's perimeter moat.

It is recommended for the Operations Building, which currently houses the laboratory, to be remodeled following removal of the laboratory to accommodate larger locker rooms, a training/conference room, and lunchroom. It is recommended that the Maintenance Building be remodeled to better accommodate the maintenance staff office and electrical bench needs, as well as to expand the Warehouse for additional storage space.

A summary of the recommended replacement project costs is shown in Table 9.4.

Table 9.4 Summary of Recommended Support Facilities Project Costs		
Project	**Project Start Date**	**Estimated Project Cost, millions**
Laboratory and Environmental Services Building	2014	$17.9
Remodel Operations Building	2023	$3.3
Expand Warehouse	2029	$1.6
Remodel Maintenance Building	2034	$1.7
	Total	**$24.5**

9.3.4 Rehabilitation Projects

Needs for rehabilitation of existing facilities and replacement of equipment were identified in Chapter 5 of the Report and are driven by aging infrastructure that is reaching the end of its useful life over the planning horizon. Overall recommendations for rehabilitation include:

- **Primary, secondary, and tertiary treatment**: Rehabilitation of the existing major liquid treatment processes including equipment replacement and structural/concrete repair for the primary sedimentation tanks, fixed film reactors, aeration basins, secondary clarifiers, and dual media filters.
- **Miscellaneous power and piping**: Rehabilitation/replacement of pumps, in-plant piping, and electrical/power support facilities such as MCCs and generators.
- **Joint influent sewer**: Rehabilitation of the influent joint interceptor sewer line and the outfall should follow an evaluation of the estimated existing and future wet weather flows.

Many of the rehabilitation projects are small and should be grouped together during execution. For the purposes of this Report, most projects are grouped together by process area. A summary of the recommended rehabilitation projects is shown in Table 9.5.

Table 9.5 Summary of Recommended Rehabilitation Projects

Project	Project Start Date	Estimated Project Cost, millions
Electrical/Power/Support Facilities	2012	$2.8
Primary Sedimentation Tanks Structure	2014	$7.3
In-Plant Piping	2014	$2.1
Collection System Modeling	2015	$0.5
Secondary Clarifiers Structure	2015	$1.5
Dual Media Filter Equipment	2016	$0.5
Dual Media Filter Structure	2016	$0.6
Fixed Film Reactors Structure and Equipment	2017	$19.4
Sludge Thickeners Structure	2017	$1.0
Sludge Thickeners Equipment	2017	$1.5
Aeration Basins Equipment	2019	$1.7
Aeration Basins Structure	2019	$2.5
Secondary Clarifiers Equipment	2021	$6.1
Joint Interceptor Sewer	2022	$30.8
	Total	**$77.7**

9.3.5 Future Regulatory Requirement Projects

Future regulations for total nitrogen and emerging contaminants removal are expected for Bay discharges over the 50-year planning horizon. This Report has identified treatment alternatives to meet the anticipated regulations, developed cost estimates to build those facilities, and has reserved space if new facilities are needed. Chapter 8 summarizes the liquid treatment alternatives to meet the identified future regulations. The lowest cost alternative for removal of total nitrogen was to add denitrification filters onto the existing liquid treatment processes. For removal of emerging contaminants, an advanced oxidation step (i.e., ozonation) was considered and the costs and space needs were estimated. Overall recommendations from Chapter 8 include:

- Continue use of and investment in existing liquid treatment processes. Cost for rehabilitating existing facilities that are also required for meeting future regulatory requirements are included in the rehabilitation projects.
- Participate in ongoing regional efforts to better characterize the water quality issues in the San Francisco Bay by participating in effluent and receiving water quality data collection, including the March 2, 2012 RWQCB Water Code Section 13267 technical report order requiring submittal of information on nutrients in wastewater discharges. Data provided under this order, along with data from all other Bay area dischargers, will serve as a tool for the RWQCB and the San Francisco Estuary Institute (SFEI) to understand nutrient loadings within the Bay. Data will include some historical and monthly sampling, testing, and reporting for the next two years.
- Participate in ongoing regulatory discussions regarding nutrients in the Bay and the benefits and impacts of moving toward advanced nutrient removal. Impacts of nutrient removal with current technologies include increased energy use and greenhouse gas emissions. Engage in discussions regarding how nutrients would be regulated (on an annual or monthly basis) as this has an impact on sizing treatment facilities. Continue efforts to reduce nutrient nonpoint sources from entering local creeks and Bays.
- Participate in discussions and efforts to reduce nutrients to the Bay through non-point source control in the watershed.
- Plan for the space and costs of nutrient removal and advanced oxidation facilities should the facilities be required.
- Continue to track other regulatory development for emerging contaminants and other pollutants of concern.
- Continue to track emerging technologies and revisit process decisions when and if nutrient removal and/or emerging contaminant removal are needed.

A summary of the recommended future regulatory project costs is shown in Table 9.6. There is regulatory uncertainty associated with both the denitrification project for nitrogen removal and the ozonation project to meet CEC removal. Therefore both projects were given a late start date, but actual implementation would be regulatory or policy driven.

Table 9.6 Summary of Recommended Future Regulatory Project Costs

Project	Project Start Date	Estimated Project Cost, millions
Trickling Filter/Activated Sludge/Denitrification Filters(1)	2028	$49.4
Ozonation	2045	$20.0
	Total	**$69.4**

Notes:
(1) The costs included here do not include the cost for the Trickling Filter rehabilitation. This cost is included under the Rehabilitation projects. The cost here reflects the costs associated with new facilities only.

9.3.6 Future Recycled Water Projects

Recycled water demands and facility needs were discussed in Chapters 3, 5, and 8. While the existing recycled water facilities are sufficient for current demands, it was found that additional storage and pumping are required to provide service to future users. In addition, the existing recycled water filters, chlorine contact tank and storage basins are aging and in need of replacement, as discussed in Section 9.3.3.

To expand the recycled water market, it has been identified that the recycled water quality needs to be lower in salts (i.e., total dissolved solids or TDS) to be protective of some of the landscaping needs. The City of Palo Alto and the RWQCP Partners have set a goal of reducing TDS from the existing average TDS of 917 mg/L to 600 mg/L. Source control measures, such as sewer lining, are being implemented to reduce intrusion of salty Bay water into the system. If these measures do not prove successful, salt reduction facilities consisting of ultrafiltration and reverse osmosis (UF/RO) can be implemented at the RWQCP site.

Recommendations for recycled water projects include:

- Replacement of filters and chlorine contact tanks, as identified under replacement projects.
- Construction of new storage facilities and booster pumps to expand capacity for peak flow demands.
- Implementation of source control measures to reduce influent TDS and, in turn, reduce TDS in the recycled water.

- If source control is unsuccessful, reserve space and funds for implementing UF/RO facilities.

A summary of the recommended recycled water project costs is shown in Table 9.7. Due to the uncertainty associated with the need for the reverse osmosis project for salinity reduction, it was given a late start date, but actual implementation would be policy driven.

Table 9.7 Summary of Recommended Recycled Water Projects

Project	Project Start Date	Estimated Project Cost, millions
Storage Tank and Booster Pump Station	2030	$14.3
Ultrafiltration/Reverse Osmosis	2050	$62.4
	Total	**$76.7**

9.3.7 Other Recommendations

The RWQCP currently tests for approximately 70 different parameters at 10 different (main process) sample stream locations. This monitoring allows for a very good assessment of the performance of most unit processes. However, there was additional special sampling required as part of this LRFP to better assess the performance of specific process units. It is recommended that SVI, primary sludge, filter backwash, gravity thickener overflow, incinerator belt press filtrate, and scum hopper overflow samples be included in the regular sampling schedule so that performance evaluations on these units can be trended, and thickening and dewatering capture rates can be more accurately calculated in the future.

Additionally, because of the emphasis on solids treatment in this LRFP and the impact that sludge flows can have on the treatment train capacity, it is also recommended that a flow meter be installed on the primary sludge stream to the gravity thickeners to better determine the solids capture and a more accurate solids balance around the solids handling equipment. The sludge density meter on the blend tank discharge should be replaced with a more reliable instrument; a more reliable and accurate meter is needed to better understand solids loadings that will be used in the projections for the Solids Facility Plan.

9.3.8 Site Plan for Recommended Facilities

Space has been allocated on the RWQCP site for each category of projects that have been recommended. It is important to reserve space not just for the facilities that are needed in the near term, but also for potential future needs. Figure 9.1 shows the overall RWQCP site plan with space reserved for future projects.

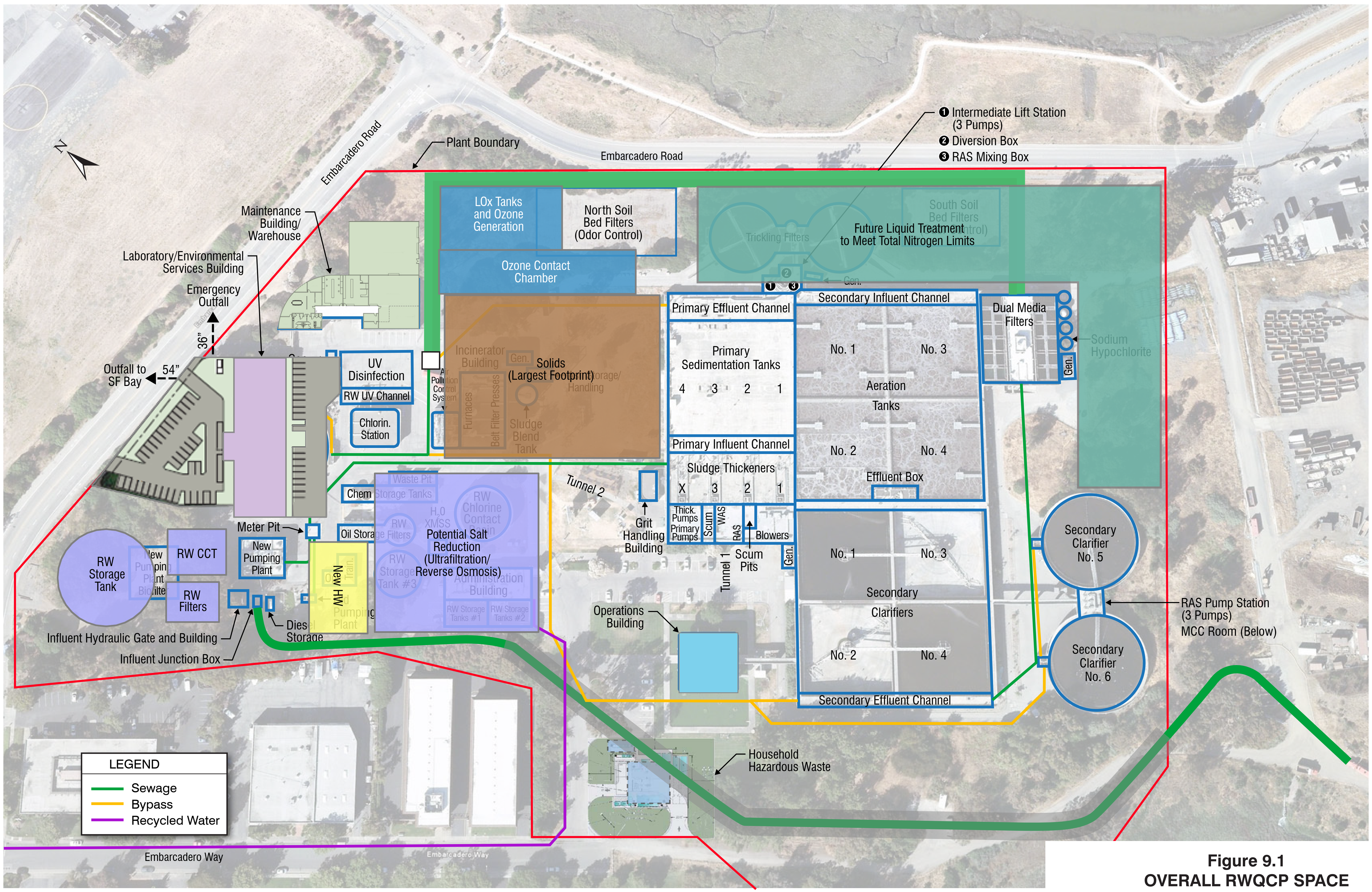


Figure 9.1
OVERALL RWQCP SPACE REQUIREMENTS FOR FUTURE FACILITIES
LONG RANGE FACILITIES PLAN FOR THE RWQCP
CITY OF PALO ALTO

pa512f13-8510.ai

9.3.9 Summary of Overall Costs for Recommended Facilities

The recommendations discussed in the previous sections of this chapter result in a significant investment in projects at the RWQCP over the next 50 years. However, many projects, such as reverse osmosis to remove salts from recycled water or ozonation to meet emerging contaminants regulations, may not be implemented in the future unless required by regulatory changes or deemed needed per policy decisions. In addition, a final decision has not been made on which solids handling process should be implemented, which has a large impact on the overall capital improvement project (CIP) program cost estimates. A summary of the total costs for the recommended facilities over the 50 year planning horizon is shown in Table 9.8. Figure 9.2 shows the percent contribution of the major project categories to the overall CIP program, including the most expensive solids handling project (i.e., anaerobic digestion), ozonation for removal of emerging contaminants, and UF/RO for removal of salt from recycled water.

Table 9.8 Summary of Recommended Project Costs

Project	Estimated Project Cost, millions
Solids Handling Projects	$13M - 89M
Replacement Projects	$54M
Rehabilitation Projects	$78M
Support Facilities Project	$25M
Future Regulatory Requirement Projects	$69M
Future Recycled Water Projects	$77M
Total	**$315 - 392M**

9.4 IMPLEMENTATION PLAN

The recommended projects for this LRFP are spread over the 50-year planning horizon and some projects are dependent on either a policy decision or a regulatory directive. For the purposes of long term CIP planning, a schedule for implementation of the recommended projects was developed with the best available information and input from City staff. The schedule for implementation is shown in Figure 9.3.

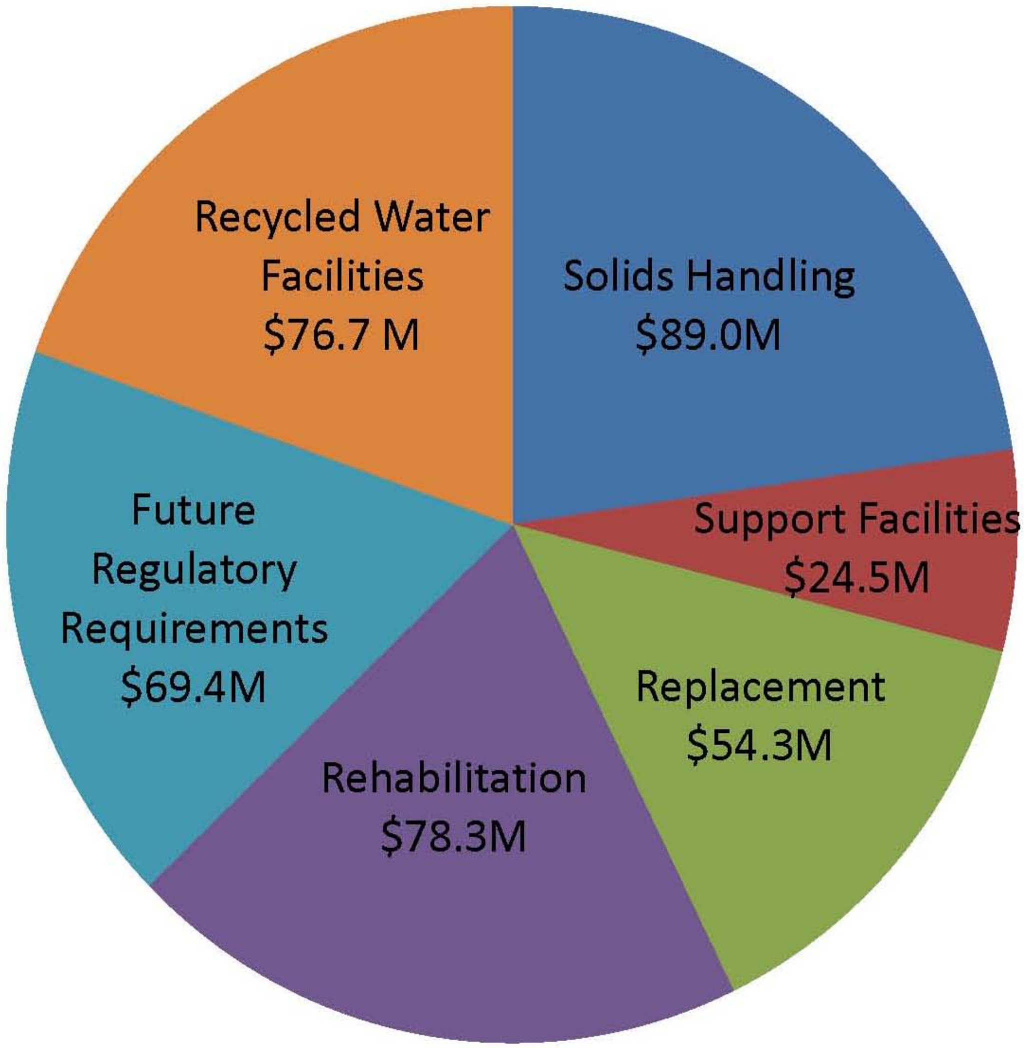


Figure 9.2 Contribution and Cost of Major Project Categories to Overall CIP Program

For the purposes of implementation, the projects have also been divided into three (3) main categories: Major CIP (larger capital cost projects that are required), Minor CIP (smaller capital cost projects that are required and can be done under the existing plant annual CIP budget) and Future Major CIP (may be required in the future based on some potential regulatory requirement). Figure 9.4 shows the contribution of the major CIP categories to the overall CIP program, including the most expensive solids handling project (i.e., anaerobic digestion), ozonation for removal of emerging contaminants, and UF/RO for removal of salt from recycled water.

9.4.1 Cash Flow

The costs for implementation of all the identified projects over the 50-year horizon are $392 million, assuming costs for anaerobic digestion for the solids project. However, as many of these projects may not be constructed until directed by a regulatory authority or the City Council, the costs for the recommended Major CIP is $218 million assuming anaerobic digestion or $141 million assuming the BAB2E solids project. Clearly, the decision on solids process has a major impact on the overall CIP costs.

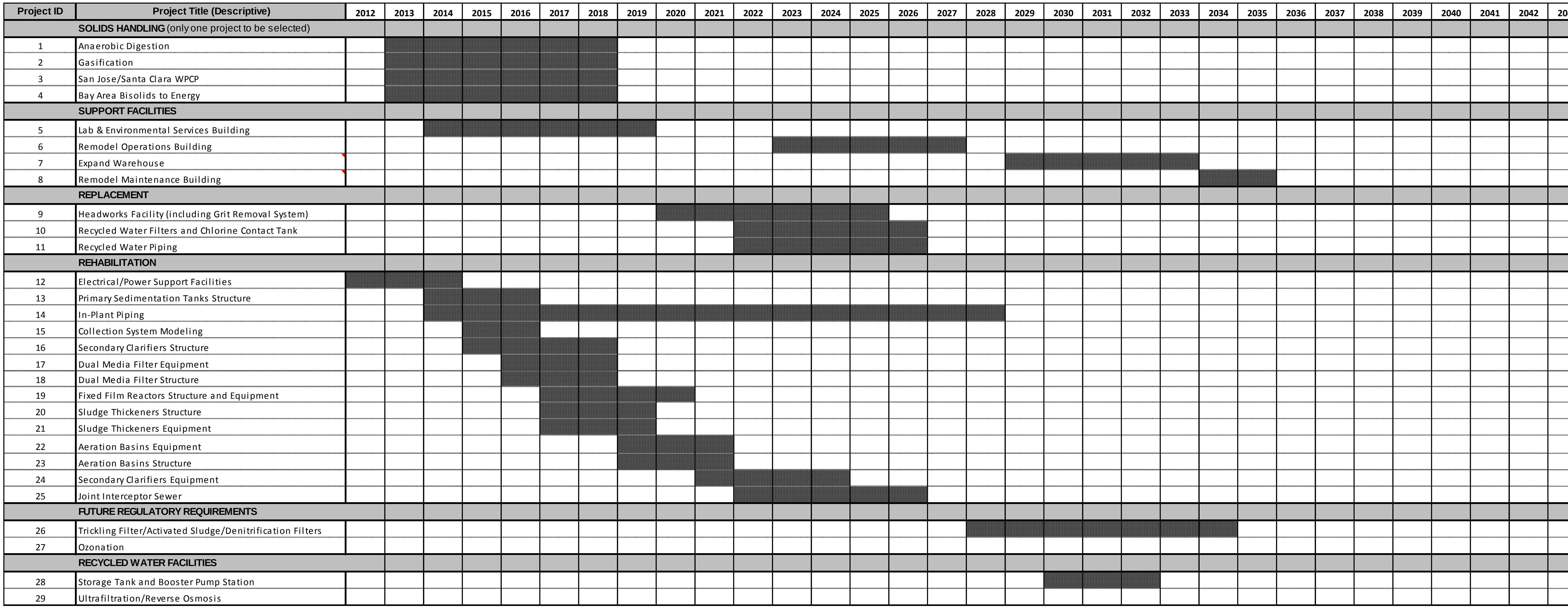
Many of the identified projects are smaller rehabilitation projects that will be funded through the existing RWQCP ongoing CIP budget that is funded by the partner agencies' contributions of $2.6 million/year (in 2011 $) adjusted annually by an inflation index, which has been averaging about 2.6%.

Larger CIP projects identified will require funding through other mechanisms such as State Revolving Fund (SRF) loans, or bonds. Figure 9.5 shows the overall cash flow for all projects identified in the CIP program regardless of the funding source based on the schedule of implementation presented in Figure 9.3.

9.4.2 Operations and Maintenance Costs

The RWQCP O&M costs were developed for each alternative based on the process components. Only the O&M costs for the recommended alternative are shown in the cash flow summary (Appendix T). For the solids alternatives, anaerobic digestion was used as the recommended project for the purposes of developing an O&M estimate. For the liquids alternatives, trickling filters, activated sludge and denitrification filters was used as the recommended project. Current O&M costs provided by the City were projected based on flow projections until either the solids or liquids project is implemented.

Figure 9.3 Schedule for Implementation of Recommended Projects



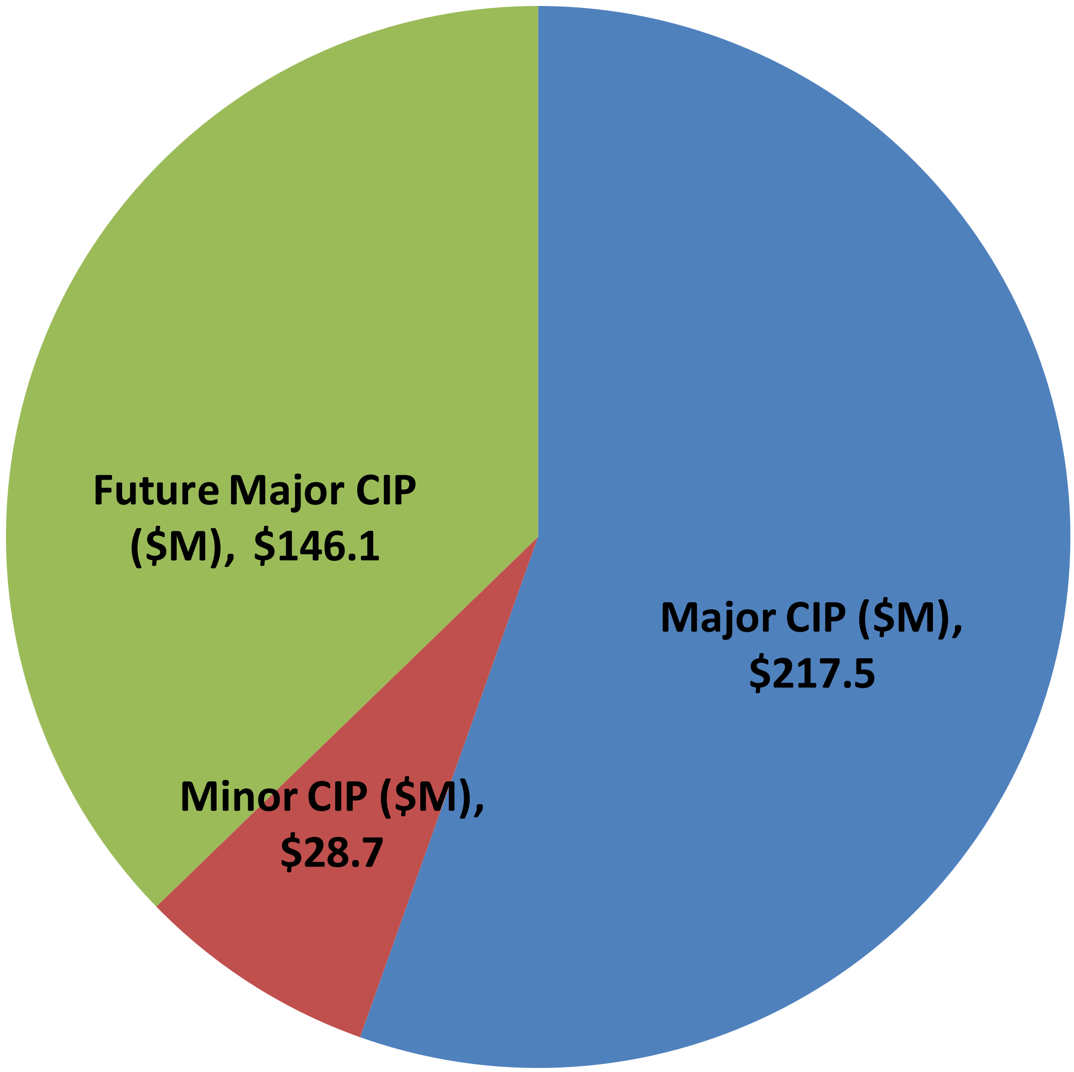


Figure 9.4 Contribution and Cost of Major CIP Categories to Overall CIP Program

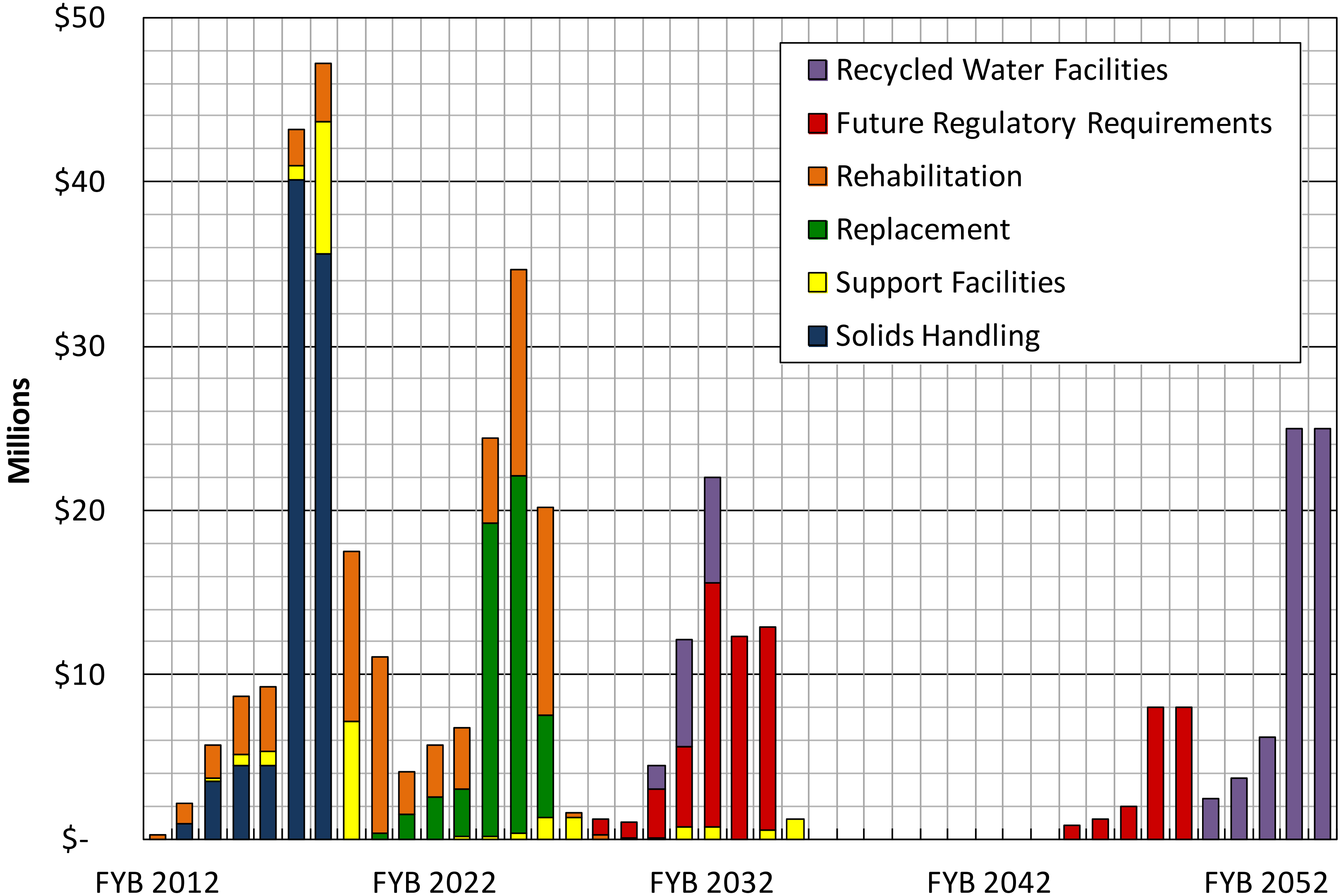


Figure 9.5 Cash Flow for the Major Project Categories of CIP Program from 2012 through 2062

The RWQCP currently expends approximately $12.8 million for its O&M expenses, this is not including costs associated with administration, engineering and pretreatment and source control. Appendix T presents the O&M cost projection for the RWQCP for both solids and liquids alternatives.

Figure 9.6 shows the projected incremental increase in O&M costs from 2015 through 2045. The O&M costs were estimated based on existing treatment for both solids and liquids staring in 2015, new anaerobic solids digestion with cogeneration facilities in 2019, and with no change to the liquids treatment over the selected period. Based on this scenario there is an anticipated decrease in plant O&M in 2019 once anaerobic digestion comes on line due to the offset of energy production with the cogeneration facilities. The O&M is then expected to increase as flow to the RWQCP increases.

9.4.3 Total Annual Cost Projection

A total annual cost projection was developed to help determine financing options and categorization into the groupings discussed above. This total annual projection was developed by combining the estimated annual capital costs for the recommended CIP and the estimated annual O&M costs. Based on the total annual cost projection, The CIPs identified in Section 9.3 above were divided into groupings based on three (3) pay approaches to the capital projects needed:

- Minor CIP - Pay as you go
- Major CIP - Debt service/grants and loans
- Future Major CIP - No firm timeline and no funding defined.

Each one of these CIP categories will be funded and planned for differently.

9.4.3.1 Minor CIP Projects

The projects that were placed on the minor CIP list were smaller projects that could be accommodated within the RWQCP's existing funding structure for small CIP items. Presently, all the partners contribute money for an annual CIP budget in the amount of $2.6 million (for 2011). This annual CIP budget is allowed to increase each year based on inflation index. The assumption used for determining which projects could fit within this annual CIP budget is that this annual budget will increase to $2.8 million in 2015. Projects were evaluated for expenditures over their anticipated project duration. The RWQCP staff did not want to use all of the annual budget for planned projects but instead wanted to leave at least $0.5 M for other projects. The RWQCP has other energy and process efficiency projects that they would like to continue implementing as well as certain periodic repair and replacement needs that would need to be met with this minor CIP budget. Table 9.9 shows the projects that fall into the minor CIP budget.

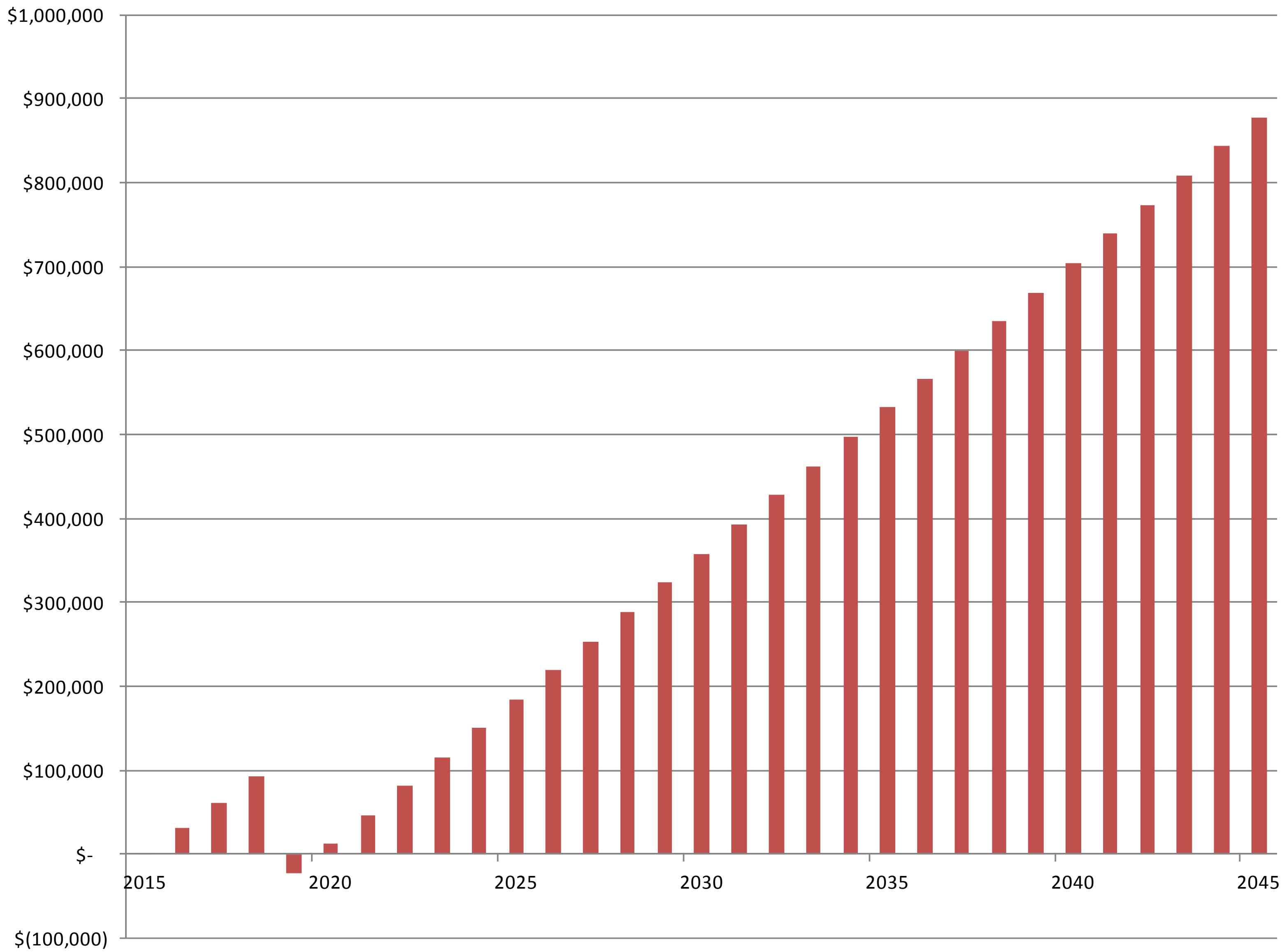


Figure 9.6 Incremental O&M Costs from 2015 through 2045 (in 2015 $)

Table 9.9 Summary of Minor Projects				
Project Title	Project Start Year	Project Duration	Year On-line	Total Project Cost ($M)
Remodel Operations Building	2023	5	2028	3.3
Expand Warehouse	2029	4	2033	1.6
Remodel Maintenance Building	2034	2	2036	1.7
Recycled Water Piping	2022	5	2027	1.3
Electrical/Power Support Facilities	2012	3	2015	2.8
In-Plant Piping	2014	15	2029	2.1
Collection System Modeling	2015	2	2017	0.5
Secondary Clarifiers Structure	2015	4	2019	1.5
Dual Media Filter Equipment	2016	3	2019	0.5
Dual Media Filter Structure	2016	3	2019	0.6
Sludge Thickeners Structure	2017	3	2020	1.0
Sludge Thickeners Equipment	2017	3	2020	1.5
Aeration Basins Equipment	2019	3	2022	1.7
Aeration Basins Structure	2019	3	2022	2.5
Secondary Clarifiers Equipment	2021	4	2025	6.1
			Total	**28.7**

9.4.3.2 Major CIP Projects

The projects which were too large to be implemented within the annual CIP budget were termed Major CIP projects. The Major CIP projects will need to be funded via means that are more traditional. Table 9.10 shows the projects that fall into Major CIP grouping. Funding for these projects is discussed in more detail in the following section.

9.4.3.3 Future CIP Projects

The Future CIP project grouping includes those projects that will be regulatory or policy driven. Currently no funding is planned for these projects. Future CIP projects are shown in Table 9.11.

Section 9.5 presents the funding alternatives that are available to the City. As discussed in this section, the RWQCP has several financing instruments available to pay for the implementation of the CIP projects. It is assumed that the RWQCP will cash finance the capital projects using revenues from rates, SRF funds and alternate financing mechanisms. Figure 9.7 shows the projects that would need these alternate funding mechanisms and have been separated into two categories: (1) the must do category (Major CIP) (2) and do not have to do category (Future Major CIP).

Table 9.10 Summary of Major Projects

Project Title	Project Start Year	Project Duration	Year On-line	Total Project Cost ($M)
Anaerobic Digestion	2013	6	2019	$89.0
Laboratory and Environmental Services Building	2014	6	2020	$17.9
Headworks Facility (including Grit Removal System)	2020	6	2026	$38.9
Recycled Water Filters and Chlorine Contact Tank	2022	5	2027	$14.2
Primary Sedimentation Tanks Structure	2014	3	2017	$7.3
Fixed Film Reactors Structure and Equipment	2017	4	2021	$19.4
Joint Interceptor Sewer	2022	5	2027	$30.8
			Total	**$217.5**

Table 9.11 Summary of Future Major Projects

Project Title	Project Start Year	Project Duration	Year On-line	Total Project Cost ($M)
Trickling Filter/Activated Sludge/Denitrification Filters	2028	7	2035	$49.4
Ozonation	2045	5	2050	$20.0
Storage Tank and Booster Pump Station	2030	3	2033	$14.3
Ultrafiltration/Reverse Osmosis	2050	5	2055	$62.4
			Total	**$146.1**

9.5 FUNDING OPTIONS

The adequate funding of capital projects is a primary constraint in project implementation. The RWQCP has several funding options available for the financing of its projects. The term "funding" refers to the method of collecting funds; the term "financing" refers to methods of addressing cash flow needs. The following sections provide examples of several instruments that can be utilized to fund the CIP capital costs.

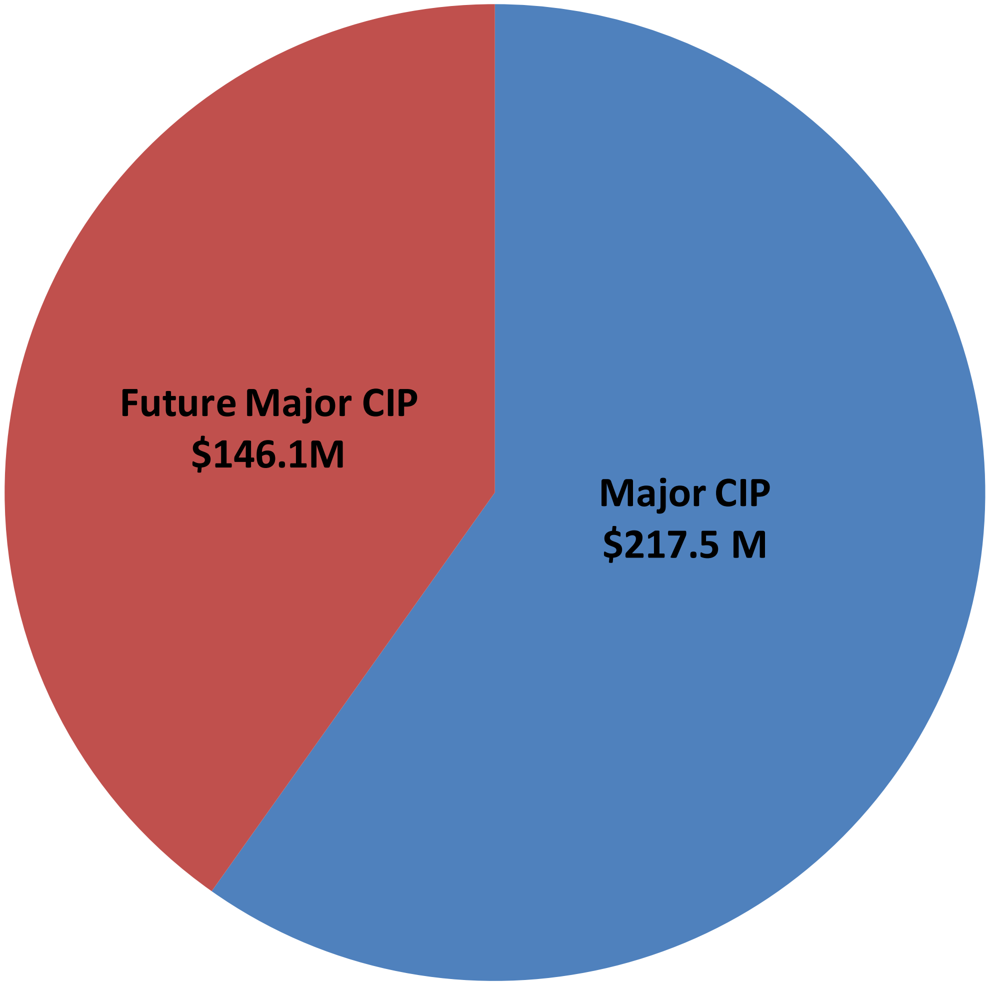


Figure 9.7 Cost of Major and Future Major CIP Categories to Overall CIP Program

9.5.1 CIP Cost Recovery

Rarely does a city or an agency have sufficient revenue to fund large capital improvements directly from user fees, which is the case with pay-as-you-go financing. Therefore, it is common to use financing instruments to meet necessary funding requirements. The main financing instruments available to the RWQCP for funding the capital costs include:

- Pay-as-you-go financing
- Debt financing
- Grants and loans

Pay-as-you-go financing refers to upfront collection of project costs from existing and new users for future capital improvement projects. Pay-as-you-go financing generally requires large rate increases and creates cash flow problems. This method can be used with smaller CIP projects.

Debt financing refers to the acquisition of funds through borrowing mechanisms. Debt financing requires the borrower to raise money for working capital or capital expenditures by selling bonds, bills, or notes to individual and/or institutional investors. In return for borrowed money, the individuals or institutions become creditors and receive a promise to repay principal and interest on the debt.

Grants and loans provide an alternate source of funds at no or minimal cost. Federal, State, and local grants provide funding at no cost for projects that meet select criteria. Grant funding is limited and is generally not a long-term solution to meet financing needs. State and Federal loan programs provide low-cost methods of borrowing for projects that meet select criteria. Most projects receiving grant and loan funding generally will need to secure supplemental funding sources.

All of these funding sources are discussed in additional detail in the following sections.

9.5.2 Pay-As-You-Go Financing

Pay-as-you-go financing involves periodic collection of capital charges or assessments from customers within the municipality's jurisdiction for funding future capital improvements. These revenues are accumulated in a capital reserve fund and are used for capital projects in future years. Pay-as-you-go financing can be used to finance 100 percent or only a portion of a given project.

One of the primary advantages of pay-as-you-go financing is that it avoids the transaction costs (e.g., legal fees, underwriters' discounts, etc.) associated with debt financing alternatives, such as revenue bonds. However, there are two common disadvantages associated with this method.

First, it is difficult to raise the required capital within the allowable time without charging existing users elevated rates. Second, it may result in inequities in that existing residents would be paying for facilities that would be utilized by, and benefit, future residents.

Several existing funding sources can be utilized to pay-as-you-go finance the project costs. These are the current fees, existing general funds, existing reserve funds, and connection fees.

The City has an existing annual CIP budget of $2.6 million that escalates according the Consumer Price Index rate (currently averaging 2.6 percent). While it is possible to fund small CIPs through this annual CIP, capital expenditures exceeding this value will need to be financed through other mechanisms.

9.5.2.1 Utility Fees and Benefit Assessment Fees

Utility fees or benefit assessments, sometimes called service fees or user fees, consist of a fee imposed on each property in proportion to the service provided to that property. Benefit assessment fees are usually included as a separate line item on the annual property tax bill sent to each property owner.

Utility fees are usually billed on a monthly or bi-monthly interval. In all other respects, benefit assessments, utility fees, and service charges are essentially identical. A utility has the authority to collect a benefit assessment fee, but only after approval by a majority of the voters, affected property owners, or rate payers.

9.5.2.2 General Fund

The City’s general fund is one type of fund available if not earmarked by law for a specific purpose. In Palo Alto, general fund money comes largely from hotel tax, title transfer taxes, property taxes, and sales taxes. The demand for general funds by other city functions (e.g., police / fire) will exceed the supply available for wastewater treatment expenses, and therefore, these funds are not considered available for these projects.

9.5.2.3 Development Charges/Connection Fees

The system development charges/connection fees/impact fees represent the cost of providing regional conveyance and treatment facilities to serve the new recycled water customers. They are one-time fees charged to customers at the time of system connection approval or permit/contract issuance. The charges for individual properties may be based on whatever assessment measures the City desires for equity.

A disadvantage to utilizing impact fees is that the fees cannot be collected until the system constructions permit stage at the earliest. The amount collected each year depends solely on the rate of growth of the City. Consequently, funds may not be available to construct new capacity at the time it is needed.

9.5.3 Debt Financing

There are several different options for debt financing of wastewater and recycled water projects, such as issuance of bonds. Bonds used for financing public works projects are generally local government tax-exempt bonds.

9.5.3.1 Revenue Bonds

Revenue bonds are historically the principal method of incurring long-term debt. This method of debt obligation requires specific non-tax revenues pledged to guarantee repayment. Because non-tax revenues, such as user charges, facility income, and other funds are the bondholder’s sole source of repayment, revenue bonds are not considered general obligations of the issuer. Revenue bonds are secured solely by a pledge of revenues. Usually the City’s revenues are derived from the facility that the bonds are used to acquire, construct, or improve. There is no legal limitation on the amount of authorized revenue bonds that may be issued, but from a practical standpoint, the size of the issue must be limited to an amount where annual interest and principal payments are well within the revenues available for debt service on the bonds. Revenue bond covenants generally include coverage provisions, which require that revenue from fees minus operating expenses be greater than debt service costs.

9.5.3.2 Certificates of Participation

Certificates of participation provide long-term financing through a lease agreement that does not require voter approval. The legislative body of the issuing agency is required to approve the lease arrangement by a resolution. The lesser may be a redevelopment agency, a non-profit organization, a joint powers authority, a for-profit corporation or other agency. The lessee is required to make payments typically from revenues derived from the operation of the leased facilities. The amount financed may include reserves and capitalized interest for the period that facilities will be under construction. One disadvantage with certificates of participation, as compared with revenue bonds, is that interest rates can be slightly higher than with revenue bonds due to the insecurity associated with the obligation to make lease payments.

9.5.3.3 General Obligation Bonds

General obligation (GO) bonds are municipal securities secured by the issuer’s pledge of its full faith, credit, and taxing power. GO bonds are backed by the general taxing authority of local governments and are often repaid using utility revenues when issued in support of a sewer or water enterprise fund.

9.5.3.4 <u>Assessment District Bonds</u>

Financing by this method involves initiating assessment proceedings. Assessment proceedings are documents in “Assessment Acts” and “Bond Acts”.

An assessment act specifies a procedure for the formation of a district (boundaries), the ordering, and making of an acquisition or improvement, and the levy and confirmation of an assessment secured by liens on land. A bond act provides the procedure for issuance of bonds to represent liens resulting from proceedings taken under an assessment act. Procedural acts include the Municipal Improvements Acts of 1911 and 1913. The commonly used bond acts are the 1911 Act and the Improvement Bond Act of 1915. The procedure most prevalent currently is a combination of the 1913 Improvement Act with the 1915 Bond Act. Charges for debt service can be included as a special assessment on the annual property tax bill. The procedure necessary to establish an assessment district may vary depending on the acts under which it is established and the district size.

9.5.4 Grants and Loans

Several grant and loan programs can be utilized to finance wastewater projects. The grant and loan options include State funded programs such as the SRF and Federal programs such as grants and loans through the Environmental Protection Agency (EPA) and US Bureau of Reclamation (USBR). There are program websites that provide the most up to date information for each of these grants and loans. It is possible that some of these grant and loan programs are discontinued and/or that new programs become available.

The advantage of these grant and loan programs is the lower cost of borrowing. However, these grant and loan programs are highly competitive and dependent upon State and Federal budget cycles.

9.5.4.1 <u>The Clean Water State Revolving Fund (CWSRF) Funding</u>

The Clean Water State Revolving Fund (CWSRF) program, established by the Federal Water Pollution Control Act (Clean Water Act or CWA), offers low interest loans for water quality projects. Annually, the program disburses between $200 and $300 million to eligible projects. Eligible projects include construction of publicly-owned facilities such as wastewater treatment facilities and water reclamation facilities. Any city, town, district, or other public body created under state law is eligible to apply for the CWSRF loan. Interest rate is ½ of the most recent General Obligation (GO) Bond Rate at time of Preliminary Funding Commitment. The current rate is 2.2 percent. The RWQCP has utilized the CWSRF loans for two of its projects in recent years – the MV/Moffett area recycled water pipeline project and the UV disinfection facility project. The interest rate for the MV/Moffett RW pipeline was 1.6 percent, and the rate for the UV disinfection facility project was 2.6 percent.

The financing Term is 20 years with a maximum $50 million per agency per year. A project may be of a multiple year duration so long as the expenses and reimbursements do not exceed the maximum $50 million per year limit. Repayment of the loan would begin one year after completion of the construction. The CWSRF loan is a reimbursement loan and would reimburse eligible expenses for project planning, design, and construction.

All proposed projects must be placed on the CWSRF competitive project list. Project placement and application is a continuous open process. Projects on the list are classified by categories as follows:

I. Treatment and delivery of treated wastewater or ground water for uses to offset State water supply and benefits the Delta.

II. Treatment and delivery of treated wastewater or ground water for uses to offset State water supply.

III. Treatment and delivery of treated wastewater for uses to offset local water supply

IV. Treatment and delivery of treated ground water for uses to offset local water supply

V. Construction of wastewater treatment facilities

VI. Miscellaneous

Wastewater treatment facilities would be classified as category V, which has a lower priority. However, it was rare that an eligible project with a properly prepared and qualified application be turned down for the SRF loan.

9.6 DEBT SERVICING

The debt incurred for any CIP projects will be serviced by the City of Palo Alto and its partners. For capital projects, the partner allocations will be determined for each project based on whether the project is a sewer or wastewater treatment plant project.

9.6.1 Capital Projects Debt Servicing Estimates

The minor CIP of $2.6M (in 2011 $) is made of contributions by the partners and as a result any projects that are completed under the minor CIP budget is already allocated to the contributing partners. Major CIP projects that will require funding will need to be paid for by the City of Palo Alto and its partners. Table 9.12 shows the aggregate estimated debt service for the projects on the Major CIP list for both Bonds and SRF funding. For Revenue Bonds, a 30-year repayment period at 4.56 percent interest was assumed. For an SRF loan, a 20-year repayment period at 2.6 percent interest was assumed.

Table 9.12 Summary of Estimate of Aggregate Debt Service for Major CIP

Year	Revenue Bond(1)	SRF Payment(2)
2013	$-	$-
2014	$452,343	$-
2015	$452,343	$-
2016	$5,959,800	$-
2017	$6,969,801	$473,551
2018	$8,171,044	$473,551
2019	$8,171,044	$6,239,223
2020	$8,171,044	$7,296,577
2021	$8,171,044	$8,554,140
2022	$8,171,044	$8,554,140
2023	$10,574,506	$8,554,140
2024	$13,358,522	$8,554,140
2025	$13,358,522	$8,554,140
2026	$13,358,522	$11,070,287
2027	$13,358,522	$13,984,831
2028	$13,358,522	$13,984,831
2029	$13,358,522	$13,984,831
2030	$13,358,522	$13,984,831
2031	$13,358,522	$13,984,831
2032	$13,358,522	$13,984,831
2033	$13,358,522	$13,984,831
2034	$13,358,522	$13,984,831
2035	$13,358,522	$13,984,831
2036	$13,358,522	$13,984,831
2037	$13,358,522	$13,511,281
2038	$13,358,522	$13,511,281
2039	$13,358,522	$7,745,608
2040	$13,358,522	$6,688,254
2041	$13,358,522	$5,430,691
2042	$13,358,522	$5,430,691
2043	$13,358,522	$5,430,691
2044	$12,906,180	$5,430,691

Table 9.12 Summary of Estimate of Aggregate Debt Service for Major CIP		
Year	**Revenue Bond[(1)]**	**SRF Payment[(2)]**
2045	$12,906,180	$5,430,691
2046	$7,398,722	$2,914,544
2047	$6,388,722	$-
2048	$5,187,478	$-
2049	$5,187,478	$-
2050	$5,187,478	$-
2051	$5,187,478	$-
2052	$5,187,478	$-
2053	$2,784,017	$-

Notes:
(1) Bonds are based on a 30 year repayment period at 4.56 percent interest.
(2) SRF loan is 20 year repayment period at 2.6 percent interest.

In addition, there is existing debt for major projects already completed. These projects include:

1. 1999 Refunding of 1990 Utility Revenue Bonds
2. 1999 Incinerator Rehabilitation Revenue Bonds
3. CPA, CMV / Moffett Area Reclaimed Water Pipeline Project SRF Loan
4. UV Disinfection Facility SRF Loan

Appendix U shows a summary of the Wastewater Treatment Fund existing and aggregate debt service. Figure 9.11 shows the total aggregate debt service required for the existing and major CIP as well as the minor CIP.

9.6.2 Partner Cost Allocation

The share that the partners will need to contribute to each project will be determined by the project type and will be based on flow and/or load allocations. The percentage allocations are different for sewer and wastewater projects and these allocations along with the cost share to each partner for each major CIP project is shown in Table 9.13 below. The amount to be contributed by each partner will also depend on the type of funding that is secured and the interest rate and payment period. The contributions required by each partner agency for the Major CIP projects for both Revenue Bonds and SRF loans are presented in Appendix U.

Costs for projects are planning level estimates and do not consider potential measures for cost control. As each project moves forward, a more detailed analysis will be performed and cost saving measures will be explored. For example, the first major project will be the solids project, which will be evaluated in more detail during preparation of the Solids Facility Plan (to be prepared in 2013) and in subsequent predesign and design efforts. Partner agencies will be encouraged to participate and provide input into these efforts.

Table 9.13 Summary of Preliminary Partner Cost Allocation for Major CIP Projects[(1)]

Partner Shares	Palo Alto	Mountain View	Los Altos	East Palo Alto	Stanford	Los Altos Hills
Percent Cost Share Based on Capacity						
Sewer	18.24%	62.50%	15.00%	0.00%	0.00%	4.26%
Wastewater Treatment	38.16%	37.89%	9.47%	7.64%	5.26%	1.58%
Project	**Cost Allocation in Millions**					
Solids Project (cost shown for Anaerobic Digestion)	$33.98	$33.74	$8.43	$6.80	$4.68	$1.41
Laboratory and Environmental Services Building	$7.81	$6.19	$1.55	$1.25	$0.86	$0.26
Headworks Facility (including Grit Removal System)	$14.83	$14.72	$3.68	$2.97	$2.04	$0.61
Recycled Water Filters and Chlorine Contact Tank	$5.42	$5.38	$1.35	$1.09	$0.75	$0.22
Primary Sedimentation Tanks Structure	$2.79	$2.77	$0.69	$0.56	$0.38	$0.12
Fixed Film Reactors Structure and Equipment	$7.41	$7.36	$1.84	$1.48	$1.02	$0.31
Joint Interceptor Sewer	$5.62	$19.25	$4.62	$ -	$ -	$1.31
Total	**$77.85**	**$89.41**	**$22.16**	**$14.15**	**$9.74**	**$4.24**

(1) Preliminary allocation. Cost sharing allocations and cost control measures will be evaluated in more detail for each individual project.

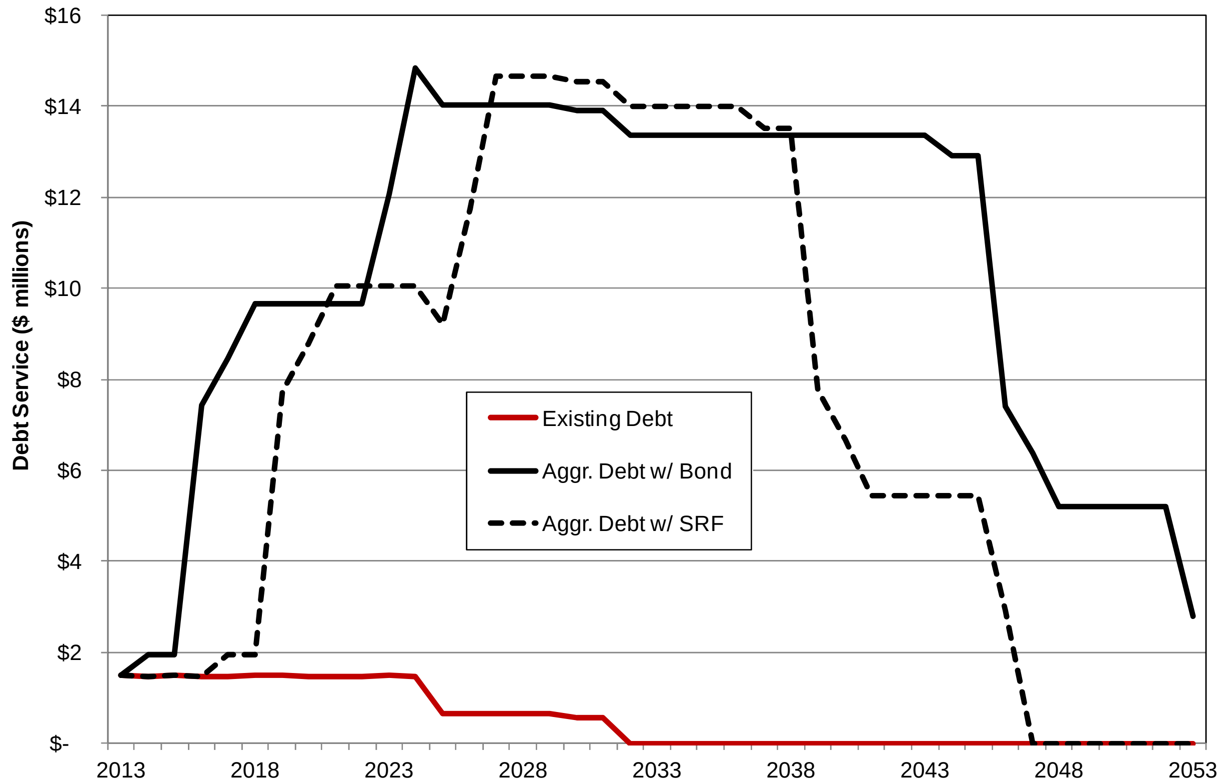


Figure 9.8 Total Aggregate Debt Service for Existing and Major CIP Programs

REFERENCES

Brown and Caldwell (April 1992) Water Reclamation Master Plan for the Regional Water Quality Control Plant.

City of Palo Alto (2010) Annual Pretreatment Report. Regional Water Quality Control Plant - Environmental Compliance Division.

City of Palo Alto (2011) Website accessed 6/22/11 http://www.cityofpaloalto.org/news/displaynews.asp?NewsID=1809&TargetID=268

Dettinger, M.D. (2005) From Climate Change Spaghetti to Climate-Change Distributions for 21st Century California. San Francisco Estuary and Watershed Science. Vol. 3, Issue 1, March 2005, Article 4.

Karl, T.R. and R.W. Knight (1998) Secular trends of precipitation amount, frequency, and intensity in the U.S.A. Bulletin of the American Meteorological Society, Vol. 79, pp. 231-241.

Kharin, V.V., and F.W. Zwiers (2005) Estimating Extremes in Transient Climate Change Simulations, Journal of Climate 18: 1156–1173.

Kharin, V.V., F.W. Zwiers, X. Zhang, and G.C. Hegerl (April 2007) Changes in temperature and precipitation extremes in the IPCC ensemble of global coupled model simulations. Journal of Climate 20:1419-1444.

Kiparsky, M. and P. Gleick (July 2003) Climate Change and California Water Resources: A Survey and Summary of the Literature. Pacific Institute for Studies in Development, Environment, and Security.

Madsen, T. and E. Figdor (2007) When it Rains, it Pours - Global Warming and the Rising Frequency of Extreme Precipitation in the United States, a report by Environment California Research & Policy Center. December.

Meehl, G. A., J. M. Arblaster, and C. Tebaldi (September 2005) Understanding Future Patterns of Increased Precipitation Intensity in Climate Model Simulations. Geophysical Research Letter, 32, L18719.

RMC (July 2006) City of Palo Alto – Recycled Water Market Survey Report.

RMC (December 2008) The City of Palo Alto Recycled Water Facility Plan.

CITY OF
PALO ALTO

2020 Sustainability and Climate Action Plan Potential Goals and Key Actions

DRAFT

Last Updated March 26, 2020

2020 SUSTAINABILITY AND CLIMATE ACTION PLAN POTENTIAL GOALS AND KEY ACTIONS

Palo Alto has long been a leader in sustainability, making impressive progress towards reducing its carbon impacts, greenhouse gas emissions, and resource consumption since adopting a Sustainability Policy[1] in 2001, reflecting the City's intention to be a sustainable community - one which meets its current needs without compromising the ability of future generations to meet their own needs. Since then, the City has undertaken a wide range of initiatives to improve the sustainability performance of both government operations and the community at large, including: adopting one of the first municipal Climate Action Plans[2] in the US in 2007; adopting a Sustainability and Climate Action Plan (S/CAP) Framework[3] in 2016, which includes an aspirational goal of reducing Greenhouse Gas (GHGs) emissions 80 percent below 1990 levels by 2030[4]; providing 100 percent carbon neutral natural gas since July 2017 — making the City of Palo Alto Utilities the first utility in the world to provide carbon neutral electricity and natural gas as a standard to all customers — having provided 100 percent carbon neutral electricity since 2013; and, in December 2017 accepting the 2018-2020 Sustainability Implementation Plan (SIP) "Key Actions" as a summary of the City's work program[5]. Sustainability is also embedded in the 2030 Comprehensive Plan[6] (adopted in 2017), with 10 goals and over 50 actions outlined in the 2030 Comprehensive Plan Implementation Plan that are explicitly or implicitly related to sustainability.

While GHG emissions reduction is not the only goal of the S/CAP, it is a major one. To achieve an 80 percent reduction target by 2030, Palo Alto will need to meet a target "GHG reduction budget" of about 224,600 MT CO2e[7]. The analyses in the 2016 S/CAP Framework (conducted in 2014-2015) projected that more than half of the needed additional reductions (117,900 MT CO2e) could come from mobility related measures, just under half (97,200 MT CO2e) from efficiency and fuel switching measures (largely in buildings), and about four percent (9,500 MT CO2e) from continuation and extension of Palo Alto's zero waste initiatives. These reduction targets are outdated and don't include recent sustainability initiatives, actions, and projects. The analyses will be revised to include current information and staff will update this document when more accurate reduction targets are established.

As a result of various City-led initiatives, programs, and activities focused on climate change and sustainability, by the end of 2018 Palo Alto had reduced GHG emissions an estimated 56.5 percent from the 1990 baseline, despite a population increase of 20.4 percent from the 1990 baseline.

---

[1] https://www.cityofpaloalto.org/civicax/filebank/documents/7856
[2] https://www.cityofpaloalto.org/civicax/filebank/documents/9946
[3] https://www.cityofpaloalto.org/civicax/filebank/documents/60858
[4] https://www.cityofpaloalto.org/news/displaynews.asp?NewsID=3534&TargetID=268
[5] https://www.cityofpaloalto.org/civicax/filebank/documents/63141
[6] https://www.cityofpaloalto.org/civicax/filebank/documents/62915
[7] MT CO2e = metric tons of CO2 equivalent

Overall, the performance of City Municipal Operations showed a 65.8 percent reduction in Scope 1 and Scope 2 emissions[8] from the 2005 baseline year.

For the City to continue progress towards its climate and sustainability goals and targets, a 2020 S/CAP Update is necessary to further study the highest impact actions to take. While the SIP focused on two key concerns—CO2 emissions and Water—and four key areas of activity: Energy, Mobility, Electric Vehicles, and Water, the 2020 S/CAP Update will include Key Actions in the following areas: Energy, Mobility, Electric Vehicles, Water, Climate Adaptation and Sea Level Rise, Natural Environment, and Zero Waste. This document outlines the proposed goals and Key Actions that will be the foundation for the 2020 S/CAP. Some of the Key Actions can be readily implemented at a staff level; some will require review and approval by Council; and some may require environmental review, including under the California Environmental Quality Act (CEQA), prior to adoption and implementation. All of the Key Actions will go through an impact analysis, which will detail the costs and benefits (including co-benefits), expected GHG remissions reductions, and sustainability benefits. In addition, in March 2019 Council approved a Sea Level Rise Adaptation Policy to provide a roadmap for creating a comprehensive Sea Level Rise Adaptation Plan, which will be incorporated into the 2020 S/CAP Update.

The City is fully committed to a sustainable future. The City owns, operates, and maintains a full-service utilities portfolio that provides electric, gas, water, and wastewater services to residents and businesses in Palo Alto. Palo Alto's continued leadership in advancing sustainability commitments has succeeded mainly because of the continued cooperation across City Departments and diverse community stakeholders, and the support of City Council. The 2020 S/CAP will be a major step forward towards the 2030 goal of 80 percent GHG reduction, which far exceeds the state of California's world-leading reduction goals of 40 percent by 2030 and 80 percent by 2050. As the rest of the country looks to California for leadership in sustainability, the City of Palo Alto will continue to lead by example.

Key Timeline Dates:

- February 2020: Council Informational Report on 2020 S/CAP Update
- March 2020: Council Approval of 2020 – 2021 Sustainability Work Plan
- March 2020: 2020 S/CAP Update Community Engagement Workshop
- April – October 2020: 2020 S/CAP topic – specific meetings
- Spring 2020: Sea Level Rise Vulnerability Assessment commences
- May 2020: Updated Business as Usual Forecast completed
- Summer 2020: Impact Analysis of 2020 S/CAP Key Actions completed
- Fall 2020: Council Study Session on 2020 S/CAP Update
- Fall 2020: 2020 S/CAP Summit to finalize goals and Key Actions
- December 2020: Draft CEQA Report completed

[8] Scope 1 and Scope 2 emissions are non-biogenic emissions that are caused by human activity. Biogenic emissions are assumed to be net carbon neutral and not reported under GHG emission reporting protocols. Scope 2 emissions from electricity were eliminated starting in 2013 by the purchase of Renewable Energy Credits (RECs) under the Carbon Neutral Plan.

- April 2021: Final CEQA Report completed
- April 2021: Sea Level Rise Adaptation Plan completed
- April 2021: Council Adopts 2020 S/CAP Update
- 2025: Update the S/CAP with further key actions
- 2030: Achieve S/CAP Goals, including 80% GHG Reduction

2020 Sustainability and Climate Action Plan GOALS

- Reduce Greenhouse Gas (GHG) emissions from the direct use of natural gas in Palo Alto's building sector by 40% below 1990 levels by 2030
- Increase Heat Pump Water Heater adoption to 25% by 2030
- Increase all-Electric homes to 20% of all residential single-family homes by 2030

- Increase active transportation mode share to 25% for local work trips by 2030
- Increase availability of transit and shared mobility services by increasing to 75% the proportion of residents within a quarter-mile walkshed of frequent transit by 2030
- Implement Complete Streets and build out the Bicycle and Pedestrian Transportation Plan

- Increase the number of EVs registered in Palo Alto, as a share of total vehicles registered, from 7% in 2018 to 50% by 2030
- Target to facilitate 50% of vehicles owned by low income households to be EVs by 2030
- Ensure there are adequate numbers and types of EV chargers in Palo Alto to support the growing number of EVs registered in and commuting to Palo Alto
- Expand the number of EVs in the City's fleet as the EV fleet market evolves

- Reduce per capita water use compared to 2019
- Increase the percentage of recycled water used (volume of recycled water/recycled water filter capacity) by 10% in 2022 compared to 2019
- Reduce the total dissolved solids by 50% compared to 2019 base year
- Manage stormwater to slow the flow to receiving waters and improve water quality to protect the SF Bay, while also treating it as a beneficial resource for alternative uses

- Develop a multi-year Sea Level Rise Adaptation Plan for Council Review by April 2021 to include a sea level rise vulnerability assessment and a community engagement strategy for plan development and implementation

- Renew, restore, and enhance resilience of our natural environment
- Maximize biodiversity and stewardship of flora, fauna, and air, soil, and water resources
- Reduce environmental impacts of our actions
- Increase tree canopy to 40% city-wide coverage by 2030
- Expand the designation of pesticide-free parks and city facilities

- Divert 95% of waste from landfills by 2030, and ultimately achieve zero waste to landfill
- Implement short- and medium-term initiatives identified in the *2018 Zero Waste Plan*

ENERGY

Building efficiency and electrification are key to achieving Palo Alto's - and California's – greenhouse gas (GHG) reduction goals. Overcoming building electrification barriers at both the local and regional level will be necessary to increase market adoption in existing buildings. Electrification - and encouraging existing buildings to upgrade to modern energy efficiency levels - may pose significant strategic and operating challenges for the City of Palo Alto Utilities (CPAU) but is an important strategy to meeting the City's aggressive GHG reduction goal.

GOALS

- Reduce GHG emissions from the direct use of natural gas in Palo Alto's building sector by 40% below 1990 levels by 2030
- Increase Heat Pump Water Heater adoption to 25% by 2030
- Increase all-Electric homes to 20% of all residential single-family homes by 2030

KEY ACTIONS

- Meet or exceed City Council-adopted energy efficiency targets
- Explore electrification of city-owned facilities with the goal of phasing out fossil fuel use in existing municipal buildings
- Phase out fossil fuel use in new and existing buildings through a combination of programs & mandates (includes partnerships and collaborations to support market transformation)
- Increase awareness and adoption of efficient electric alternatives to gas appliances and all-electric buildings through community engagement
- Implement an all-electric utility rate
- Explore opportunities to increase energy resilience (e.g. energy storage, microgrids)
- Explore the impact of building decarbonization on City's gas utility and develop mitigation strategies
- Continue to purchase carbon offsets to match natural gas emissions as a transitional measure. Evaluate potential local offset purchases

KEY PERFORMANCE INDICATORS

- GHG emissions from the building sector
- Heat Pump Water Heater plus new residential construction permits
- Number of all-Electric homes / customers on all-electric utility rate

ENERGY

Emissions from natural gas use represent about 32 percent of Palo Alto's remaining carbon footprint if we exclude PaloAltoGreen Gas offsets. The decreasing emissions of California and Palo Alto's energy supply due to renewable energy opens the opportunity to reduce natural gas use through electrification in addition to continued efficiency measures. Palo Alto will first seek to reduce natural gas usage through energy efficiency and conservation, followed by electrification of water heating, space heating, clothes drying and cooking where practical and cost effective.

MOBILITY

Road transportation represents the largest percentage of Palo Alto's existing carbon footprint – and a congestion headache. GHG emissions are a function of two factors: Vehicle Miles Traveled (VMT), addressed here, and the carbon intensity (GHG/VMT), addressed in the next section. Reducing GHG/VMT is largely driven by Federal Standards, state policy and vehicle offerings (including fuel efficiency and EVs). However, VMT and EV adoption can be influenced by local programs and policies.

GOALS

- ➲ Increase active transportation mode share to 25% for local work trips by 2030
- ➲ Increase availability of transit and shared mobility services by increasing to 75% the proportion of residents within a quarter-mile walkshed of frequent transit by 2030
- ➲ Implement Complete Streets and build out the Bicycle and Pedestrian Transportation Plan

KEY ACTIONS

- Fund the TMA with the goal of reducing SOV commute-trips downtown by 30%
- Make transit investments that significantly enhance coverage, service quality, frequency, speed and/or access
- Expand and improve bicycle and pedestrian facilities, connectivity, convenience, and/or safety in a manner that significantly increases the % of trips taken by walking or biking
- Adopt TDM Ordinance per Comp Plan Policy
- Increase the number of City Employees utilizing commute benefits
- Encourage the use of bike and/or scooter sharing, and the provision of required infrastructure throughout Palo Alto, especially at transit stations and stops, job centers, community centers, and other destinations
- Enhance traffic signals to improve traffic flow and reduce idling and associated GHG emissions
- Increase the number of bike facilities, including bike parking and signalized intersections with bicycle accommodations (e.g. bicycle signal heads, bicycle detection, colored bicycle lanes)

KEY PERFORMANCE INDICATORS

- Commute mode share for all modes
- Transit ridership and proportion of residents within a quarter-mile walkshed of frequent transit
- Commute Benefits participation by City Employees
- Miles of bikeways and number of enhanced intersections

The mobility marketplace is changing rapidly: Lyft and Uber are changing the landscape; Autonomous Vehicles are anticipated to increase in market share; and, land use and mobility interact in substantial and complex ways.

ELECTRIC VEHICLES

More than half of Palo Alto's emissions come from transportation, making adoption of Electric Vehicles (EVs) a crucial component to reaching our carbon reduction goals. Compared to fossil fuel vehicles, EVs are cheaper to drive, have lower maintenance costs, and produce no emissions. Driving and charging an EV in Palo Alto especially makes sense given the City's carbon neutral electricity supply and low electric retail rates.

GOALS

- ➲ Increase the number of EVs registered in Palo Alto, as a share of total vehicles registered, from 7% in 2018 to 50% by 2030
- ➲ Target to facilitate 50% of vehicles owned by low income households to be EVs by 2030
- ➲ Ensure there are adequate numbers and types of EV chargers in Palo Alto to support the growing number of EVs registered in and commuting to Palo Alto
- ➲ Expand the number of EVs in the City's fleet as the EV fleet market evolves

KEY ACTIONS

- Ensure that at least 75% of the community is aware of the environmental and economic benefits of electric vehicles and the programs available to them
- By 2022 quantify the public and private EV charger network needed within the community to support 50% EV penetration in Palo Alto, and develop an implementation plan to establish that charging network
- Develop programs to assist and incentivize private EV charging installations in hard to reach locations such as multifamily properties, non-profits, and small commercial sites to ensure adequate and diverse EV charging infrastructure
- By 2022, develop a strategic plan to encourage charging of inbound EVs within Palo Alto
- Continue to electrify municipal fleet as opportunities arise, and by 2021 develop a comprehensive fleet electrification workplan and associated EV charging needs

KEY PERFORMANCE INDICATORS

- EVs registered in Palo Alto
- EVs registered in low income households in Palo Alto
- Percentage of EVs in City's fleet and availability of municipal charging infrastructure
- Number and type of EV charging ports/infrastructure in Palo Alto
- Percentage reduction of transportation-related emissions due to EVs

ELECTRIC VEHICLES

Palo Alto has the highest adoption rate of Electric Vehicles (EVs) in the US, with 1 in 3 new vehicles registered as electric in 2017. Survey results show that 70% of Palo Alto residents are extremely interested in their next vehicle to be an EV if they knew EV charging would be readily available.

WATER

Water is a limited resource in California, and its availability will be further impacted by climate change and new environmental regulations. Both potable water supplies and hydroelectric needs could be challenged by long-term shifts in California's precipitation regime. With shifting climate patterns, and significant long-term water supply uncertainty, it would be prudent to reduce water consumption while exploring ways to capture and store water, as well as to increase the availability and use of recycled water.

GOALS

- Reduce per capita water use compared to 2019[9]
- Increase the percentage of recycled water used (volume of recycled water/recycled water filter capacity) by 10% in 2022 compared to 2019
- Reduce the total dissolved solids by 50% compared to 2019 base year
- Manage stormwater to slow the flow to receiving waters and improve water quality to protect the SF Bay, while also treating it as a beneficial resource for alternative uses[10]

KEY ACTIONS

- Maximize cost-effective water conservation & efficiency
- Expand the use of effluent from the RWQCP through Non-Potable Reuse, Indirect Potable Reuse, or Direct Potable Reuse
- Establish quantifiable baseline and targets for implementation of green stormwater infrastructure on private property, municipal facilities and public rights-of-way by 2024
- Design and build a salt removal facility for the PA Wastewater Treatment Plant
- Develop a "One Water" Portfolio for Palo Alto

KEY PERFORMANCE INDICATORS

- Per capita water use (Gallons Per Capita Per Day)
- Percentage recycled water use
- Total dissolved solids in recycled water

WATER

Water reuse will increase in importance as California's population expands and climate change and new environmental regulations pose uncertainties in imported water supply availability. Whether a water supply shortage exists or not, "Making Water Conservation a California Way of Life" is a concept embraced by the City.

[9] Water use goals will be updated to indoor residential use targets and irrigation use targets after Making Conservation a California Way of Life regulations are established

[10] Green Stormwater Infrastructure (GSI) goals will be updated once additional quantification work is conducted over the next three years to provide accurate, realistic and publicly vetted metrics.

CLIMATE ADAPTATION AND SEA LEVEL RISE

The State of California anticipates that relative sea level rise projections stemming from GHG emissions and related climate change pose significant economic, environmental and social risks to communities along the San Francisco Bay Shoreline, including the City of Palo Alto. Research shows that these projections may worsen if GHG emission trajectories continue unabated. To prepare for rising tides in the years ahead, the City of Palo Alto City Council adopted a Sea Level Rise Adaptation Policy in March 2019 which bridges the high-altitude general policy statements in various City plans to an eventual nuts-and-bolt Sea Level Rise Adaptation Plan and timeline which staff aims to complete by April 2021.

GOAL

➲ Develop a multi-year Sea Level Rise Adaptation Plan for Council Review by April 2021 to include a sea level rise vulnerability assessment and a community engagement strategy for plan development and implementation

KEY ACTIONS

- Commence work on Sea Level Rise Vulnerability Assessment (Spring 2020)
- Begin development of a Sea Level Rise Adaptation Plan (specific plan elements to be determined for staff and Council consideration during 2020)
- Review the recommendations of SAFER levee alignment (SAFER is the *Strategy to Advance Flood protection Ecosystems, and Recreation* feasibility report coordinated by San Francisquito Creek Joint Powers Authority)
- Discuss the Sea Level Rise levee alignment alternatives with Valley Water and other adjacent neighboring agencies
- Implement the Sea Level Rise Adaptation Plan after Council adoption

KEY PERFORMANCE INDICATORS

- Completed Sea Level Rise Vulnerability Assessment
- Council-approved Sea Level Rise Adaptation Plan
- Council review of proposed sea level rise levee alignments (2021)

Sea level rise in San Francisco Bay is anticipated to range between three feet to more than ten feet by 2100 with rising tides likely thereafter. In Palo Alto, many City services and infrastructure that are essential to the City's public health, safety, and economy are located within areas that are predicted to be inundated by Bay water if adaptation measures are not implemented. How will we prepare? What will we protect? How will we adapt? Where will we, if necessary, retreat?

REGENERATION AND NATURAL ENVIRONMENT

Sustainability is not only about mitigation, adaptation, and resilience, but also regeneration – identifying opportunities for renewal, restoration, and growth of our natural environment. Palo Alto will continue to build and restore the natural environment and its ecosystem services and the bio-capacity that supports it, including soils, tree canopy, biodiversity, and other components. Enhancing and maintaining Green Stormwater Infrastructure will use natural areas and systems to provide habitat, flood protection, storm water management, cleaner air, cleaner water, and human health enhancement.

GOALS

- Renew, restore, and enhance resilience of our natural environment
- Maximize biodiversity and stewardship of flora, fauna, and air, soil, and water resources
- Reduce environmental impacts of our actions
- Increase tree canopy to 40% city-wide coverage by 2030
- Expand the designation of pesticide-free parks and city facilities

KEY ACTIONS

- Explore programs and policies that use Palo Alto's public and private natural capital (e.g., canopy, soils, watersheds) to provide local carbon offsets and other environmental benefits
- Evaluate and modify plant palette selection to maximize biodiversity and soil health to adapt to the changing climate, and incorporate buffers for existing natural ecosystems
- Coordinate implementation of the Urban Forest Master Plan and Parks Master Plan to create pathways to parks and encourage appreciation of natural ecosystems
- Explore expanding the requirements of the Water Efficient Landscape Ordinance (WELO) to further the S/CAP Goals
- Implement the Green Stormwater Infrastructure plan
- Ensure No Net Tree Canopy Loss
- Develop methods to allow for both solar panels and trees
- Reduce the toxicity and the total amount of pesticides used in the city
- Ensure the protection of our ecosystem through the plan review and permitting process
- Restore degraded areas and channelized creeks and create wildlife corridors

KEY PERFORMANCE INDICATORS

- Tree Canopy
- Percent reduction of pesticide use

In 2005, Palo Alto adopted the Ahwahnee Principles for Resource Efficient Land Use[11] (as modified for local use), a set of guidelines emphasizing sustainable urban planning. These principles were developed by the Local Government Commission and modified to adapt them to the particular situation in Palo Alto.

[11] https://www.cityofpaloalto.org/civicax/filebank/documents/32650

ZERO WASTE

Reducing waste is an important strategy for both GHG reductions and overall sustainability. Approximately 42% of GHG emissions in the U.S. are associated with the flow of materials through the economy, from extraction or harvest of materials and food, production and transport of goods, provision of services, reuse of materials, recycling, composting, and disposal. Zero Waste is a holistic approach to managing materials in a closed loop system (circular economy), where all discarded materials are designed to become resources for others to use.

GOALS

- Divert 95% of waste from landfills by 2030, and ultimately achieve zero waste
- Implement short- and medium-term initiatives identified in the *2018 Zero Waste Plan*

KEY ACTIONS

- Expand the Deconstruction and Construction Materials Management Ordinance
- Eliminate single-use disposable cups and containers by expanding the Disposable Foodware Ordinance
- Require food waste prevention and edible food recovery measures for commercial food generators
- Promote residential food waste reduction
- Incentivize the use of reusable diapers
- Champion waste prevention, reduction, reusables, and the sharing economy (e.g., waste prevention technical assistance for businesses, provide waste reduction grants, promote adoption of a "Zero Waste lifestyle", promote access to goods over ownership)

KEY PERFORMANCE INDICATORS

- Diversion rate
- Number of *Zero Waste Plan*[12] initiatives implemented

Palo Alto's current diversion rate is 82%. Diversion includes all waste prevention, reuse, recycling, and composting activities that divert materials from landfills. Getting to our 95% goal will require refinement of existing programs, the addition of new policies and programs, working with manufacturers to redesign products, and working with businesses and residents that purchase products that will eventually become waste. In 2018, Palo Alto City Council accepted the updated *Zero Waste Plan*, which contains new programs and initiatives needed to meet the City's sustainability and zero waste goals.

[12] https://www.cityofpaloalto.org/civicax/filebank/documents/66620