INTEGRATED MASTER PLAN for the MAIN WASTEWATER TREATMENT PLANT

E120: Integrated Roadmap

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EBMUD

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TABLE OF CONTENTS

APPENDIX vi
FIGURES vii
TABLES ix
ACRONYMS x
EXECUTIVE SUMMARY 1
Master Plan Drivers and Triggers 2
Regulations 2
Aging Infrastructure 3
Capacity 4
Climate Change Resiliency 4
Process Improvements 5
Master Plan Integrated Roadmap 7
Aging Infrastructure Roadmap 13
Resource Recovery Roadmap 13
Nutrient Roadmap 14
CHAPTER 1 INTRODUCTION 1-1
1.1 Purpose 1-1
1.2 Background 1-1
1.3 Master Plan Drivers and Triggers 1-4
1.4 Regulatory Drivers 1-5
1.4.1 Nutrient Discharges 1-5
1.4.2 Biosolids Management 1-7
1.4.3 Air Emissions 1-7
1.4.4 Consent Decree 1-8
1.5 Aging Infrastructure Driver 1-9
1.6 Capacity Driver 1-9
1.7 Climate Change Resiliency Driver 1-10
1.7.1 Sea Level Rise 1-10
1.7.2 Biogas Utilization 1-10
1.7.3 Greenhouse Gas Emissions 1-11
1.7.4 Recycled Water 1-11
1.8 Process Improvements 1-12
1.9 Implementation Triggers 1-13
CHAPTER 2 FLOW AND LOAD PROJECTIONS 2-1
2.1 Medium Growth Scenario 2-1
2.2 Resource Recovery Scenarios 2-4
CHAPTER 3 AGING INFRASTRUCTURE 3-1
3.1 Infrastructural Renewal Needs 3-1
3.2 Seismic Resiliency 3-2
CHAPTER 4 NUTRIENT MANAGEMENT 4-1
4.1 Master Plan Target Alternatives Evaluation 4-1
4.1.1 Increased Recycled Water 4-5
4.1.2 Sidestream Treatment 4-6
4.1.3 No High Strength Waste + Sidestream Treatment 4-6
4.1.4 Right-Size R2 + Sidestream Treatment 4-7

4.1.5 High-Purity Oxygen Activated Sludge Nitrification + Sidestream Treatment 4-7
4.1.6 Split Treatment (High-Purity Oxygen Activated Sludge + Activated Sludge Biological Nutrient Removal) 4-8
4.1.7 Master Plan Target Economic Analysis 4-9
4.1.8 Master Plan Target Non-Economic Analysis 4-11
4.1.9 Master Plan Target Conclusions 4-12
4.2 Nutrient Roadmap 4-14
4.2.1 Master Plan Target 4-17
4.2.2 Level 2 Off-Ramp – Full Mainstream Treatment 4-20
4.2.3 Level 3 Off-Ramp 4-22
CHAPTER 5 BIOSOLIDS MANAGEMENT 5-1
5.1 Background and Economic Trends 5-1
5.2 Biosolids Management Alternatives 5-3
5.2.1 Status Quo 5-4
5.2.2 Off-Site Storage Facility 5-6
5.2.3 Post-Digestion Technology 5-10
5.3 Biosolids Implementation Plan 5-14
CHAPTER 6 SOLIDS FACILITIES 6-1
6.1 Solids Dewatering 6-1
6.1.1 Solids Dewatering Challenges 6-2
6.1.2 Solids Dewatering Alternatives 6-3
6.1.3 Dewatering Alternatives Evaluation 6-9
6.1.4 Impact of Resource Recovery on Dewatering Capacity 6-11
6.1.5 Dewatering Implementation Plan 6-13
6.2 Anaerobic Digesters 6-14
CHAPTER 7 CLIMATE CHANGE RESILICIENCY 7-1
7.1 Sea Level Rise 7-1
7.2 Biogas Utilization 7-1
7.3 Greenhouse Gas Emissions 7-4
7.4 Recycled Water 7-5
CHAPTER 8 PUMPING SYSTEMS 8-1
8.1 Influent Pump Station 8-1
8.2 Effluent Pump Station 8-1
8.3 Implementation Plan 8-2
CHAPTER 9 LIQUIDS FACILITIES 9-1
9.1 Covering of Primary Sedimentation Tanks 9-1
9.2 Secondary Treatment System Capacity Improvements 9-2
9.3 Secondary Treatment System Capacity Alternatives Analysis 9-3
9.4 Economic Evaluation 9-7
9.4.1 Impact of Resource Recovery on Secondary Treatment Capacity 9-9
9.5 Secondary Treatment Capacity Implementation Plan 9-10
9.6 Disinfection 9-11
CHAPTER 10 PROCESS IMPROVEMENTS 10-1
10.1 Grit Improvements 10-1
10.2 Struvite Management 10-2
10.3 Sludge Screening 10-3

CHAPTER 11 INTEGRATED ROADMAP 11-1
11.1 Impact of Resource Recovery on Project Alternatives........ 11-1
11.2 R2 Alternatives........ 11-2
11.2.1 Net Present Value Evaluation........ 11-2
11.3 Implementation Plan........ 11-7
Aging Infrastructure Roadmap........ 11-9
Resource Recovery Roadmap........ 11-9
Nutrient Roadmap........ 11-10
11.3.1 Master Plan Timeline and Project Costs........ 11-14
11.3.2 Master Plan CIP Annual Operating Projections........ 11-18
11.4 Site Plans........ 11-22
CHAPTER 12 REFERENCES AND APPENDICES A-1

APPENDIX

Appendix A – E00: Wastewater System Overview
Appendix B – E10: Previous and Ongoing Studies Summary
Appendix C – E20: MWWTP Regulatory Requirements
Appendix D – E30: Condition Assessment and Seismic Study
Appendix E – E40: Climate Action and Sustainability Plan
Appendix F – E50: MWWTP Master Plan Goals and Objectives
Appendix G – E60: Resource Recovery Summary and Projections
Appendix H – E70: Influent Flows and Loads Projections
Appendix I – E80: Existing Plant Performance
Appendix J – E90 Electrical Capacity Study
Appendix K – E100: Biogas Utilization Report
Appendix L – C30: Market Assessment
Appendix M – C40: Basis for Cost Estimate
Appendix N – C50: Evaluation Criteria
Appendix O – C60: Plant-Wide Process Model Report
Appendix P – C70: Capacity Assessment
Appendix Q– C80: Nutrient Reduction Alternatives Report
Appendix R – C80.1: Sidestream Treatment Report
Appendix S – C90: Biosolids Management Report
Appendix T – Workshop Materials and Meeting Minutes
Appendix U – Nitrification in High-Purity Oxygen Activated Sludge Analysis
Appendix V – Primary Sedimentation Tank Evaluation
Appendix W – Reduce R2: Scenarios: Flow and Loads and Process Model Results
Appendix X – R2 Scenario Net Present Value
Appendix Y – Process Improvement Details
Appendix Z – Details Table of Near-Term and Long-Term Master Plan Projects
Appendix AA – Integrated Master Plan in Brief
Appendix AB – Co-thickening and Recuperative Thickening

FIGURES

Figure ES-1. Illustration of roadmap concept with a trigger leading to an off-ramp..............ES-1
Figure ES-2. Master Plan drivers and associated implementation triggers ES-6
Figure ES-3. Near-term implementation roadmap (Gantt chart)..ES-11
Figure ES-4. Near-and long-term implementation roadmap..ES-12
Figure 1-1. MWWTP site plan and timeline of constructed facilities.....................................1-2
Figure 1-2. MWWTP process flow diagram..1-3
Figure 1-3. Implementation triggers for the Master Plan roadmap.......................................1-13
Figure 3-1. Highest-priority seismic rehabilitation projects at the MWWTP...........................3-3
Figure 4-1. Historical and projected TIN discharges from the MWWTP 4-3
Figure 4-2. TIN load projections for Master Plan Target alternatives.....................................4-4
Figure 4-3. Economic comparison of Master Plan target alternatives 4-10
Figure 4-4. Non-economic comparison of Master Plan target alternatives for criteria shown on right side...4-11
Figure 4-5. Nutrient management roadmap 4-15
Figure 4-7. Site plan of SST facilities to meet the Master Plan Target in the planning horizon..4-18
Figure 4-8. Site plan for SST and split treatment to meet the Master Plan Target beyond the planning horizon...4-20
Figure 4-9. Site plan for full mainstream treatment to meet the Level 2 Off-Ramp...............4-21
Figure 4-10. Site plan for full mainstream treatment to meet the Level 3 Off-Ramp 4-22
Figure 5-1. Historical and projected biosolids management costs..5-2
Figure 5-2. Biosolids management cost projections for the status-quo alternative..................5-5
Figure 5-3. Schematic of off-site storage alternative..5-6
Figure 5-4. Biosolids management cost projections for the off-site storage alternative compared with the status quo..5-9
Figure 5-5. Biosolids management cost projections for the thermal dryer alternative compared with the status quo...5-12
Figure 5-6. Site plan for the post-digestion technology alternative with a thermal dryer........5-13
Figure 5-7. Implementation plan for biosolids management..5-15
Figure 6-1. Site plan for the new Dewatering Building...6-5
Figure 6-2. Implementation plan for the new Dewatering Building alternative 6-5
Figure 6-3. Floor plan for alternative to rehabilitate the existing Dewatering Building...........6-8
Figure 6-4. Implementation plan for the rehabilitate existing Dewatering Building alternative6-8
Figure 6-5. Economic evaluation of dewatering alternatives...6-10
Figure 6-6. Non-economic evaluation of dewatering alternatives..6-11
Figure 6-7. Implementation plan for the new Dewatering Building paired with Right-Size R2..6-13
Figure 7-1. Simplified schematic of biogas production and electricity generation at the MWWTP 7-1
Figure 9-1. Implementation plan for covering the PSTs..9-2
Figure 9-2. Conceptual site plan of CEPT...9-5
Figure 9-3. Schematic of step-feed configuration...9-6
Figure 9-4. Net present value analysis of secondary treatment capacity alternatives in 2021 dollars..9-8
Figure 9-5. Implementation schedule for step-feed...9-10

Figure 11-1. R2 alternatives and capital outlay schedule (in 2021 dollars)............................11-4
Figure 11-2. Capital costs of the R2 alternatives in 2021 dollars..11-5
Figure 11-3. NPV of the R2 alternatives...11-6
Figure 11-4. Near- and long-term integrated roadmap..11-8
Figure 11-5. Implementation timeline for the integrated roadmap.......................................11-17
Figure 11-6. Master Plan site plan for years 2020 to 2030 11-23
Figure 11-7. Master Plan site plan for years 2030 to 2040 11-24
Figure 11-8. Master Plan site plan for years 2040 to 2050 11-25
Figure 11-9. Master Plan site plan off-ramps...11-26

TABLES

Table ES-1. Summary of Master Plan project costs....ES-8
Table 1-1. Nutrient reduction targets assumed for the Master Plan....1-6
Table 2-1. Projections for flows and loads at the IPS (including influent wastewater and LSW) under the Medium Growth Scenario....2-2
Table 2-2. Projections for HSW flows and loads under the Medium Growth Scenario....2-3
Table 3-1. Implementation plan for highest-priority seismic rehabilitation projects at the MWWTP....3-4
Table 4-1. Net present value comparison of Master Plan target alternatives[a]....4-9
Table 4-2. SST "no regrets" evaluation....4-13
Table 4-3. Master Plan target implementation timeline....4-17
Table 4-4. Implementation plan for split treatment....4-19
Table 4-5. Implementation plan for full mainstream treatment to meet the Level 2 Off-Ramp4-21
Table 5-1. Planning criteria for the off-site storage facility alternative....5-7
Table 5-2. Planning criteria for the thermal dryer....5-11
Table 6-1. Solids dewatering and loadout equipment....6-1
Table 6-2. Planning criteria for new Dewatering Building alternative....6-4
Table 6-3. Planning criteria for alternative to rehabilitate the existing Dewatering Building....6-7
Table 6-4. Net present value comparison of dewatering alternatives in 2021 dollars....6-10
Table 6-5. Impact of R2 on dewatering capacity....6-12
Table 9-1. Planning criteria for covering the PSTs....9-1
Table 9-2. Secondary treatment system improvement alternatives....9-4
Table 9-3. Secondary treatment capacity for different R2 scenarios....9-9
Table 10-1. Comparison of AGTs with industry recommendations....10-1
Table 10-2. Capital cost estimates for AGT improvements....10-2
Table 11-1. Summary of annual operating costs and benefits for R2 NPV analysis....11-3
Table 11-2. Summary of Master Plan costs and implementation timeline....11-15
Table 11-3. Projected annual average power demand at the MWWTP[a]....11-19
Table 11-4. Projected annual average biosolids management costs....11-20
Table 11-5. Projected annual average revenue modifications....11-20
Table 11-6. Projected additional labor requirements (as full-time equivalent positions)....11-21
Table 11-7. Projected annual average chemical costs....11-21

ACRONYMS

AB	Assembly Bill
ADC	Alternative Daily Cover
ADW	Average Dry Weather
AGT	Aerated Grit Tank
AS BNR	Activated Sludge Biological Nutrient Removal
BAAQMD	Bay Area Air Quality Management District
BACWA	Bay Area Clean Water Agencies
Bay	San Francisco Bay
BMP	Best Management Practice
BNR	Biological Nutrient Removal
BOD	Biological Oxygen Demand
CBOD	Carbonaceous Biological Oxygen Demand
CEPT	Chemically Enhanced Primary Treatment
CIP	Capital Improvement Program
COD	Chemical Oxygen Demand
CPI	Consumer Price Index
District	East Bay Municipal Utility District
DO	Dissolved Oxygen
EBMUD	East Bay Municipal Utility District
EBRWF	East Bayshore Recycled Water Facility
EICG	Emission Inventory Criteria and Guidelines
ELD	Electronic Logging Device
EPA	Environmental Protection Agency
EPS	Effluent Pump Station
ES	Executive Summary
ESA	Extended Service Agreement
FOG	fats, oil, grease
GHG	Greenhouse Gas
gpd	Gallons per Day
gpd/ft^2	Gallons per Day per Square Foot
gpm	Gallons per Minute
GST	Gravity Sludge Thickener
HPOAS	High-Purity Oxygen Activated Sludge
HRA	Health Risk Assessment
HRT	Hydraulic Residence Time
HSW	High-Strength Waste
I&I	Inflow and Infiltration
IPS	Influent Pump Station
ISS	Inert Suspended Solids
kg	Kilogram
kg-N/d	Kilograms of Nitrogen per Day

kg-N/L	Kilograms of Nitrogen per Liter
kg-P/d	Kilograms of Phosphorus per Day
kg-P/L	Kilograms of Phosphorus per Liter
lb/d	Pound per Day
lb/ft^3/day	Pound per Cubic Foot per Day
LSW	Low-Strength Waste
MBR	Membrane Bioreactor
MD	Maximum Day
mgd	Million Gallons per Day
mg-N/L	Milligrams of Nitrogen per Liter
mg-P/L	Milligrams of Phosphorus per Liter
MLE	Modified Ludzack-Ettinger
MLSS	Mixed Liquor Suspended Solids
MM	Maximum Month
MW	Megawatt
MWWTP	Main Wastewater Treatment Plant
NPV	Net Present Value
NWP	Nutrient Watershed Permit
O&M	Operations and Maintenance
O2	Oxygen
OPP	Oxygen Production Plant
PFAS	Per- and polyfluoroalkyl substances
PG&E	Pacific Gas & Electric
PGS	Power Generation Station
POTW	Publicly Owned Treatment Works
PPA	Power Purchase Agreement
PST	Primary Sedimentation Tank
R2	Resource Recovery
RARE	Richmond Advanced Recycled Expansion
RAS	Return Activated Sludge
REC	Renewable Energy Credit
RRP	Risk Reduction Plan
RWF	Regional Wastewater Facility
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SFPUC	San Francisco Public Utilities Commission
SLW	Solid-Liquid Waste
SOR	Surface Overflow Rate
SST	Sidestream Treatment
SVI	Sludge Volume Index
TAC	Toxic Air Contaminant
TIN	Total Inorganic Nitrogen (Ammonia + Nitrate + Nitrite)
TKN	Total Kjeldhal Nitrogen

TN	Total Nitrogen (TKN + Nitrate + Nitrite)
TP	Total Phosphorus
TS	Total Solids
TSS	Total Suspended Solids
TWAS	Thickened Waste Activated Sludge
VOC	Volatile Organic Compounds
VS	Volatile Solids
VSS	Volatile Suspended Solids
WAPA	Western Area Power Administration
WAS	Waste Activated Sludge
WWF	Wet Weather Facility

EXECUTIVE SUMMARY

The goal of the East Bay Municipal Utility District's (District's) Integrated Main Wastewater Treatment Plant (MWWTP) Master Plan (Master Plan) is to inform an integrated and adaptive 30-year roadmap of major projects for the District's capital improvement program (CIP) to address new regulations, capacity constraints, climate change resiliency, and the continuous challenge of aging infrastructure.

The concept of a roadmap is to set the path for the future based on the best information available now, and to illustrate how that path can be altered by various triggers, which divert the District's course onto off-ramps, as shown in Figure ES-1. The roadmap is "integrated" because it holistically considers all of the District's competing priorities and synthesizes them into a plan for capital improvements over the next 30 years. Due to uncertainty, it is unknown if and when triggers will occur. Accordingly, the roadmap is not a recipe for immediate implementation. Many of the necessary next steps are largely out of the District's control, such as regulatory development, evolution of flows and loads to the plant over time, economic factors that change over time, and other unknowns that can't be anticipated. Even as those uncertainties are resolved over time, the District will still need to perform more detailed engineering analyses to confirm and refine the analyses performed and conclusions made as part of this Master Plan.

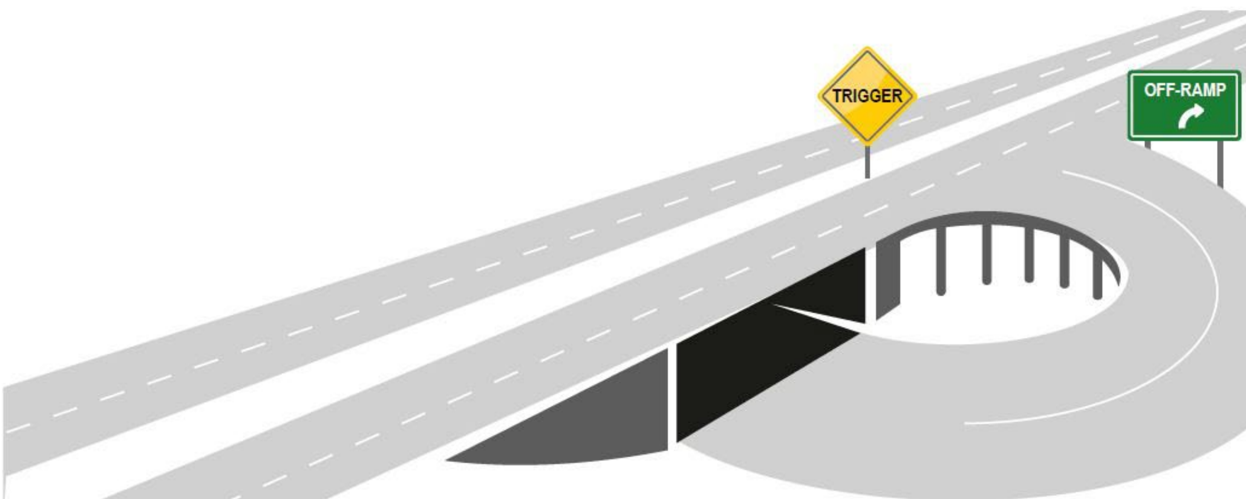

Figure ES-1. Illustration of roadmap concept with a trigger leading to an off-ramp

This report summarizes the evaluations and analyses that were undertaken to determine the best overall solutions that align with the District's strategic goals and guiding principles. The roadmap is comprised of both near-term CIP projects (defined as 2021 to 2030) and long-term CIP projects (defined as 2031 to 2050). The term "planning horizon" refers to the 30-year outlook ending in 2050.

For a succinct summary of the Master Plan, refer to the *Integrated Master Plan in Brief* (Appendix AA).

Master Plan Drivers and Triggers

Four primary drivers were considered for the Master Plan: regulations, aging infrastructure, capacity, and climate change resiliency. To account for future uncertainties, triggers were established to provide a basis for the implementation timeline of projects in the roadmap. Figure ES-2 summarizes the drivers and associated triggers on which the Master Plan is based.

Regulations

Regulations are discussed in detail in Appendix C. The roadmap for regulations considers nutrients, biosolids, air emissions, and the Consent Decree:

- **Nutrients:** Nutrients in the San Francisco Bay (Bay) are a major issue for the Bay Area water quality community. Historically, the Bay has not shown adverse effects by nutrient loading even though it is nutrient enriched compared to other estuaries around the country. Stakeholders throughout the region wish to better understand this resiliency, and whether it may be threatened in the future.

  Numerous scientific monitoring and modeling studies are being conducted to understand the impact of nutrients on the Bay. This includes the San Francisco Estuary Institute's Regional Monitoring Program, which the District helps fund and oversee. While these nutrient studies are ongoing, the District is working with other Bay stakeholders, including regulators, publicly owned treatment works (POTWs), and scientists, to ensure that any future nutrient effluent limits are based on sound science.

  Nutrient discharge regulations for POTW dischargers have evolved since the first Nutrient Watershed Permit (NWP) was issued in 2014. In the near-term, nutrient discharge regulations are expected to follow the seasonal total inorganic nitrogen (TIN) load targets that are currently included in the 2019 NWP Fact Sheet. For the District, this means staying below a seasonal TIN load target of 11,000 kg/day by year 2029. Due to the uncertainty with the timing of more stringent regulations, the Master Plan also considers a lower seasonal TIN load target and a potential future TIN limit equal to 15 mg-N/L (referred to in this report as the Level 2 Off-Ramp). These lower targets were assumed to occur at the end of the planning horizon.

- **Biosolids:** Biosolids management costs in the near-term are expected to be impacted by two factors: the passage of Senate Bill (SB) 1383 "Short-Lived Climate Pollutants: Organic Waste Methane Emissions Reductions," and the Electronic Logging Device rule (ELD or e-log). The organic diversion requirements under SB1383 will eventually eliminate wet weather management options (alternative daily cover [ADC] and landfill disposal) that the Bay Area has historically relied on. The limited wet weather management options have already resulted in rising biosolids management costs, which are expected to continue to rise until more wet weather management options are established. The ELD rule increases hauling costs, particularly for long haul distances. Lastly, regulations on per- and polyfluoroalkyl substances (PFAS) in biosolids may also emerge in the near future, which could result in lower land application rates, longer haul distances, and higher management costs.

- **Air Emissions:** The primary air emissions regulation identified as impacting the Master Plan is the Bay Area Air Quality Management District's (BAAQMD) Rule 11-18, which concerns toxic air contaminants (TACs), which are compounds that are known to increase the risk of cancer and/or other serious health effects. The extent to which these compounds are emitted from treatment process tanks at the MWWTP is unknown, but is expected to be limited. Implementation of Rule 11-18 will occur over many steps. The first step, which as not yet started, involves sampling and characterization of TACs emitted from POTWs. Subsequently, a health risk assessment (HRA) will be performed to determine the relative impact of the TACs to local air quality. If that impact exceeds the risk action level threshold, those POTWs will be required to implement projects to comply with Rule 11-18. The list of air contaminants that fall under Rule 11-18 has been increased by the California Air Resources Board under Assembly Bill 617. For the MWWTP, the need for implementing capital projects to comply with Rule 11-18 is uncertain. Currently, the expectation is that the regulation will not necessitate capital improvements due to the limited extent of emissions. The approach under this roadmap is to continue to work with BAAQMD on the initial implementation of Rule 11-18 and to adapt as the outcome becomes clearer.

- **Consent Decree:** In 2014, the District and satellite agencies entered into a Consent Decree to significantly reduce inflow and infiltration (I&I) from the collection system during wet weather. Reductions in I&I are achieved through a combination of activities, including repair of private sewer laterals and capital projects. The Consent Decree has a duration 22 years, ending in 2036. For the Master Plan, the analysis is focused on the processes within the MWWTP boundary, and the assumption is that the District's existing I&I reduction approach to Consent Decree will continue. Therefore, the Master Plan does not propose any modifications to treatment processes at the MWWTP to address peak wet weather flows beyond ensuring that sufficient hydraulic capacity remains available as the population grows. The District will continue to comply with the Consent Decree, and no additional projects were identified for inclusion in the roadmap beyond the existing ongoing efforts to comply with the Consent Decree.

Aging Infrastructure

The MWWTP was originally constructed in 1951, and the majority of facilities were constructed over 40 years ago. To maintain reliable treatment, continued rehabilitation and replacement of aging infrastructure is needed across all treatment processes, as well as seismic rehabilitation projects for specific facilities. The focus of the Master Plan with respect to aging infrastructure was to ensure that all investments are strategic and "no regrets." For example, renewal of aging infrastructure is not prudent if, within a short timeframe, the infrastructure may need to be replaced to address a different driver such as a new regulatory requirement.

Capacity

The Master Plan is based on flow and load projections through the end of the planning horizon. The projections are based on anticipated growth within the wastewater service area, as well as the projected evolution of the District's Resource Recovery (R2) program. A capacity assessment was performed for the present through the planning horizon to identify process capacity constraints and projects that are needed to alleviate those constraints. The capacity assessment identified that, under certain rare conditions, there are currently limitations at the Influent and Effluent Pump Stations. The secondary clarifiers have a hypothetical capacity deficiency during worst-case conditions of projected organic loading, peak flow, and sludge volume index, which have never occurred simultaneously. The dewatering centrifuges and solids hoppers also have capacity deficiencies under current flow and loading conditions, which occur more frequently, but can be managed through existing operational practices. Based on the future projections, a capacity limitation in 2040 was identified for the oxygen reactors.

Climate Change Resiliency

The climate change resiliency driver included sea level rise, biogas utilization (renewable energy), greenhouse (GHG) emissions, and recycled water as follows:

- **Sea Level Rise:** The District performed a vulnerability assessment to identify the extent to which District wastewater facilities are affected by sea level rise (Appendix E). The assessment showed that the facilities located within the central portion of the MWWTP are expected to avoid inundation due to sea level rise within the planning horizon. The Dechlorination Facility and Transition Structure near the shoreline of the Bay are at risk of flooding during 100-year storm surges beginning under current conditions. All future projects will consider the District's climate change design guidelines for any capital projects and, if determined to be impacted by sea level rise in the future, will implement preventative measures to avoid impacts of inundation due to future sea level rise, even beyond the Master Plan planning horizon.
- **Biogas Utilization:** Consideration of biogas utilization projects is a continuously updating process. The factors that influence the potential of biogas utilization projects include (1) biogas production, which is influenced by the mix of R2 wastes accepted; (2) the available technology options, which are continually being expanded and improved; and (3) the performance and economics of existing biogas utilization at the MWWTP. Biogas utilization is not strictly a regulatory obligation of the District, and consideration of biogas utilization projects are opportunistic, often prompted by opportunities outside the control of the District such as the availability of grant funding. Other drivers of biogas utilization projects include the renegotiation of the 5-year power purchase agreement (PPA) with the Port of Oakland (Port), renegotiation of the maintenance contract for the turbine, and consideration of the District's GHG emissions from the MWWTP. This mix of considerations, the details of which can change frequently, requires a process of regular updates and re-analysis.
- **Greenhouse Gas Emissions:** In September 2020, the District established a goal for the wastewater system to reduce indirect GHG emissions to net zero and to reduce direct emissions by 50% by 2040 (District Policy 7.07).
- **Recycled Water:** Expansion of recycled water helps make the District's water supply portfolio more resilient in a changing climate. This Master Plan for the MWWTP does not

expand on work previously completed in February 2019 for the District's Recycled Water Master Plan, but does consider the possibility of synergistic benefits, such as the reduction in nitrogen loading to the MWWTP brought on by satellite recycled water treatment. Increased recycled water delivery from the MWWTP supports the District's goal of achieving 20 mgd of recycled water by 2040.

Process Improvements

Process improvements are defined as projects that can provide benefits through improved process performance and/or reduction of operations and maintenance (O&M). While not a primary driver of the Master Plan, some process improvement projects were identified and evaluated to determine preliminary design criteria, costs, and benefits. The projects are not required, but the benefits they provide could justify implementation at strategic times when capital funding is available. These projects fall outside the four primary Master Plan driver categories of regulatory, aging infrastructure, capacity, or climate change resiliency.

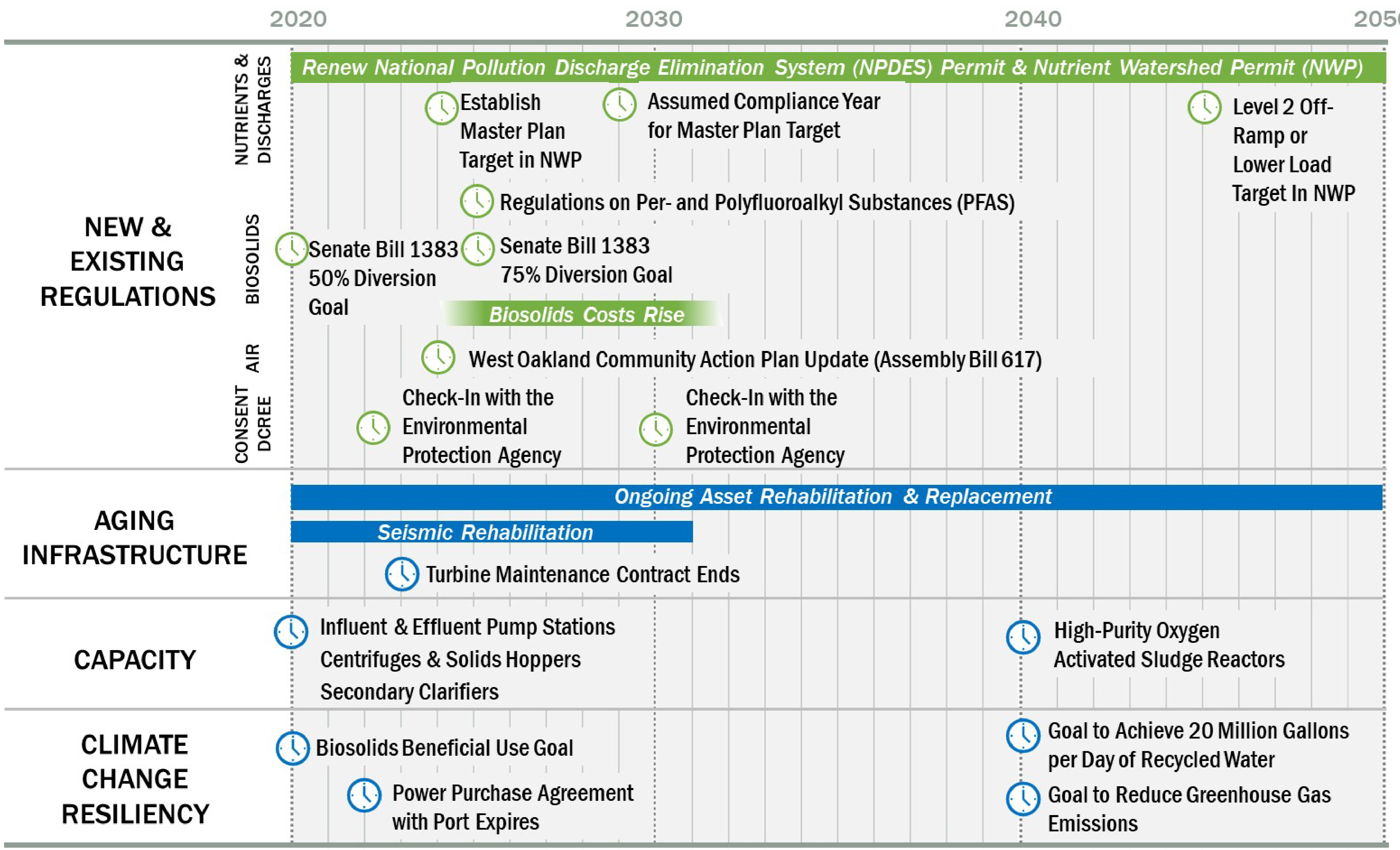

Figure ES-2. Master Plan drivers and associated implementation triggers

Master Plan Integrated Roadmap

The integrated roadmap sets the expected path of strategies and capital improvements for the next 30 years at the MWWTP, synthesizing a variety of competing priorities that will address future regulations, upgrade aging infrastructure, relieve capacity constraints, provide climate change resiliency, and improve process performance. The integrated roadmap is presented in the following section through verbal descriptions, summary tables, visual diagrams, and site plans.

Projects throughout the planning horizon are summarized in Table ES-1. The timing and implementation of near-term projects is illustrated as a Gantt chart in Figure ES-3. The integrated roadmap is illustrated as a decision-tree diagram in Figure ES-4.

Table ES-1. Summary of Master Plan project costs

Master Plan Project	Description	Capital Cost (2021 Dollars)	Implementation Timeline and Driver
Nutrients			
Right-Size R2	Reduce or eliminate select R2 waste streams (protein and dairy wastes) to reduce TIN discharges and provide time for the District to plan, design, construct, and finance nutrient removal projects. Reduction in R2 streams can also be balanced with biogas production to minimize flaring.	No Capital Cost	2021 - 2050 *(Regulatory and Climate Change Resiliency)*
Sidestream Treatment	Implement sidestream treatment for compliance with Master Plan Target for nutrient discharges. Assumed new tankage.	No Change to R2: $92 million Right-Size R2: $64 million	2024 - 2031 *(Regulatory)*
Split Mainstream Treatment (Split Treatment)	Implement split treatment (HPOAS + AS BNR) if regulations require meeting a lower TIN load target. Includes relocation of Maintenance Center.	$420 million	2041 - 2054 *(Regulatory)*
Mainstream Nutrient Removal	Convert to mainstream nitrogen removal if regulations require meeting Level 2 TIN target (Level 2 Off-Ramp). Includes relocation of Maintenance Center and Administration and Laboratory Building.	$1,330 million	2041 - 2054 *(Regulatory)*
Biosolids Management			
Off-Site Storage	Construct off-site storage, if determined to be feasible and when biosolids management costs approach $115/wet ton.	$81 million	2023 - 2030 *(Regulatory)*
Post-Digestion Facility	Construct on-site post-digestion facility (thermal dryer) when biosolids management costs approach $155/wet ton.	$199 million	2033 - 2040 *(Regulatory)*
Solids Facilities			
New Dewatering Building Phase 1	Construct new Dewatering Building to address aging infrastructure and capacity limitations.	$74 million	2022 - 2029

Master Plan Project	Description	Capital Cost (2021 Dollars)	Implementation Timeline and Driver
			(Capacity and Aging Infrastructure)
New Dewatering Building Phase 2	Expand New Dewatering Building to include one additional hopper and truck bay when the District approaches projected flows and loads in 2040 assuming "Right-Size R2."	$12 million	2040 - 2044 *(Capacity)*
Pumping Systems			
Influent and Effluent Pump Stations	Implement improvements to address capacity limitations and aging infrastructure.	$77 million	2022 - 2030 *(Capacity and Aging Infrastructure)*
Liquids Facilities			
Cover the Primary Sedimentation Tanks (PSTs)	Evaluate the effectiveness of covering the PSTs to provide treatment of foul air for improved odor control. Implementation occurs only after seismic retrofit construction. Includes cost of cover all PSTs.	$66 million	2031 - 2045 *(Regulatory)*
Chemical Enhanced Primary Treatment (CEPT)	Implement CEPT as a bridge for addressing secondary treatment capacity limitations until step-feed is implemented.	$4 million	2021 - 2024 *(Capacity)*
Step-Feed Phase 1	Implement step-feed for half of high-purity oxygen activated sludge (HPOAS) reactors to address secondary clarifier capacity limitations.	$15 million	2028 - 2032 *(Capacity)*
Step-Feed Phase 2 and Aerator Upgrades	Implement step-feed for remaining half of HPOAS reactors and replace Stage 2 aerators to address capacity limitations.	$21 million	2034 - 2039 *(Capacity)*
Process Improvements			
Aerated Grit System Improvements	Implement improvements to enhance grit removal.	$30 million	2039 - 2046 *(Process Improvement)*

Master Plan Project	Description	Capital Cost (2021 Dollars)	Implementation Timeline and Driver
Struvite Management	Implement struvite mitigation technology to address O&M challenges at dewatering equipment and centrate pipelines.	$30 to $50 million	2035 - 2041 *(Process Improvement)*
Sludge Screening	Implement sludge screening based on O&M challenges, end use requirements, and/or post-digestion facility requirements.	$16 million	2034 - 2040 *(Process Improvement)*

Near-Term Project Timelines

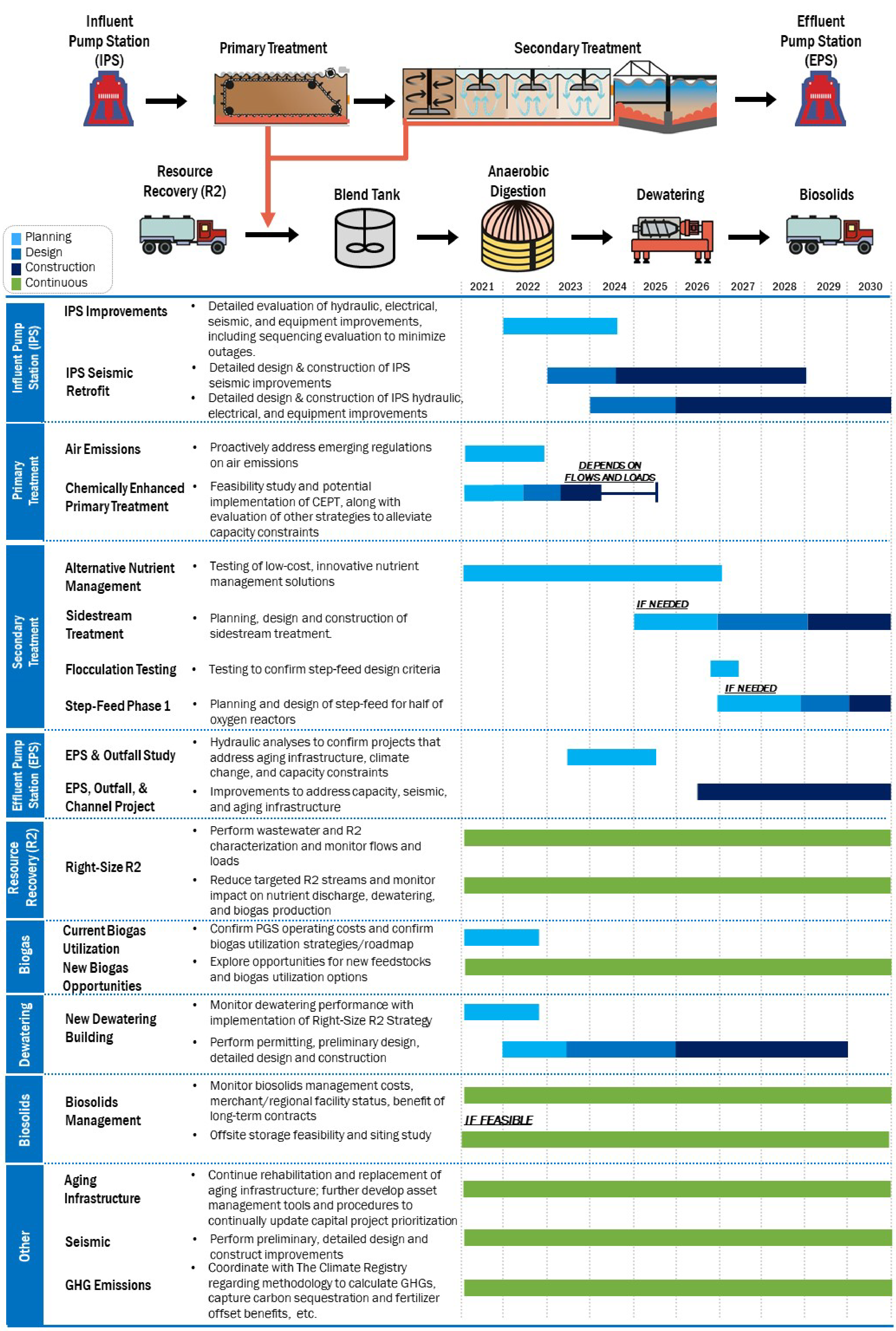

Figure ES-3. Near-term implementation roadmap (Gantt chart)

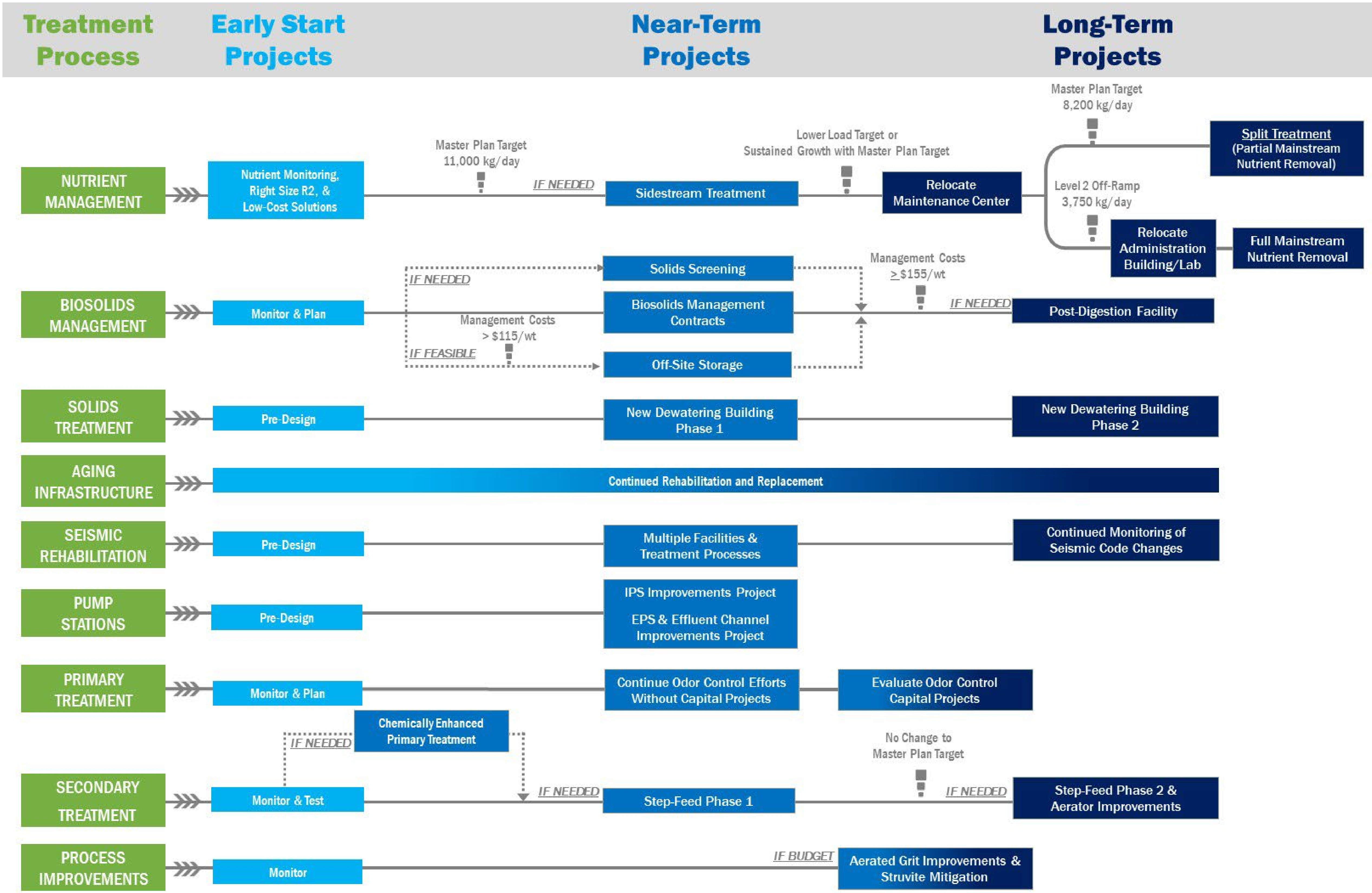

Figure ES-4. Near-and long-term implementation roadmap

Aging Infrastructure Roadmap

Infrastructure at the MWWTP is aging and in need of continued renewal. The District has forecasted the need for a minimum of $40 million per year on average for the next 30 years in order to replace in-kind the existing infrastructure currently in place before it fails. Infrastructure renewal projects only rehabilitate or replace the structures, equipment, piping, and other facilities in their current form and function without improvements in performance, safety, or other benefits. The following projects were identified as priorities for the near-term CIP:

- Influent Pump Station (IPS): Electrical, seismic, and select equipment repair/replacement
- Grit Removal System: Concrete rehabilitation and select equipment replacement
- Oxygen Production Plant: Select improvements to address safety and extend useful life
- High-Purity Oxygen Activated Sludge (HPOAS) Reactors: Concrete rehabilitation of reactors and ancillary improvements
- Secondary Clarifiers: Continued rehabilitation of all clarifiers
- Effluent Pump Station (EPS) and Effluent Channel: Concrete rehabilitation and mechanical rehabilitation
- Dechlorination Facility: Piping replacement, emergency generator replacement, concrete rehabilitation and other reliability improvements
- Anaerobic Digesters: Seismic improvements, equipment upgrades, and coating rehabilitation
- Electrical System: Continued motor control center replacements, seismic retrofits, and other reliability improvements
- Power Generation Station: Replacement of aging equipment and piping, upgraded cooling equipment, improved heat exchangers
- Plant Utilities and Support Buildings: Miscellaneous equipment repairs

The complete details of aging infrastructure capital projects are in the District's Biennial CIP. Renewal of aging infrastructure will remain the primary near-term focus of capital projects for the District. The New Dewatering Building project will replace the dewatering and biosolids cake storage function of the existing Dewatering Building, and as a result, will eliminate the need for a major rehabilitation project for that existing building. No other major project was identified that would eliminate the need for previously identified infrastructure renewal projects in the CIP.

Chapter 3 describes the aging infrastructure roadmap in more detail.

Resource Recovery Roadmap

The near-term roadmap for R2 includes the opportunistic reduction or elimination of protein (i.e., blood) and dairy (i.e., dissolved air flotation) waste streams, which is referred to as "Right-Size R2." Elimination of these waste streams reduces TIN loads discharged to the Bay and provides solids dewatering capacity benefits to give the District time to plan, design, construct, and finance new dewatering and sidestream treatment (SST) facilities. The near-term roadmap for R2 includes further characterization of the R2 wastes to determine more precisely the sources and quantities of TIN in R2 wastes, as well as to identify other waste streams that could be reduced or eliminated to provide near-term benefits to capacity, nitrogen reduction, and biogas production.

The long-term roadmap for R2 assumes that the select waste streams would be reduced or eliminated over the course of the planning horizon. The long-term roadmap should be continuously updated as the mix of R2 wastes evolves, as nutrient and biosolids regulations become more defined, and as the District implements CIP projects (i.e., SST and a New Dewatering Building) that would influence the MWWTP's nitrogen loading to the Bay.

Chapter 11 describes the R2 roadmap in more detail.

Nutrient Roadmap

The near-term nutrient roadmap involves the implementation of the "Right-Size R2" strategy followed by SST. In parallel, the District will continue to investigate low-cost, innovative nutrient reduction solutions such as split battery testing to utilize existing infrastructure and forestall the need for new nutrient removal infrastructure. The timeline for SST is dependent on multiple factors, including the timing and details of new regulations, growth of influent flows and loads, observed effluent nitrogen loads discharged to the Bay, and the status of recycled water projects that can reduce nutrients sent to the MWWTP. Pilot testing of SST is necessary to confirm feasibility, refine design criteria, and more precisely define the cost.

The long-term roadmap for nutrients is based on the implementation of mainstream nutrient removal if regulations shift to a lower TIN load target or effluent concentration limits.

Chapter 4 describes the nutrient roadmap in more detail.

Biosolids Management Roadmap

The near-term biosolids management roadmap is based on a combination of parallel activities, including negotiating longer-term management contracts that secure wet weather beneficial uses; monitoring local price trends and the status of new merchant facilities; and considering early commitments to new merchant facilities. Further evaluation of the feasibility and cost of off-site storage in the Bay Area and/or Merced County is recommended. If feasible, off-site storage should be implemented when biosolids management costs approach $115/wet ton.

The long-term biosolids management roadmap is based on implementation of a post-digestion facility (i.e., thermal dryer) when biosolids management costs approach $155/wet ton.

Chapter 5 describes the biosolids management roadmap in more detail.

Solids Dewatering Roadmap

The near-term solids dewatering roadmap includes the planning, design, and construction of the New Dewatering Building project. The new building can be phased such that the first phase would provide capacity for projected flows and loads until 2040.

The long-term roadmap includes the second phase of the new building, which would include the installation of additional centrifuges, a new hopper, and a truck bay if flows and loads continue to increase.

Chapter 6 describes the solids dewatering roadmap in more detail.

Climate Change Resiliency Roadmap

The roadmap for climate change resiliency considers sea level rise, biogas utilization, GHGs, and recycled water as described below. Chapter 7 describes the climate change resiliency roadmap in more detail.

Sea Level Rise

The District will continue to implement its climate change design guidelines on capital projects in areas that are vulnerable to sea level rise. The near- and long-term roadmap does not identify any projects specifically for sea level rise.

Biogas Utilization

The biogas utilization roadmap is the least prescriptive within the overall Master Plan roadmap. The District continually explores options for biogas utilization and will continue to do so after this Master Plan. Current economic and regulatory conditions are not favorable to alternatives to the District's current practice of generating renewable electricity through a turbine and three engines. While operations and maintenance of the turbine and engines are an ongoing challenge, the benefits outweigh the costs and challenges.

However, current conditions can and will change, and there are several potential avenues for increasing the value of the electricity that the District will pursue in the near-term. Specifically, the District will explore a competitive request for proposals for a new PPA after the current PPA with the Port of Oakland expires in 2024. In addition, the District is currently piloting a program for on-site electric vehicle charging at the MWWTP, which can take advantage of State of California incentives through the Low Carbon Fuel Standard program and will be expanded if the pilot is successful.

There are several other considerations in the Master Plan that may potentially change biogas utilization, including future nutrient regulations, near-term dewatering capacity challenges, and GHG emissions reduction goals. These considerations aren't expected to force any changes to the existing renewable energy production scheme at the MWWTP in the near term, but could and likely will over a longer time frame. In addition, there are factors outside the District's control that could result in more positive conditions for the expansion of biogas utilization. State and federal policies, as well as technological innovation could improve the outlook for biogas utilization benefits. The District will continue to re-evaluate new opportunities, engage with regulators on a proactive basis, and reach out to potential project partners.

Greenhouse Gases

The near-term roadmap includes continued coordination with The Climate Registry to guide the calculation of the District's GHG emissions. Based on the District's recently adopted GHG emission policy for the wastewater system (Policy 7.07), the roadmap includes strategies to minimize emissions at the MWWTP that include:

- Reducing TIN discharges to the Bay with Right-Size R2, low-cost innovative nutrient management solutions, and SST.
- Eliminating diesel use by switching to 100% renewable diesel.
- Consideration of eliminating natural gas use by converting building boiler systems to electric systems.
- Obtaining fertilizer offset credit and carbon sequestration for biosolids beneficial uses.
- Prioritizing biogas use to a post-digestion facility to further minimize use of natural gas.

Recycled Water

The roadmap for all recycled water projects originates in the District's Recycled Water Master Plan Update (EBMUD 2019). The near-term roadmap includes continued coordination for the potential expansion of EBRWF and evaluation of a potential Pt. Isabel Water Recycling Facility.

The long-term roadmap provides flexibility and land for a potential potable reuse facility at the MWWTP, although it is not currently anticipated to occur prior to 2050.

Influent and Effluent Pump Station Roadmap

The near-term roadmap for the IPS and EPS includes aging infrastructure rehabilitation, seismic rehabilitation, and capacity improvements. Chapter 9 describes the IPS and EPS roadmap in more detail.

Primary Sedimentation Tank Roadmap

The near-term roadmap for the primary sedimentation tanks (PSTs) includes seismic retrofits. If flows and loads increase as projected in the Master Plan analysis, then chemically enhanced primary treatment (CEPT) could be implemented to address secondary system capacity limitations on an intermittent or as-needed basis. Testing would be necessary to confirm design criteria for CEPT prior to implementation. To track how flow and load projections develop over time, water quality will continue to be monitored.

The long-term roadmap for the PSTs includes potentially covering the PSTs and providing foul air treatment. The District continually investigates low-cost operational changes to proactively manage odors. Prior to implementation, a full evaluation of the best overall approach to controlling odors will consider pre-chlorination and sludge blanket control optimization, among others.

Chapter 9 describes the PST roadmap in more detail.

Secondary Treatment Roadmap

If flows and loads increase as projected in the Master Plan analysis, the near-term roadmap for the secondary system includes performing targeted flocculation testing to define design criteria for the step-feed configuration, implementation of CEPT, and phased conversion to the step-feed configuration. Improvements to the Stage 2 aerators are identified for Phase 2 of step-feed conversion.

The timing of these projects is highly dependent on actual influent loads. The projections used in the Master Plan analysis are likely conservative based on the most recently collected influent data, and the roadmap projects for the secondary treatment system are not likely to be needed immediately. As a result, the primary effort of the near-term roadmap for the secondary system is to routinely monitor flow and load trends to determine if the capacity trigger has been met.

If nutrient regulations are stricter than anticipated (e.g. effluent TIN concentration limits), then early implementation of mainstream nutrient removal would be required. As a result, Phase 2 of step-feed conversion would not be needed.

Chapter 9 describes the secondary treatment roadmap in more detail.

Disinfection Roadmap

The near-term roadmap includes the implementation of previously identified CIP projects to address aging infrastructure in the hypochlorite dosing system and at the Dechlorination Facility. Alternative disinfection technologies have been evaluated by the District, and no technologies were determined to be suitable.

The long-term roadmap includes continued monitoring and re-evaluation of alternative disinfection technologies. If mainstream nutrient removal were implemented, the secondary effluent water quality would be improved, potentially allowing some alternative disinfection technologies to be more suitable.

Chapter 9 describes the disinfection roadmap in more detail.

Process Improvements Roadmap

Process improvements identified for the roadmap include grit removal improvements at the Blend Tank and the aerated grit tanks; struvite mitigation projects; and screening of solids. These projects could improve operational performance, but are optional. Given other infrastructure renewal needs, these projects would only be implemented when CIP funds are available. Chapter 10 describes the process improvements roadmap in more detail.

Aesthetics and Function Roadmap

It is recommended that a program be developed to integrate aesthetics and function at the MWWTP. Currently, facilities vary in architectural style, colors, and materials, and as a result, lack a unifying theme. Standardization of architectural and aesthetic guidelines will create a cohesive style. In addition to aesthetics, the overall site plan of future facilities must be functional. This includes considerations such as vehicle/truck routing, pedestrian travel, parking, and the ability to secure off certain areas for O&M or construction staging. These considerations will be developed further as part of the New Dewatering Building project, which is a large-scale, prominent new building that will require additions and modifications to existing vehicle routing, and will influence future planned facilities such as SST.

CHAPTER 1 INTRODUCTION

1.1 Purpose

The goal of the East Bay Municipal Utility District's (District's) Integrated Main Wastewater Treatment Plant (MWWTP) Master Plan Project (Master Plan) is to inform an integrated and adaptive 30-year roadmap of major projects for the District's capital improvement program (CIP) to address new regulations, capacity constraints, climate change resiliency, and the continuous challenge of aging infrastructure.

This report summarizes the evaluations and analyses that were undertaken to determine the best overall solutions that align with the District's strategic goals and guiding principles. The roadmap is comprised of both near-term CIP projects (defined as 2021 to 2030) and long-term CIP projects (defined as 2031 to 2050). The term "planning horizon" refers to the 30-year outlook ending in 2050.

This report is organized as follows:

- Chapter 1: Introduction
- Chapter 2: Flow and Load Projections
- Chapter 3: Aging Infrastructure
- Chapter 4: Nutrient Management
- Chapter 5: Biosolids Management
- Chapter 6: Solids Facilities
- Chapter 7: Climate Change Resiliency
- Chapter 8: Pumping Systems
- Chapter 9: Liquids Facilities
- Chapter 10: Process Improvements
- Chapter 11: Integrated Roadmap
- Chapter 12: References and Appendices

1.2 Background

The MWWTP is located in West Oakland and is bordered by Interstate 80/580 and 880 to the north, Union Pacific Railroad to the east, and City of Oakland property to the south and southwest. A site plan and a process flow diagram of the MWWTP are provided in Figure 1-1 and Figure 1-2. A complete description of the treatment facilities is provided in Appendix A. A summary of previous and ongoing studies is provided in Appendix B.

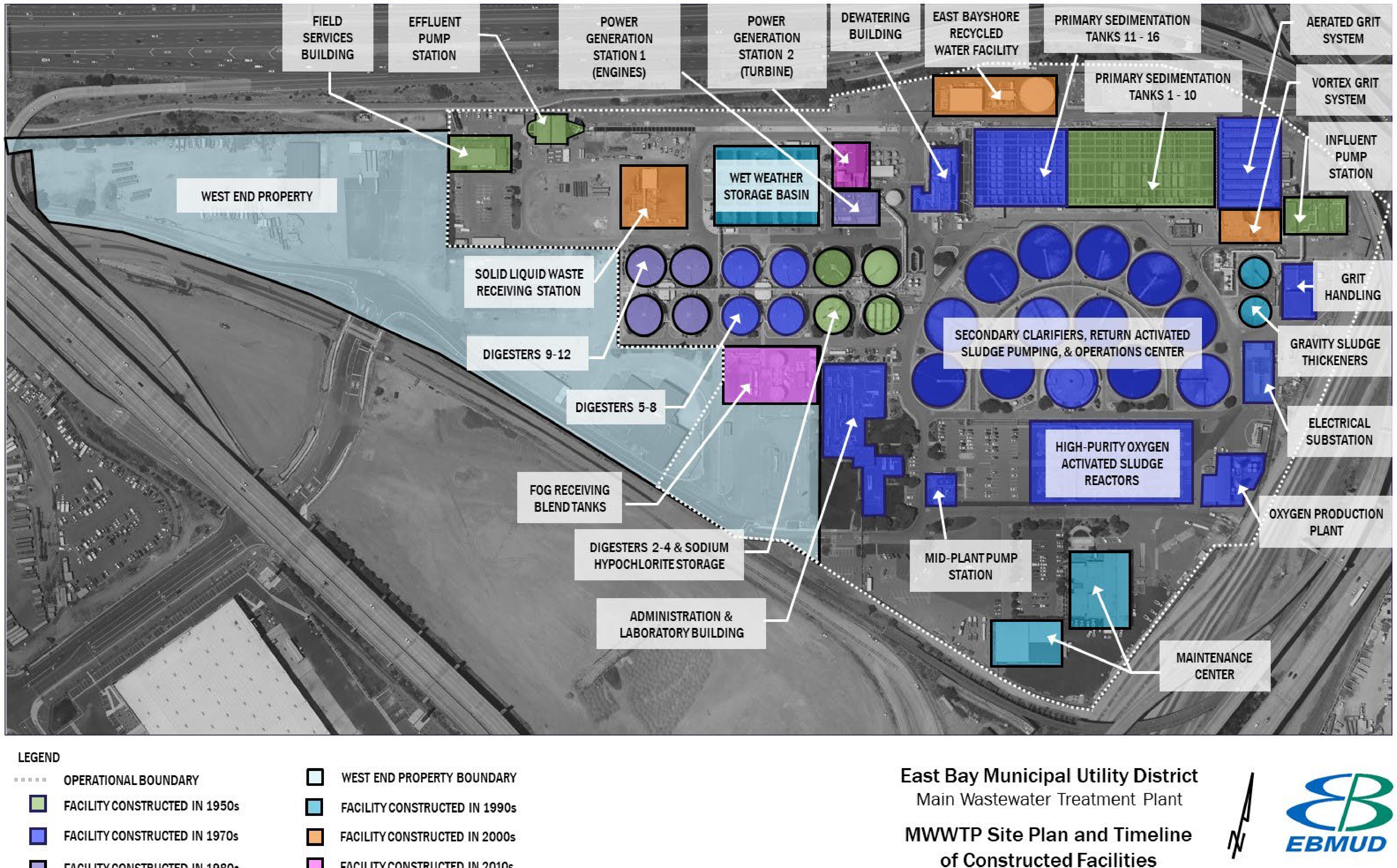

Figure 1-1. MWWTP site plan and timeline of constructed facilities

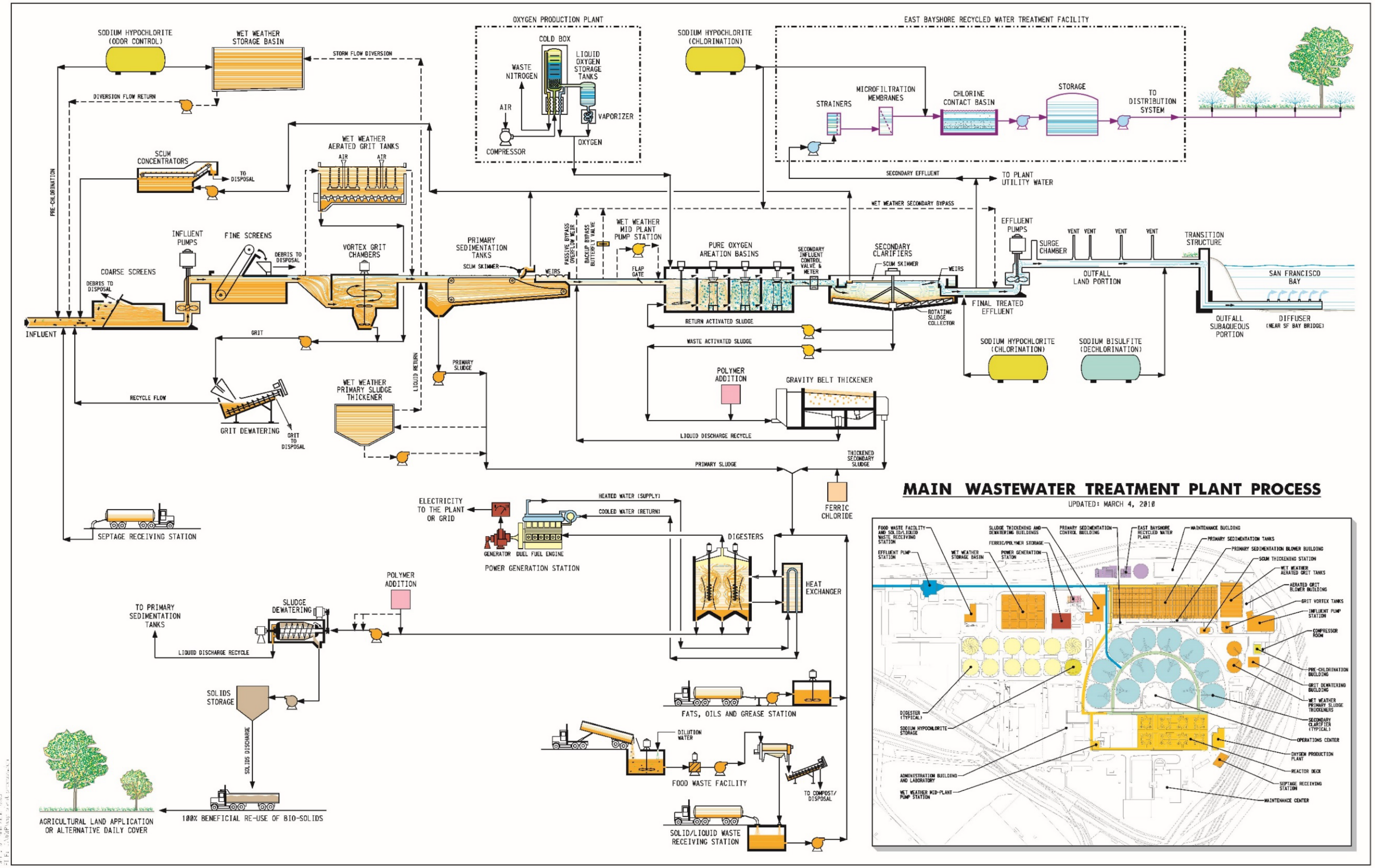

Figure 1-2. MWWTP process flow diagram

The MWWTP discharges to the San Francisco Bay (Bay) under the District's National Pollutant Discharge Elimination System Permit (Order No. R2-2020-0024). Raw wastewater is pumped, screened, and degritted prior to primary sedimentation, secondary biological treatment (high-purity oxygen activated sludge [HPOAS] reactors and secondary clarification), chlorine disinfection, and dechlorination. Treated wastewater is discharged to the Bay through an outfall located 1.2 miles away from the shoreline at a depth of approximately 50 ft. The permitted dry weather secondary capacity is 120 million gallons per day (mgd); however, the secondary system can treat flows up to 168 mgd with all units in service. During wet weather events, blending is permitted for flows greater than 150 mgd. During blending, primary effluent and secondary effluent are mixed together prior to disinfection, dechlorination, and discharge. A portion of secondary effluent is reused at the MWWTP, and a portion is diverted to the East Bayshore Recycled Water Facility (EBRWF) to produce non-potable recycled water that is used locally primarily for landscape irrigation.

The District operates a Resource Recovery (R2) program that accepts three types of trucked wastes: low-strength wastes (LSW), high-strength wastes (HSW), and high-strength brine waste (K2 brine waste). LSW is added to the plant headworks and typically includes water treatment sludge, septage, and brine waste streams. LSW converges with wastewater from the interceptors prior to entering the Influent Pump Station (IPS) where influent water quality is monitored. HSW is discharged to two receiving stations and pumped to the Blend Tanks, where it mixes with primary sludge and thickened waste activated sludge (TWAS). The mixture is then pumped to the anaerobic digesters for solids treatment. The HSW waste streams typically include liquid organic waste; dairy waste; fats, oils, and grease (FOG); and food waste. Digestion of the HSW streams increases biogas and energy production such that in recent years, the District has produced more energy than is required to operate the MWWTP. Excess power is currently sold to the Port of Oakland (Port) through a power purchase agreement (PPA). K2 brine waste is discharged to the plant effluent channel immediately upstream of the Effluent Pump Station (EPS).

The R2 waste streams increase nitrogen and solids loading at the MWWTP. Based on the plant process model that was developed for the Master Plan (Appendix O), LSW and HSW contribute approximately 20% of the total inorganic nitrogen (TIN) load discharged to the Bay, 35% of the biosolids, and 60% of biogas produced. The nitrogen and phosphorus in R2 wastes also contribute to the formation of struvite (magnesium ammonium phosphate) in the digesters, dewatering centrifuges, transfer sludge, digested sludge, and centrate pipelines.

1.3 Master Plan Drivers and Triggers

Four primary drivers were considered for the Master Plan: regulatory, aging infrastructure, capacity constraints, and climate change resiliency. Process improvements were also considered to identify projects that could improve process performance and ease operations and maintenance (O&M) challenges. Implementation triggers were established to provide a basis for the implementation timeline of projects. The following subsections provide an overview of each driver and explain how the drivers were used as the basis for developing project implementation timelines.

1.4 Regulatory Drivers

Regulations on nutrient discharges, biosolids management, and air emissions were identified as key regulatory drivers for CIP projects over the 30-year planning horizon. Appendix C includes a comprehensive review of current and future regulations.

1.4.1 Nutrient Discharges

Nutrients in the Bay are a major issue for the Bay Area water quality community. Historically, the Bay has not been adversely impacted by nutrient loading even though it is nutrient enriched compared to other estuaries around the country. Stakeholders throughout the region wish to better understand this resiliency, and whether it may be threatened in the future.

Numerous scientific monitoring and modeling studies are being conducted to understand the impact of nutrients on the San Francisco Bay (Bay). This includes the San Francisco Estuary Institute's Regional Monitoring Program, which the District helps fund and oversee. While these nutrient studies are ongoing, the District is working with other Bay stakeholders, including regulators, publicly owned treatment works (POTWs), and scientists, to ensure that any future nutrient effluent limits are based on sound science.

In April 2014, the Regional Water Quality Control Board (RWQCB) issued the *Waste Discharge Requirements for Nutrients from Municipal Wastewater Discharges to San Francisco Bay* (Order No. R2-2014-0014). The regional order, which is commonly referred to as the Nutrient Watershed Permit (NWP), required Bay dischargers to perform both a nutrient reduction study and effluent monitoring. To comply with the NWP requirements, the District prepared the 2018 Nutrient Reduction Study under the Bay Area Clean Water Agencies (BACWA) joint power authority. The 2018 Nutrient Reduction Study included an analysis of facility upgrades and cost estimates at the 37 BACWA POTWs that would be needed to meet the following nutrient removal levels:

- **<u>Level 1 – Optimization:</u>** Defined as the maximum level of nutrient removal that could be achieved through optimization of existing treatment facilities and with minimal capital improvement projects.
- **<u>Level 2 - Nutrient Removal:</u>** Defined as a total nitrogen (TN) concentration-based limit equal to 15 mg-N/L and a total phosphorous (TP) concentration-based limit equal to 1 mg-P/L.
- **<u>Level 3 – Nutrient Removal:</u>** Defined to meet a TN concentration-based limit of 6 mg-N/L and a TP concentration-based limit of 0.3 mg-P/L.

The NWP was renewed in 2019 and includes in the fact sheet seasonal TIN load targets for each Bay discharger. It is anticipated that the seasonal load targets in the 2019 NWP fact sheet will be regulated within the planning horizon of the Master Plan, potentially as early as 2024/2025 (anticipated year of NWP renewal).

While there have been ongoing studies to inform the RWQCB on the impact of nutrients on the Bay, there is still uncertainty with respect to timing and the constituent (or form) that will be regulated. Based on the 2019 NWP, ongoing science-based studies of the Bay, and the District's discussions with the RWQCB, the Master Plan considered the seasonal TIN (not TN) load target that is included in the 2019 NWP fact sheet (referred to herein as the Master Plan Target). The Master Plan Target was considered to be the primary nutrient regulatory endpoint to occur in the 30-year planning horizon. Table 1-1 provides details on the Master Plan Target. The Level 2 Off-Ramp presented in Table 1-1 is a lower nutrient endpoint that could occur either during the 30-year planning horizon or after the Master Plan horizon, depending on conditions in the Bay. For the purposes of the Master Plan, the earliest that the Level 2 Off-Ramp was assumed to occur was in 2045, with a compliance year of 2055. TP was not included as a nutrient endpoint for the Master Plan Target or the Level 2 Off-Ramp because it has not been identified as the growth-limiting nutrient in the Bay. The Level 3 Off-Ramp was assumed to occur beyond the Master Plan horizon and was considered for land use planning purposes only.

Table 1-1. Nutrient reduction targets assumed for the Master Plan

Nutrient Endpoint	Nitrogen	Phosphorus	Estimated Year Included in Permit [a]	Estimated Compliance Year [a]
Current Baseline[b]	TIN = 9,500 kg-N/d TIN = 54 mg-N/L	840 kg-P/d 4.8 mg-P/L	--	--
Master Plan Target	TIN Seasonal Load Target = 11,000 kg-N/d[c]	No target anticipated	2024±	2030±
Level 2 Off-Ramp[a,d]	TIN = 15 mg-N/L TIN Load = 3,750 kg/d	No target anticipated	2045±	2055±
Level 3 Off- Ramp [a,e]	TN = 6 mg-N/L	0.3 mg-P/L	Outside of Master Plan Horizon	Outside of Master Plan Horizon

a. Timing is uncertain and contingent on findings of ongoing science-based studies of the Bay.

b. Current baseline is for 2016-2020 dry weather seasons.

c. TIN load target is included in the 2019 NWP Fact Sheet. The seasonal period is defined as May 1 through September 30.

d. The averaging period is uncertain, but was assumed to be an annual average based limit (concentration or load based limit). TIN was assumed as the constituent because the 2019 NWP states that nitrogen is the growth-limiting nutrient for phytoplankton in the Bay, and TIN is the bioavailable form of nitrogen.

e. Concentration-based limit that is based on the Level 3 nutrient removal assumptions included in the 2018 Nutrient Reduction Study. An annual averaging period is assumed.

1.4.2 Biosolids Management

Within the planning horizon, Class B land application of biosolids during dry weather months is considered a secure outlet with adequate capacity and numerous benefits, including lower cost, improvements to soil fertility and water retention capacity, and carbon sequestration. Currently, there is no regulatory requirement to further process biosolids to Class A biosolids cake or product specifically for land application. However, the following key considerations were identified in the development of biosolids management alternatives for the Master Plan:

- **Limited local wet weather outlets:** In recent years, solid waste regulations went into effect and have resulted in biosolids becoming less desirable for use at landfills. In some cases, landfills have stopped accepting biosolids altogether for alternative daily cover (ADC). In addition, Senate Bill (SB) 1383 "Short-Lived Climate Pollutants: Organic Waste Methane Emissions Reductions," was passed, which sets targets for diversion of organics from landfills that become enforceable in 2022. In response to this new regulation, it is anticipated that landfills or the jurisdictions where landfills reside will prohibit biosolids use at landfills, regardless of whether it is for ADC or disposal. As a result, ADC or landfill diversion is not considered a reliable or cost-effective outlet in the future. The primary alternative to ADC or landfill is diversion to merchant facilities for storage or post-digestion processing. The increased demand and limited supply have resulted in cost increases at merchant facilities, and this trend is anticipated to continue until more merchant capacity is brought online.
- **Increases in Hauling/Transportation Costs:** The Federal Motor Carrier Safety Administration published the Electronic Logging Device (ELD or e-log) rule, which requires truck drivers to maintain an electronic log of the time spent driving. ELDs facilitate compliance with rules that limit a truck driver's hours of service. The ELDs have a greater impact on biosolids routes that are longer (e.g. from the MWWTP to Merced), because a hauler may need more drivers to complete the same number of deliveries. More drivers have been required to meet this new regulation, in particular on these longer routes, and therefore overall biosolids management costs have increased.
- **Perfluoroalkyl and polyfluoroalkyl substances (PFAS):** PFAS are a group of chemicals used to make fluoropolymer coatings and products that resist heat, oil, stains, grease, and water. In the state of California, monitoring of PFAS in biosolids started in 2020. Federal and/or state regulations on PFAS are anticipated to be developed within the next three years, likely starting with monitoring requirements. There is no clear guidance yet on whether PFAS will be regulated in biosolids. If biosolids are regulated for PFAS at either the state or federal level, and depending on how strict those regulations are, it could result in limits to land application of biosolids, which would have significant cost implications.

1.4.3 Air Emissions

Air regulations for the Master Plan focus on the Bay Area Air Quality Management District's (BAAQMD) Rule 11-18 "Reduction of Risk from Air Toxic Emissions at Existing Facilities." Rule 11-18 was adopted in 2017 and requires an update to the health risk assessment (HRA) at the MWWTP, which was last performed in 1991. The list of toxic air contaminants (TACs) that falls under Rule 11-18 has been expanded by the California Air Resources Board, as part of the Criteria Air Pollutants and TACs Reporting Regulation under Assembly Bill (AB) 617 and under the Air Toxics "Hot Spots" Program Emission Inventory Criteria and Guidelines (EICG) under

AB 2588. The BAAQMD intends to follow the updated EICG, including development of a sector-specific short list. It has been stated that the wastewater sector may have until 2026 to develop the shortlist of wastewater-specific compounds. In the meantime, BAAQMD will be conservative in the choice of data that it uses in the HRA, relying on Environmental Protection Agency (EPA) AP-42, California Air Toxic Emission Factors and collecting source test data from facilities (updating emission factors as possible).

The BAAQMD is expected to start HRAs for POTWs sometime in 2021 with an expected duration of 18 months. If the BAAQMD determines through preliminary calculations that the District exceeds the cancer or non-cancer risk action level, the BAAQMD will commence an 18-month process consisting of a Data Review (7 months), the Draft HRA (7 months), and 4 months for review with the District resulting in a final HRA. Once the HRA has been finalized, if cancer risk scores are greater than the risk action level of 10 per million, the District would need to develop a Risk Reduction Plan (RRP). The RRP would be developed over an 18-month duration. Upon adoption of the RRP, annual progress reports must be produced during the 5-year implementation timeline (an extension of up to 5 years for implementation can be requested). Facilities located within an at-risk AB 617 community (as is the case for the District) may be asked to accelerate implementation of their RRPs to be in compliance with both AB 617 and Rule 11-18. Installing additional pollution controls (e.g., diesel particulate filters or other post-combustion controls) on the existing engines will likely be the most effective way to reduce the Risk Action Level to below 10 per million.

Regulation 13 is another future regulation that has the goal of reducing statewide greenhouse gas emissions (GHGs). Upon drafting regulatory language, BAAQMD staff learned they do not have enough data upon which to base a regulation. Therefore, development of the regulation has been suspended while BAAQMD collects information on best management practices (BMPs) currently utilized to control methane and volatile organic compounds (VOC) emissions. Thus, Regulation 13 is not anticipated to impact CIP projects within the planning horizon of the Master Plan. However, the District will likely want to participate in surveys and studies that will summarize BMPs to minimize emissions of methane and VOCs and confirm if the BMPs should be standard permit conditions.

1.4.4 Consent Decree

In 2014, the District and satellite agencies entered into a Consent Decree to significantly reduce inflow and infiltration (I&I) from the collection system during wet weather. Reductions in I&I are achieved through a combination of activities, including repair of private sewer laterals and capital projects. The Consent Decree has a duration 22 years, ending in 2036. For the Master Plan, the analysis is focused on the processes within the MWWTP boundary, and the assumption is that the District's existing I&I reduction approach to Consent Decree will continue. Therefore, the Master Plan does not propose any modifications to treatment processes at the MWWTP to address peak wet weather flows beyond ensuring that sufficient hydraulic capacity remains available as the population grows. The District will continue to comply with the Consent Decree, and no additional projects were identified for inclusion in the roadmap beyond the existing ongoing efforts to comply with the Consent Decree.

1.5 Aging Infrastructure Driver

The aging infrastructure driver refers to two components:

- Existing capital assets such as facilities, structures, and equipment that deteriorate over time, and require rehabilitation and replacement. As shown in Figure 1-1, the structures and facilities at the MWWTP were constructed at various stages over the past 70 years.

- Structural facilities that can be seismically retrofitted to improve structural performance during a seismic event.

Aging infrastructure improvements are needed for a variety of reasons, including to maintain the current performance and function of the MWWTP, improve reliability, and reduce failures. The focus of the Master Plan with respect to aging infrastructure was to ensure that all investments are strategic and "no regrets." For example, renewal of an aging capital asset is not prudent if, within a short timeframe, that asset is replaced to address a different driver such as a regulatory project.

As part of the Master Plan, the District performed a thorough inventory of the condition of the existing capital assets at the MWWTP, which is summarized in the Infrastructure Renewal Needs Task Report (Appendix D). The structural, electrical, and mechanical condition of existing capital assets with an estimated value of $10,000 or more was evaluated. This study concluded that $40 million per year is needed for infrastructure renewal at the MWWTP for the next 30 years.

In addition, the District also performed detailed geotechnical and seismic structural analyses. The analyses identified the need for seismic rehabilitation of structures to meet the safety and seismic reliability goals established by the District. The results of those two analyses were considered in the development of the Master Plan roadmap.

1.6 Capacity Driver

A capacity assessment of the major unit processes at the MWWTP was performed to determine whether unit processes have adequate hydraulic and process capacity to accommodate flow and load projections at different checkpoints within the planning horizon. The capacity assessment considered growth in the population and R2 program as described in Chapter 2, as well as redundancy criteria established by the District (refer to Appendix I and Appendix P).

1.7 Climate Change Resiliency Driver

Climate change resiliency includes sea level rise, biogas utilization, GHG emissions, and water reuse. Each of these categories are discussed below.

1.7.1 Sea Level Rise

The District performed a vulnerability assessment to identify the extent to which District wastewater facilities are affected by sea level rise (Appendix E). The assessment showed that the facilities located within the central portion of the MWWTP are expected to avoid inundation due to sea level rise within the planning horizon. The Dechlorination Facility and Transition Structure near the shoreline of the Bay are at risk of flooding during 100-year storm surges beginning under current conditions. All future projects will consider the District's climate change design guidelines for any capital projects and, if determined to be impacted by sea level rise in the future, will implement preventative measures to avoid impacts of inundation due to future sea level rise, even beyond the Master Plan planning horizon.

1.7.2 Biogas Utilization

The MWWTP generates biogas in sufficient quantities to fuel its engines and turbine and generate renewable electricity that is used to power the MWWTP. The District currently exports and sells excess electricity according to the terms of a PPA with the Port. The District is evaluating alternative biogas utilization options for the Master Plan with the following considerations:

- The costs of operating and maintaining the engines and turbines has increased over the years. The engines were originally installed in 1985 and require ongoing maintenance and regular overhauls to maintain performance and extend life. The turbine requires an ongoing maintenance contract with the manufacturer for maintenance, monitoring, and regular overhauls. The current agreement with Solar Turbines is set to expire in November 2023 and currently costs the District in excess of $700,000 per year. In addition, the support equipment (e.g. gas compressors, exhaust equipment, cooling equipment, heat exchangers, piping, and other components) requires considerable maintenance attention.
- Biogas production is highly dependent on the characteristics and quantity of R2 trucked waste deliveries, with approximately one half to two thirds of total biogas originating from trucked high-strength waste. Future biogas production will depend on which types of waste continue to be delivered to the District.
- There has been a downward trend in the value of renewable energy prices. The District's PPA with the Port expires in 2022. In advance of this event, District staff has performed a market assessment for surplus renewable power by engaging with parties that are potentially interested in the upcoming PPA, including the Port, East Bay Community Energy, Peninsula Clean Energy, and other regional community choice aggregators. The District issued a Request for Expressions of Interest and received two responses. Based on the responses, the District expects to obtain more favorable terms in the future PPA; however, negotiations are still ongoing.

- The cost of purchased power at the MWWTP has remained low in recent years (approximately $0.07/kWh, but the value fluctuates from year to year, with some signs of trending up).

The factors described above provide insight on an implementation timeframe for the District to either continue with existing practices and/or develop new biogas utilization alternatives. New alternatives must integrate with other Master Plan projects and align with the Master Plan guiding principles and objectives such as achieving 100% renewable energy, maximizing R2, and reducing GHG emissions. For more information on biogas utilization, refer to Appendix K.

1.7.3 Greenhouse Gas Emissions

The District's goal for the wastewater system is to reduce indirect emissions to a net zero increase and reduce direct emissions by 50% by 2040, compared to 2000 levels (District Policy 7.07). At the MWWTP, the indirect emissions include power use, and the direct emissions include combustion of fuel (i.e., natural gas) and treatment/discharge of wastewater (e.g., nitrogen content of wastewater discharges and process emissions).

In 2019, the District began utilizing a GHG emissions inventory methodology developed by The Climate Registry known as the Water-Energy Nexus protocol. The 2019 protocol modifications added new sources of GHG emissions, thereby increasing the District's GHG inventory substantially. Additional sources were added in 2020, which further increased the District's inventory. The District has been collaborating with The Climate Registry to review possible options to account for carbon sequestration and fertilizer offset credits resulting from land application of biosolids. Further discussions and formal agreements with the District's biosolids haulers will likely be required before these offsets could be included in the District's inventory.

Based on these established goals, the Master Plan includes the consideration of technologies that are less energy-intensive, maximize biogas use, provide for the continued beneficial use of biosolids, and increase GHG offsets associated with carbon sequestration and avoided fertilizer use.

1.7.4 Recycled Water

In 2019, the District prepared the Recycled Water Master Plan Update. The updated plan identified non-potable and potable reuse projects that could achieve the District's goal of 20 mgd of water reuse by 2040. Two non-potable reuse projects have been identified for additional evaluation to confirm project costs and implementation details:

- Phased expansion of the East Bayshore Recycled Water Facility to ultimately deliver up to 2.6 mgd of recycled water to irrigation customers in Oakland, Emeryville, Alameda, Albany and Berkeley.
- Satellite treatment at Pt. Isabel Wet Weather Facility to produce recycled water that is suitable as feed water at the North Richmond Water Reclamation Plant and/or the Richmond Advanced Recycled Expansion (RARE) facility.

In addition to these projects, the Recycled Water Master Plan Update also included the consideration of potable reuse at the MWWTP. Potable reuse projects are very costly, with many challenges from a practical, regulatory, environmental, and community-impact perspective. Because of those challenges, further consideration of a potable reuse project would require a major change in drivers, for example, a new regulation requiring diversion of treated wastewater effluent.

1.8 Process Improvements

Process improvements are defined as capital projects that can provide performance benefits such as improved performance, reduction of O&M, enhanced reliability, or synergistic benefits to other processes. These projects could be implemented at any time when capital funding is available, but they are not essential. These projects are not driven by regulations, capacity constraints, or aging infrastructure.

As part of the treatment performance evaluation (Appendix I) and capacity assessment (Appendix P), the following potential process improvement projects were identified:

- Aerated Grit System – Could be optimized to improve grit removal efficiency.
- Struvite Removal – Struvite precipitation in various locations, including the digesters, dewatering system, and centrate piping, has been identified as an O&M issue that impacts performance. Struvite recovery and/or mitigation solutions were considered. All struvite removal processes have high capital costs. Based on the current direction of nutrient regulations, it is not anticipated that phosphorus load or concentration limits will be regulated over the planning horizon. If phosphorous regulations were in place, a struvite removal technology could be justified to reduce phosphorous levels in the effluent; however, in the absence of phosphorous limits, such a technology is only under consideration as a potential optimization to reduce O&M and improve reliability.

1.9 Implementation Triggers

Figure 1-3 provides an overview of the four Master Plan drivers and the timing of implementation triggers that provide the basis for the Master Plan CIP projects. Note that optimization projects do not have a time-based trigger and can implemented at any time in the planning horizon. As noted throughout this chapter, there is uncertainty with respect to the timing of regulatory triggers, but the years indicated in Figure 1-3 provide the basis for the assumptions used in the Master Plan roadmap.

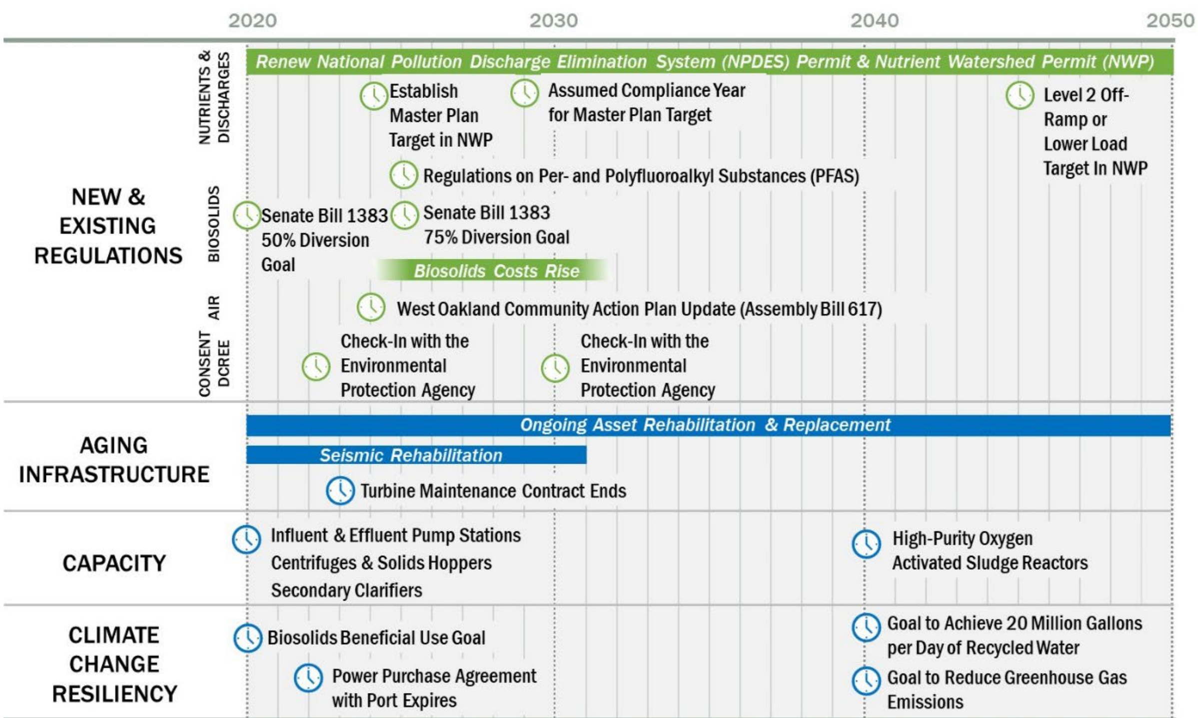

Figure 1-3. Implementation triggers for the Master Plan roadmap

CHAPTER 2 FLOW AND LOAD PROJECTIONS

The term "flows and loads" refers to hydraulic and mass loading. The District developed projections for the growth of flows and loads at the MWWTP through the planning horizon for:

- **Influent Wastewater:** Influent wastewater refers to municipal wastewater coming from the collection and interceptor systems from residential, commercial, institutional, and industrial users.
- **Resource Recovery (R2) Wastes:** R2 wastes include both low-strength waste (LSW) and high-strength waste (HSW). LSW converges with influent wastewater prior to entering the Influent Pump Station (IPS) where influent water quality is monitored. HSW is discharged to two receiving stations and pumped to the Blend Tanks, where it mixes with primary sludge and thickened waste activated sludge (TWAS). The mixture is then pumped to the anaerobic digesters for solids treatment.

Appendix G and Appendix H provide the detailed analyses that were performed for these projections.

2.1 Medium Growth Scenario

Three growth scenarios (low, medium, and high) were developed to bracket the expected range of growth of flows and loads given various uncertainties. The Master Plan analyses described in subsequent chapters assumed medium growth in both the service area and the R2 program, which is hereby referred to as the Medium Growth Scenario.

Tables 2-1 and 2-2 summarize the flow and load projections for various conditions, including average dry weather (ADW), maximum month (MM), maximum day (MD). Flows and loads are expressed in million gallons per day (mgd) and pounds per day (lb/d), respectively.

Table 2-1 shows projections for flows and loads at the IPS (including influent wastewater and LSW) under the Medium Growth Scenario. Table 2-2 shows projections for HSW under the Medium Growth Scenario.

Table 2-1. Projections for flows and loads at the IPS (including influent wastewater and LSW) under the Medium Growth Scenario

Condition	2020	2030	2040	2050
Flow				
ADW, mgd	52	56	61	66
MM, mgd	115	124	134	146
MD, mgd	281	284	289	294
Carbonaceous Biological Oxygen Demand (cBOD) Loading				
ADW, lb/d	170,200	192,500	217,600	246,000
MM, lb/d	207,700	234,900	265,500	300,300
MD, lb/d	365,600	413,500	467,500	528,600
Total Suspended Solids (TSS) Loading				
ADW, lb/d	193,600	218,500	246,700	278,400
MM, lb/d	282,200	318,500	359,700	406,000
MD, lb/d	601,400	678,800	766,400	865,100
Total Kjeldahl Nitrogen (TKN) Loading[a]				
ADW, lb/d	26,500	30,000	33,700	38,100
MM, lb/d	31,800	36,000	40,500	45,800
MD, lb/d	35,000	40,000	44,600	50,500
Total Phosphorus (TP) Loading[a]				
ADW, lb/d	4,300	4,900	5,500	6,200
MM, lb/d	5,400	6,100	6,900	7,800
MD, lb/d	6,000	6,800	7,700	8,700

a. TKN:NH3-N ratio is 1.60; TP:OP ratio is 1.91

Table 2-2. Projections for HSW flows and loads under the Medium Growth Scenario

Condition	2020	2030	2040	2050
Flow, mgd				
ADW, gpd	240,600	235,000	240,000	244,600
MM, gpd	288,700	282,000	287,700	293,500
MD, gpd	409,000	399,500	407,600	415,800
Chemical Oxygen Demand (COD) Loading				
ADW, lb/d	177,940	192,800	196,700	200,700
MM, lb/d	213,500	231,400	236,000	240,800
MD, lb/d	302,500	327,700	334,400	341,100
Total Solids (TS) Loading				
ADW, lb/d	141,400	147,600	150,500	153,600
MM, lb/d	169,700	177,000	180,600	184,300
MD, lb/d	240,400	250,800	255,900	261,000
Volatile Solids (VS) Loading				
ADW, lb/d	114,700	122,300	124,800	127,300
MM, lb/d	137,700	146,800	149,700	152,700
MD, lb/d	195,000	207,900	212,100	216,400
Total Nitrogen (TN) Loading				
ADW, lb/d	6,900	7,000	7,100	7,300
MM, lb/d	8,200	8,400	8,600	8,700
MD, lb/d	11,700	11,900	12,100	12,400

In addition, solids peaking factors were developed for various solids process streams using historical data from 2015 through 2018. This approach considered the variable nature of R2, as well as the time response of solids systems to influent peak flows and loads. Appendix P includes a description of the methodology that was used.

2.2 Resource Recovery Scenarios

The contributions from different R2 streams were considered with respect to project sizing, cost, and implementation timing. Flows and loads for the following R2 scenarios were developed utilizing historical R2 characterization data (Appendix W). Chapter 11 further describes the impact of the following R2 scenarios:

- **No Change to R2**: This alternative represents the status quo. R2 would continue to be received at the MWWTP assuming the Medium Growth Scenario.
- **Right-Size R2:** R2 would continue to be received at the MWWTP with a targeted reduction in HSW. The reduction in HSW assumes eliminating protein (i.e., blood) and dairy (i.e., dissolved air flotation) wastes.
- **No High Strength Waste (HSW):** HSW streams would be eliminated, and the R2 program would only include LSW streams under the Medium Growth Scenario.
- **No Low-Strength Waste (LSW):** LSW streams would be eliminated, and the R2 program would only include HSW streams under the Medium Growth Scenario.
- **No R2:** All R2 wastes, including both HSW and LSW, would be eliminated. The MWWTP would only treat influent wastewater flows from the District's service area.

CHAPTER 3 AGING INFRASTRUCTURE

The Main Wastewater Treatment Plant (MWWTP) was originally constructed in 1951, and the majority of facilities were constructed over 40 years ago. To maintain reliable treatment, continued rehabilitation and replacement of aging infrastructure is needed across all treatment processes, as well as seismic rehabilitation projects for specific facilities. The focus of the Master Plan with respect to aging infrastructure was to ensure that all investments are strategic and "no regrets." For example, renewal of aging infrastructure is not prudent if, within a short timeframe, that asset is replaced to address a different driver such as a regulatory project.

3.1 Infrastructural Renewal Needs

The District performed a comprehensive review of capital assets at the MWWTP to identify and prioritize renewal needs. A visual condition assessment was performed, and the remaining useful life was estimated for all major mechanical, electrical, instrumentation, and structural capital assets. Additionally, the District performed a seismic evaluation of structures at the MWWTP to identify and prioritize rehabilitation of structures to meet the reliability and life safety goals. Finally, the District has identified facilities that require additional investigation and testing to confirm the condition and/or remaining useful life.

The District will continue to update the renewal priority projects as additional investigations are conducted, and these updates will ultimately inform future Capital Improvement Program (CIP) efforts. Projects identified for renewal in the next ten years include:

- Influent Pump Station (IPS): Electrical, seismic, and select equipment repair/replacement
- Grit Removal System: Concrete rehabilitation and select equipment replacement
- Oxygen Production Plant: Select improvements to address safety and extend useful life
- High-Purity Oxygen Activated Sludge (HPOAS) Reactors: Concrete rehabilitation of reactors and ancillary improvements
- Secondary Clarifiers: Continued rehabilitation of all clarifiers
- Effluent Pump Station (EPS) and Effluent Channel: Concrete rehabilitation and mechanical rehabilitation
- Dechlorination Facility: Piping replacement, emergency generator replacement, concrete rehabilitation and other reliability improvements
- Anaerobic Digesters: Seismic improvements, equipment upgrades, and coating rehabilitation
- Electrical System: Continued motor control center replacements, seismic retrofits, and other reliability improvements
- Power Generation Station: Replacement of aging equipment and piping, upgraded cooling equipment, improved heat exchangers
- Plant Utilities and Support Buildings: Miscellaneous equipment repairs

The complete details of aging infrastructure capital projects are in the District's Biennial CIP. Renewal of aging infrastructure will remain the primary near-term focus of capital projects for the District. The New Dewatering Building project would replace the dewatering and biosolids cake storage function of the existing Dewatering Building, and as a result, would eliminate the need for a major rehabilitation project for that existing building. No other major project was identified in the Master Plan roadmap in the near term that would eliminate the need for previously identified infrastructure renewal projects in the CIP. The Master Plan modified the following previously identified CIP projects:

- The CIP previously included two centrifuge replacement projects (Phase 2 and Phase 3); these projects have been replaced with a new CIP project for the New Dewatering Building (Phase 1).
- Odor control at the Dewatering Building is currently included in the CIP because improvements are needed for continued operation with the WAS thickening system. Adjustments to this project's scope are recommended prior to design/implementation to reflect that in the future the system will only provide odor control for WAS thickening.
- The CIP previously included Stage 3 HPOAS reactor aerator improvements. These improvements were included as part of the step-feed HPOAS reactor improvements to provide a single, coordinated project.

3.2 Seismic Resiliency

The District recently performed a seismic evaluation study of the structures at the MWWTP, which included a desktop analysis and detailed structural evaluations. Seismic rehabilitation projects of critical facilities were identified and developed to meet the District's life safety goals, and are shown in Figure 3-1. The schedule and preliminary budget costs of these rehabilitation projects are presented in Table 3-1. The schedule and budget costs for these projects will be refined as projects are implemented.

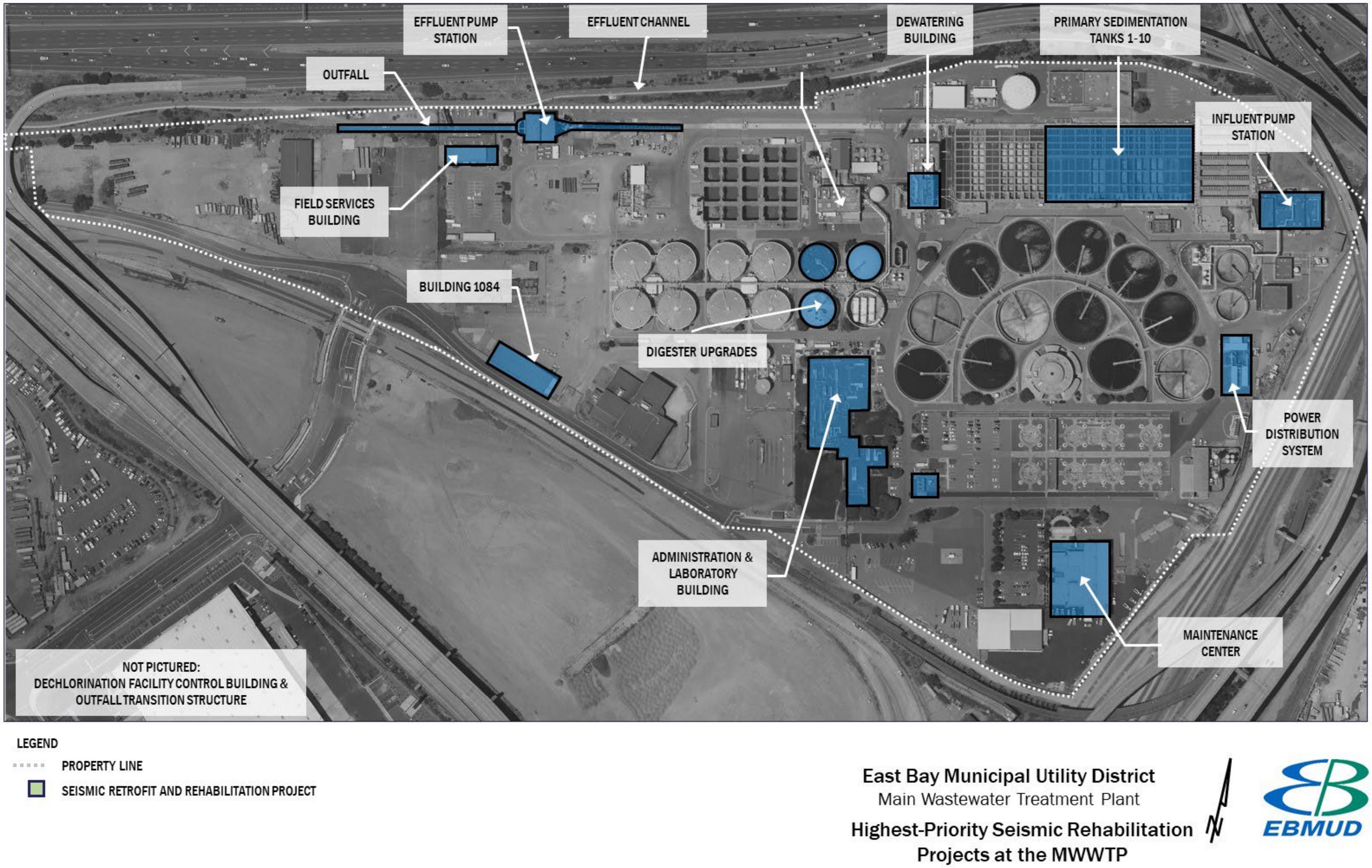

Figure 3-1. Highest-priority seismic rehabilitation projects at the MWWTP

Table 3-1. Implementation plan for highest-priority seismic rehabilitation projects at the MWWTP

Facility	Project Start	Basis for Implementation	Project Costs (Million)
Administration & Laboratory Building	FY22	Safety, building is occupied space	$0.5
Building 1084	FY22	Safety, building storage emergency response equipment that must be accessible following an earthquake	$1
Maintenance Center	FY22	Safety, building is occupied space	$12
Field Services Building	FY22	Safety, building is occupied space	$1
Power Distribution Facilities	FY22	Critical facility/reliability Continued use of facilities through planning horizon	$4
IPS	FY23	High priority for treatment reliability	$33
PSTs 1-10 Phase 1	FY24	High priority for treatment reliability	$55
EPS	FY28	Treatment reliability Continued use through planning horizon	$9
Outfall at MWWTP	FY28	High priority for treatment reliability	$6
Plant Effluent Channel	FY28	High priority for treatment reliability	$4
Digester Phase 4	FY29	Treatment reliability Continued use through planning horizon	$18
		Total	**$144**

CHAPTER 4 NUTRIENT MANAGEMENT

Nutrients in the San Francisco Bay (Bay) are a major focus of the Bay Area water quality community. Historically, the Bay has not been adversely impacted by nutrient loading even though it is considered nutrient enriched compared to other estuaries around the country. Stakeholders throughout the region have been working together to better understand this nutrient resiliency, and whether it may be threatened in the future.

Numerous scientific monitoring and modeling studies are being conducted to understand the impact of nutrients on the San Francisco Bay. This includes the San Francisco Estuary Institute's Regional Monitoring Program, which the District helps fund and oversee. While these nutrient studies are ongoing, the District is working with other Bay stakeholders, including regulators, publicly owned treatment works, and scientists, to ensure that any future nutrient effluent limits are based on sound science.

This chapter summarizes the nutrient roadmap to meet increasingly stringent water quality requirements, including the Master Plan Target, the Level 2 Off-Ramp, and the Level 3 Off-Ramp, as defined in Chapter 1. This roadmap builds on the Sidestream Treatment Alternatives Report (Sidestream Report) in Appendix R and the Nutrient Reduction Alternatives Report (Nutrient Report) in Appendix Q, in which Anita MOX and activated sludge biological nutrient removal (AS BNR) in the Modified Ludzak Ettinger (MLE) configuration were selected as placeholder technologies for planning purposes.

4.1 Master Plan Target Alternatives Evaluation

Multiple alternatives were evaluated that would each be capable of meeting a potential dry weather load cap target of 11,000 kg/day of total inorganic nitrogen (TIN), referred to as the Master Plan Target, at the Main Wastewater Treatment Plant (MWWTP). For planning purposes, it was assumed that the Master Plan Target would be issued in the 2024 Nutrient Watershed Permit with a compliance year of 2029. Figure 4-1 shows the seasonal TIN load discharged from 2015 through 2020, as well as the future projected discharges based on the Medium Growth Scenario and process model results. The effluent TIN has fluctuated, but remained generally stable in the last five years; however, projections could exceed 11,000 kg/day as early as 2021 if growth follows the assumptions of the Medium Growth Scenario. The load target may be exceeded later than 2021 if growth is less than planned.

The following alternatives were considered using the plant-wide process model with the Medium Growth Scenario:

- Increased recycled water
- Sidestream treatment (SST)
- Elimination of high-strength waste streams + sidestream treatment (No HSW + SST)
- Reduction in high-strength waste streams + sidestream treatment (Right-Size R2 + SST)
- Nitrification in the high-purity oxygen activated sludge reactors + sidestream treatment (HPOAS Nitrification + SST)
- Split Treatment (HPOAS and AS BNR)

Figure 4-2 illustrates how these alternatives would reduce TIN loads over the planning horizon. Some of the alternatives by themselves do not reduce TIN sufficiently for the entire planning horizon, so they are paired with subsequent SST. Accordingly, in Figure 4-2, these alternatives show two reductions over time.

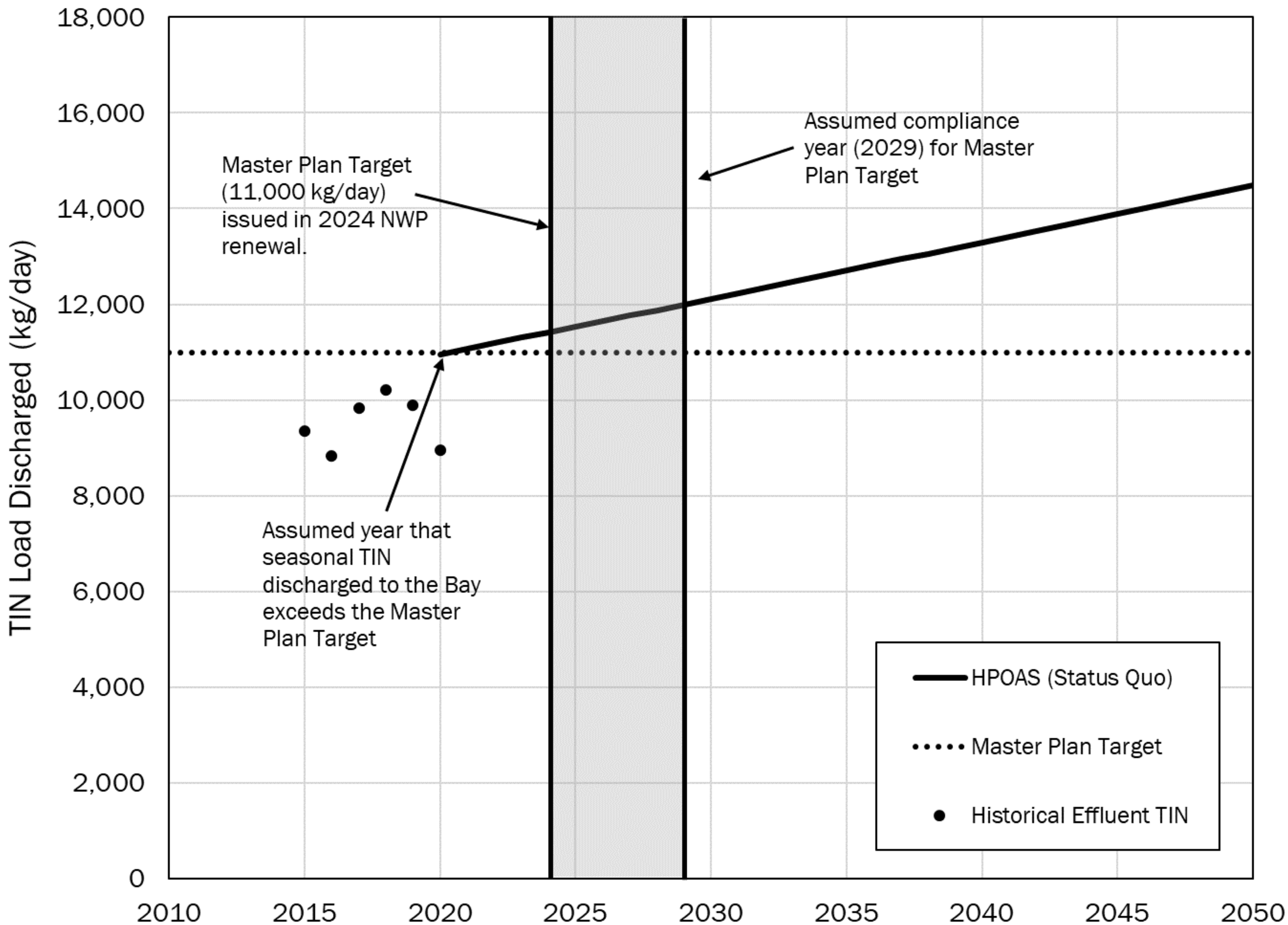

Figure 4-1. Historical and projected TIN discharges from the MWWTP

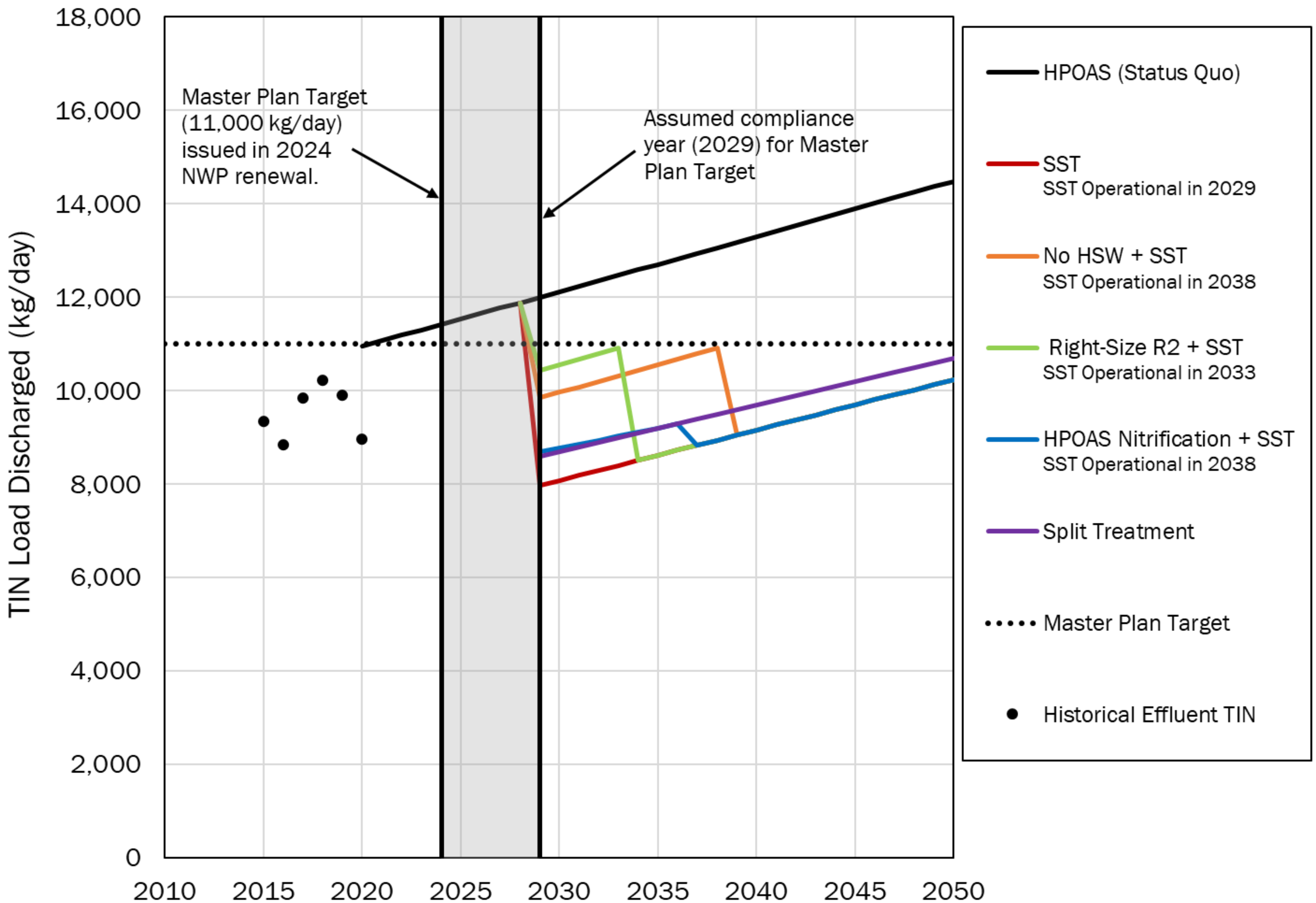

Figure 4-2. TIN load projections for Master Plan Target alternatives

4.1.1 Increased Recycled Water

Recycled water produced at the MWWTP contains TIN at the same concentration as the final effluent. If production of recycled water at the East Bayshore Recycled Water Facility (EBRWF) were increased, there would be a reduction in TIN loads discharged to the Bay. There would be an additional TIN reduction if a satellite recycled water treatment facility were constructed within the District's wastewater service area.

For the Master Plan, a recycled water alternative considered two potential future projects: expansion of the EBRWF and a new facility at the Pt. Isabel Wet Weather Facility (WWF).

- **East Bayshore Recycled Water Facility:** In recent years, the average recycled water demand at the EBRWF has been approximately 0.1 mgd on an annual basis, with summer peaks of 0.2-0.3 mgd. Recycled water is primarily used seasonally for landscape irrigation in Oakland and Emeryville. The District is currently evaluating opportunities to increase off-site recycled water deliveries from the EBRWF. Previous studies have identified that non-potable recycled water deliveries could increase up to 2.6 mgd with significant expansion of the recycled water distribution system (Brown and Caldwell, 2018). In the near-term, recycled water deliveries could increase to a seasonal average demand of 0.5 mgd, which would result in approximately a 0.8% reduction in seasonal TIN discharges.
- **Pt. Isabel Water Recycling Facility:** The District is evaluating the feasibility and costs of constructing a satellite recycled water facility at the Pt. Isabel WWF (hereby referred to as the Pt. Isabel Water Recycling Facility). The Pt. Isabel Water Recycling Facility would likely include biological nitrogen removal (BNR) and filtration for up to 3 mgd of influent wastewater. The recycled water would be produced year-round for industrial process water and seasonally for landscape irrigation. If the project were implemented, TIN load discharges from the MWWTP could decrease by approximately 5%. This percentage is consistent with the satellite treatment alternative described in Appendix Q. The 5% reduction in TIN discharge loads would provide the District with approximately 5 years of compliance under the Medium Growth Scenario. To provide compliance for the 30-year planning horizon, the satellite recycled water facility would need to be paired with another solution.

The recycled water projects noted above were not further developed as near-term nutrient management strategies for compliance with the Master Plan Target for the following reasons:

- The EBRWF has a minor impact on the TIN load discharged from the MWWTP since the recycled water demand is a small percentage of the MWWTP's flow. The expansion of the distribution system would require significant capital investment, and additional nutrient reduction at the MWWTP would still be needed for regulatory compliance.
- Reliance on reuse demands (landscape irrigation and/or industrial reuse) for regulatory compliance presents a risk because future recycled water demands could be season, unreliable, or altogether eliminated.
- While the Pt. Isabel Water Recycling Facility could provide TIN load reduction benefits, the timing of the project is uncertain, and the project does not eliminate the need for additional nutrient reduction at the MWWTP.

It is recommended that the status and implementation plan for recycled water projects be monitored and further coordinated with nutrient management at the MWWTP.

4.1.2 Sidestream Treatment

Sidestream treatment would treat the dewatering centrate return flow, which contains concentrated nitrogen and phosphorus loads. For planning purposes, the Anita MOX (anammox) process was selected as a placeholder technology. More detail on this alternative is provided in Appendix R.

As shown in Figure 4-2, implementing SST would reduce TIN loads and provide compliance with the Master Plan Target for the 30-year planning horizon, after which additional nutrient reduction would be needed.

The water quality of the dewatering centrate is unique and variable due to the R2 program. Pilot testing of one or more anammox processes is recommended to confirm performance and design criteria, as well as to provide operational experience. With the refinement of design criteria, it is also recommended that additional engineering evaluations be performed to confirm if existing tankage could be repurposed for either the SST reactors or upstream equalization/pretreatment. For the Master Plan roadmap, new tankage was assumed; however, additional analyses of the gravity sludge thickeners (GSTs) and primary sedimentation tanks (PSTs) were performed to evaluate the possibility of re-purposing existing tankage for SST:

- **Gravity Sludge Thickeners:** The GSTs could be re-purposed and used as the reactor tanks for several anammox processes. Additional tankage would be required for equalization and pretreatment upstream of the anammox process, and new piping would be required to convey the centrate from the Dewatering Building. Additional engineering evaluation is recommended to confirm the need for seismic rehabilitation of the GSTs, potential for struvite precipitation on conveyance piping, and refinement of tank retrofit/repurposing costs. See Appendix R for more detail.
- **Primary Sedimentation Tanks**: Three PSTs could be repurposed for equalization, pre-treatment, and process reactor tankage. Chemically enhanced primary treatment (CEPT) would be utilized during the wet weather season to increase the capacity of the remaining 13 PSTs. Additional studies should be performed to confirm and further refine design criteria, cost estimates, CEPT chemical dosage, and performance of the PSTs under peak flow conditions. See Appendix V for more detail.

4.1.3 No High Strength Waste + Sidestream Treatment

HSW is a significant source of nitrogen at the MWWTP. Based on the plant-wide process model (Appendix O), it is estimated that HSW contributes approximately 20% of the TIN loads discharged to the Bay.

For this alternative, all HSW streams would be eliminated. For planning purposes, it was assumed that HSW could be stopped rapidly or immediately in 2029; however, the elimination of the HSW program would likely be phased and gradually transitioned over time.

As shown in Figure 4-2, eliminating all HSW streams would keep TIN loads below the Master Plan Target for eight years until 2037, after which SST would be necessary to provide additional TIN reduction. Once SST were implemented, the HSWs that were eliminated could be brought back, provided that SST be designed to accommodate the additional loads. However, it would take time (potentially years) to re-establish the HSW customer base. Further analysis would be required to evaluate which waste streams to potentially bring back.

Based on process model results, the elimination of HSW would reduce biogas production by an estimated 50% and biosolids production by approximately 13%. Refer to Chapter 11 and Appendix W for more detail.

4.1.4 Right-Size R2 + Sidestream Treatment

The Right-Size R2 alternative would target and eliminate HSW streams that have a significant nitrogen load. Protein (i.e., blood) and dairy (i.e., dissolved air flotation) wastes were identified as the HSW streams that would provide the most nutrient reduction and were the focus of this alternative due to their high nitrogen content and relatively high volume of deliveries.

As shown in Figure 4-2, this alternative would reduce TIN loads discharged to the Bay and the Master Plan Target would not be exceeded until 2034, after which SST would be needed for additional TIN reduction. Similar to the "No HSW" alternative, the elimination of dairy and protein waste streams was assumed to be a rapid decrease, but would in reality occur as a gradual transition over time.

The Right-Size R2 alternative is expected to have some impact on biogas and biosolids production; however, the impact is reduced compared with the No HSW alternative. The Right-Size R2 alternative would reduce biogas production by approximately 10% and biosolids production by 3%. A key advantage of this alternative is that it provides time for the District to plan, design, and construct SST while minimizing the negative impacts of completely eliminating all of the HSW streams. Refer to Chapter 11 and Appendix W for more detail.

4.1.5 High-Purity Oxygen Activated Sludge Nitrification + Sidestream Treatment

This alternative would vary by the season. During the summer, the HPOAS reactors would be operated in a nitrifying mode. During the winter and shoulder months, the HPOAS system would be operated in the current non-nitrifying mode. The duration for the nitrifying mode of operation could be modified; three months was selected to provide adequate time for startup and transition between operating modes. Although this alternative would leverage existing infrastructure, it would still require capital investments for system upgrades and new infrastructure as follows:

- To achieve nitrification, the solids retention time (SRT) would be increased in the HPOAS reactors, which would increase the solids loading rate to the secondary clarifiers. CEPT and new return activated sludge (RAS) pumps were assumed to increase secondary clarifier capacity by reducing the mixed liquor suspended solids (MLSS) concentration and increasing RAS pumping capacity.
- The aerators in Stages 2, 3 and 4 would be upgraded to meet the higher oxygen demands for nitrification.

- Alkalinity addition would be utilized to maintain a neutral pH and reduce the SRT required for nitrification. The fourth stage of the reactors would be vented to minimize chemical addition.
- Denitrification would occur in the first stage of the reactors, which would remain unaerated. Nitrified secondary effluent would be recirculated to the Influent Pump Station (IPS) to provide additional denitrification. Recirculation of nitrified secondary effluent to IPS could provide some odor control benefits and could reduce the amount of sodium hypochlorite that is used at IPS for odor control.

Appendix U provides additional detail on this alternative. The District is currently performing full-scale testing of nitrification in the HPOAS reactors. The full-scale testing will provide additional information on the upgrades required for this alternative, the TIN reduction that can be achieved, and the economic feasibility of the alternative.

Seasonal nitrification would provide TIN reduction and compliance with the Master Plan Target through 2037, at which time the MLSS concentration would approach 4,500 mg/L, which is considered the upper limit based on the highest observed concentration at the MWWTP and the highest secondary clarifier modeled scenario. SST would need to be online by 2037 to maintain compliance with the Master Plan Target. Once SST is implemented, seasonal nitrification in the HPOAS reactors could be discontinued.

4.1.6 Split Treatment (High-Purity Oxygen Activated Sludge + Activated Sludge Biological Nutrient Removal)

This alternative would consist of two parallel secondary treatment processes: 75% of secondary influent flow would be treated by the existing HPOAS system and 25% of the secondary influent flow would be treated by a new, AS BNR (MLE) system. Six of the existing HPOAS reactors and nine of the existing secondary clarifiers would remain dedicated to the HPOAS process to remove BOD and TSS, but not nutrients. For the new AS BNR process, two HPOAS reactors and three secondary clarifiers would be converted, and three new bioreactors would be constructed. RAS pumping modifications would be implemented so that the RAS from both processes would remain separate. The combined effluent from both treatment processes would provide compliance with the Master Plan Target through 2050.

4.1.7 Master Plan Target Economic Analysis

An economic analysis of the alternatives described above was performed. Capital and annual operating costs were considered to develop net present value (NPV) estimates for the 30-year planning horizon. Table 4-1 and Figure 4-3 summarize the results of the economic evaluation.

Table 4-1. Net present value comparison of Master Plan target alternatives[a]

Parameter	SST	No HSW + SST[a]	Right-Size R2 + SST[a]	HPOAS Nitrification + SST[a]	Split Treatment
Capital Outlays	99	64	104	183	616
Annual Operating Costs (Includes Revenue)	18	51	28	34	48
Rehabilitation & Replacement Costs	3	1	3	2	79
Total NPV	**120**	**117**	**135**	**219**	**742**

a. SST included with alternative to provide compliance with the Master Plan Target through the end of the planning horizon. SST assumed to be brought online in 2037 with the No HSW alternative, in 2034 with the Right-Size R2 alternative, and in 2037 with the HPOAS Nitrification alternative.

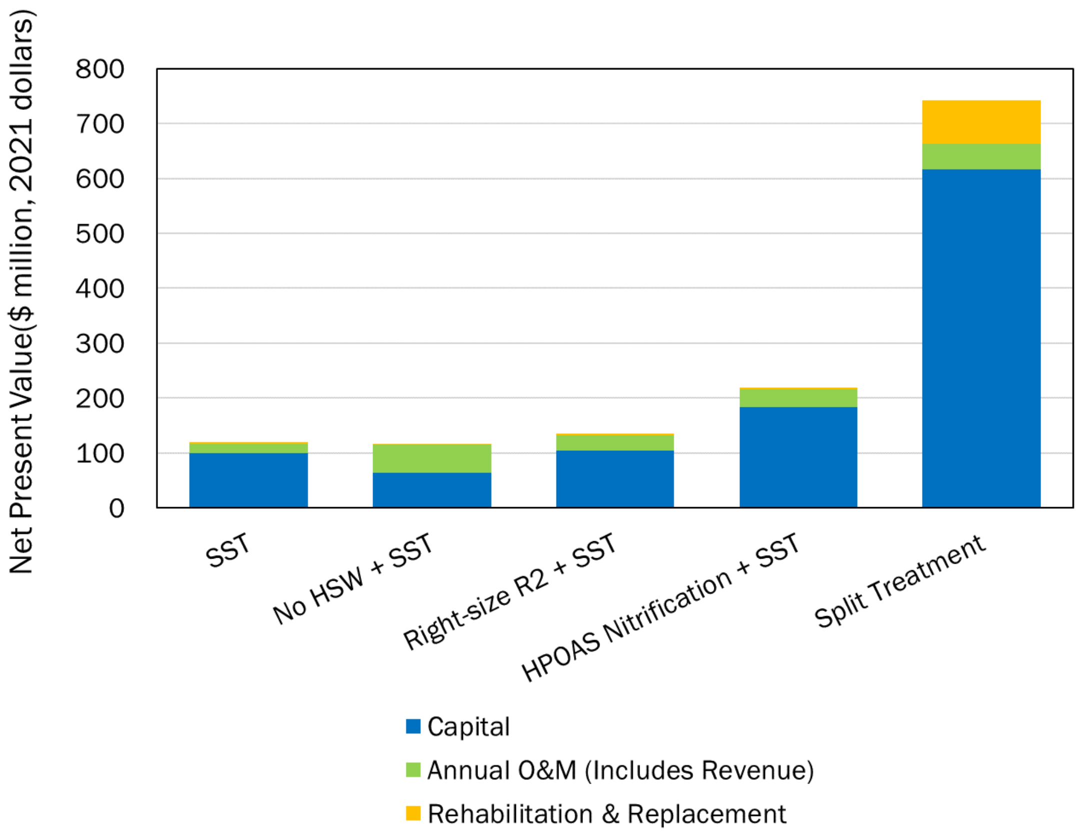

Figure 4-3. Economic comparison of Master Plan target alternatives

The NPV is similar for the SST, No HSW, and Right-Size R2 alternatives. HPOAS Nitrification has a higher NPV primarily due to various capital upgrades and investments. Split Treatment has the highest NPV due to the large capital investment needed to build nutrient removal for 25% of the flow.

4.1.8 Master Plan Target Non-Economic Analysis

A non-economic analysis of the alternatives described above was performed. The alternatives were evaluated using criteria described in Appendix N. Each alternative was assigned a score of 1 to 5 for each criterion. The criterion weighting was then considered to determine the overall weighted score for the alternative. The three criteria with the highest weighting and thus greatest impact on the overall score were safety, flexibility to meet current/future regulations, and technology maturity/reliability. Figure 4-4 shows the results of the non-economic analysis as a bar graph where a higher score ranks better.

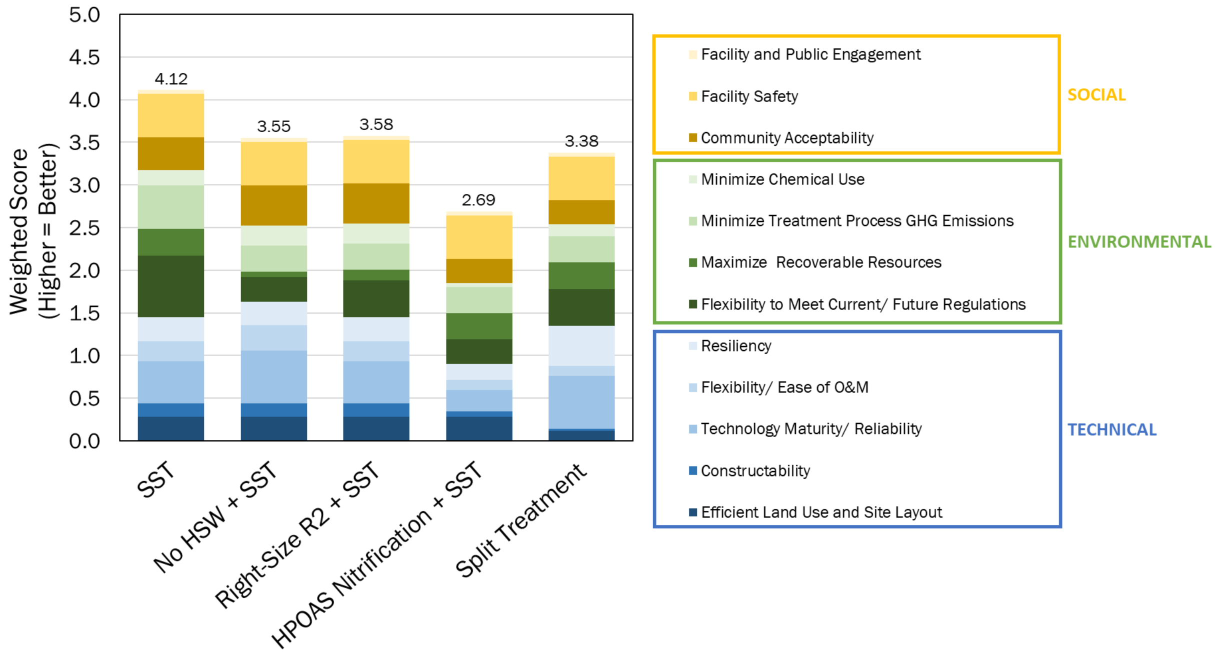

Figure 4-4. Non-economic comparison of Master Plan target alternatives for criteria shown on right side

Implementing SST alone has the highest non-economic score largely because it has a compact footprint, does not require modifications to the mainstream process, and maximizes the revenue received due to the R2 Program. The alternatives in which HSW is eliminated or reduced have slightly lower scores largely because the benefits of the R2 program are reduced. The HPOAS Nitrification alternative has a low score due to the necessary capital investments, the limited operational experience operating in this mode, and the operational complexity of operating in two modes throughout the year. Split Treatment ranked slightly lower than the SST, No HSW and Right-Size R2 alternatives, which is primarily due to land requirements of this option.

4.1.9 Master Plan Target Conclusions

The final recommendation considers the economic and non-economic evaluations. Overall, the SST and Right-Size R2 alternatives are the highest-ranking alternatives, as they have both a low NPV and a high non-economic score. Accordingly, SST was selected as the alternative to carry forward into the Master Plan CIP. The Right-Size R2 alternative is further considered in the Master Plan roadmap because it provides the District with time to plan, design, construct, and finance SST, if needed.

The “No HSW + SST” alternative was not selected because HSW provides some benefits. Furthermore, for planning purposes, the SST alternative is more conservative than assuming elimination of all HSW deliveries. As the regulations for a nutrient load cap are finalized, the District could still decide to choose to eliminate all HSW, if the variables the influence that decision—including tipping fee and renewable energy revenue, O&M costs, and others—evolve and result in different conclusions.

HPOAS nitrification is not currently recommended for the roadmap based on the economic and non-economic evaluation; however, as the District obtains more experience from full-scale pilot testing, this should be confirmed and/or further refined based on the actual configuration of infrastructure necessary to successfully operate in nitrification mode, refined sequencing of implementation, and updated cost estimates to match those assumptions.

Further analysis was performed to confirm that SST is a “no-regrets” investment if the Level 2 Off-Ramp were subsequently required. Table 4-2 compares the NPV of AS BNR with and without SST to meet the Level 2 Off-Ramp. Note that AS BNR was selected as the placeholder technology for the Level 2 Off-Ramp (see Appendix Q).

Table 4-2. SST "no regrets" evaluation

Element	AS BNR	SST with AS BNR
Strategy To Meet Level 2 Off-Ramp	AS BNR to treat 100% of secondary influent flow without SST	SST with AS BNR to treat 100% of flow
SST Bioreactor Volume (million gallons)	0	1.5
HPOAS Bioreactor Volume (million gallons)	0	0
Aeration Basin Volume for Master Plan Target (million gallons)	57 (12 Bioreactors)	52 (11 Bioreactors)
Total Capital for Level 2 Off-Ramp ($ millions)	1,300	1,300
NPV of Annual Operating Costs ($ millions)	160	100
NPV of Rehabilitation & Replacement ($ millions)	340	320
Total NPV ($ millions)	**1,800**	**1,700**

The comparison shows that implementing AS BNR with SST has a lower NPV than implementing AS BNR without SST. SST reduces the size, power requirements, tankage, and chemical usage of the AS BNR treatment process. Therefore, investing in SST to meet the Master Plan Target is considered "no regrets" because there are economic benefits if mainstream nutrient removal were subsequently needed.

4.2 Nutrient Roadmap

The nutrient roadmap is a guiding plan for meeting a progression of nutrient targets and triggers. The roadmap is driven by the timing of new regulations, and so the schedules included in this roadmap are tentative, pending if and when those regulations go into effect. Furthermore, the nutrient roadmap is based on how influent and R2 loading grow over time. The solutions in the roadmap are sufficient to meet the level of nutrient reduction required, so solutions are phased to meet the expected future regulations.

The nutrient roadmap is based on the regulatory endpoints and timelines included in Table 1-1. Figure 4-5 presents the nutrient roadmap. Figure 4-6 illustrates the TIN discharged over time as the nutrient roadmap is implemented to meet the Master Plan Target and the Level 2 Off-Ramp.

Note that effluent TIN projections also incorporate the biosolids roadmap with a post-digestion facility (thermal dryer) going online in 2040. The thermal dryer would have a nutrient-rich condensate stream that would be recycled back to the liquids treatment process. Refer to Chapter 5 for more details.

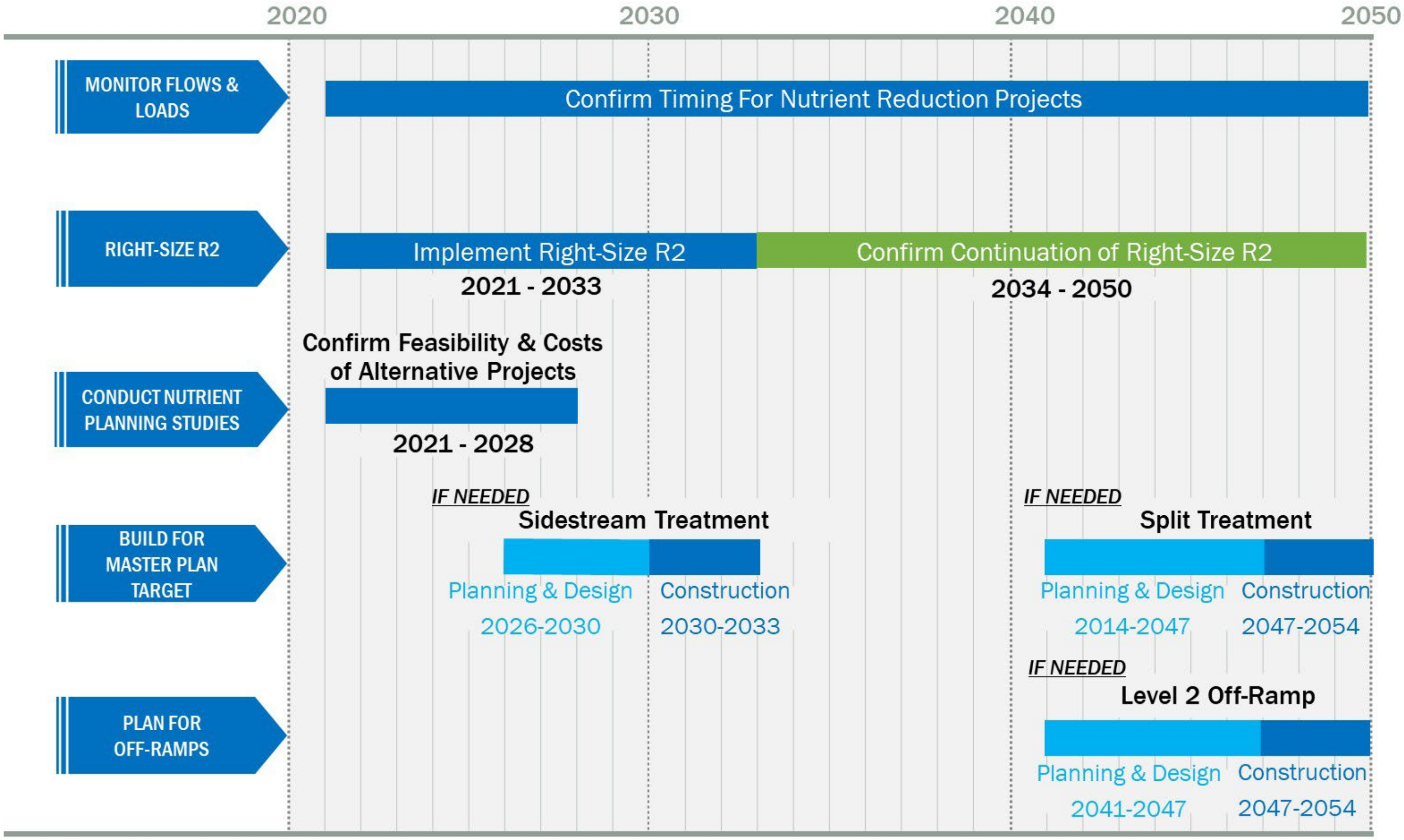

Figure 4-5. Nutrient management roadmap

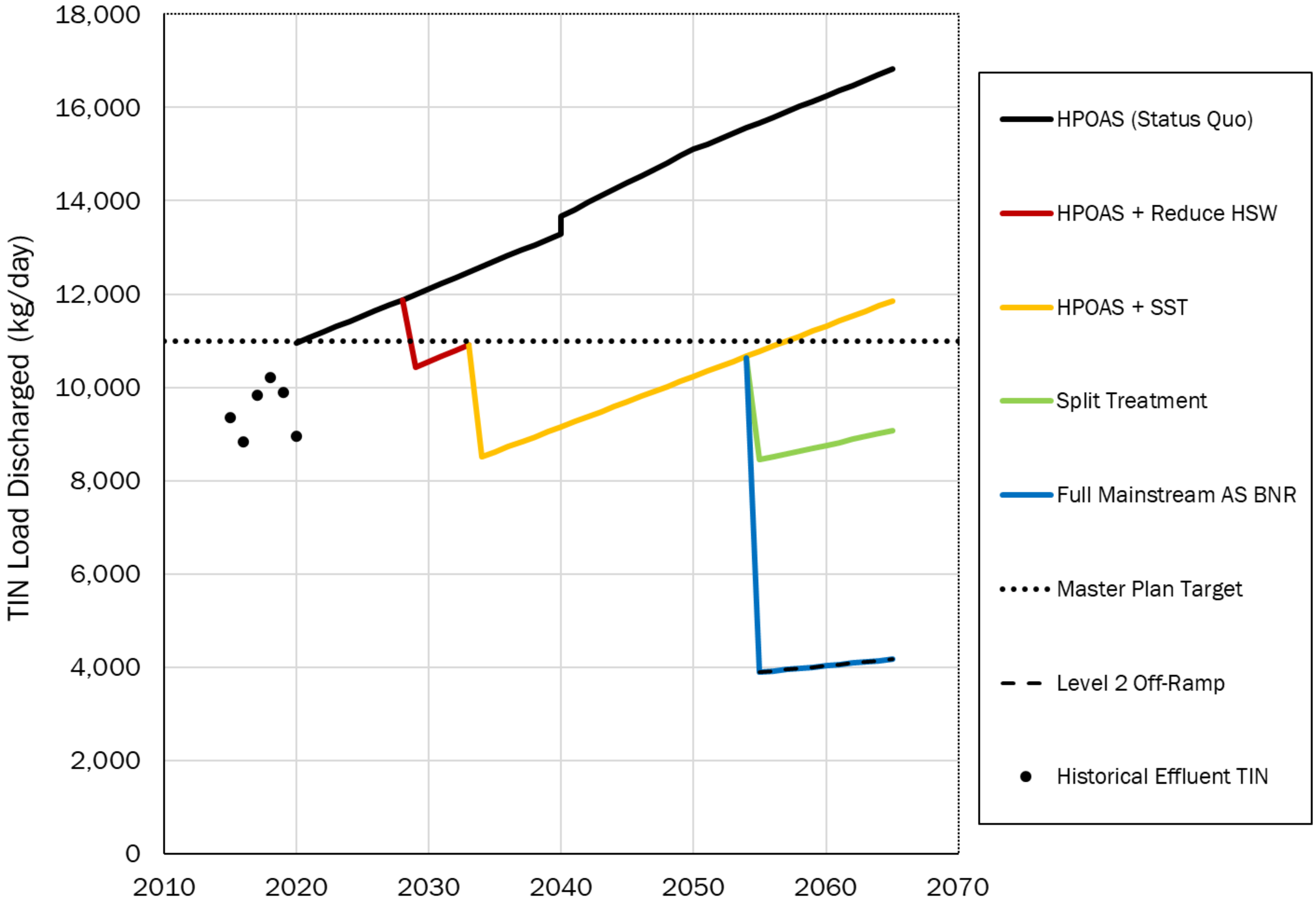

Figure 4-6. Effluent TIN projection for nutrient management roadmap

4.2.1 Master Plan Target

Right Size R2 + Sidestream Treatment

The assumed compliance year for the Master Plan Target is 2029. SST would provide adequate TIN load reduction for compliance with the Master Plan Target over the planning horizon. Prior to implementing SST, the District could implement the Right-Size R2 alternative to reduce TIN load discharges to the Bay and to provide time to plan, design, construct, and finance SST. Right-Size R2 would likely be implemented over time with the reduction in nitrogen-rich waste streams being reduced gradually. For this reason, reducing the HSW streams should start in advance of the Master Plan Target to provide time to adjust the project implementation timeline and to provide adequate time to pilot test SST technologies. Pilot testing of SST is recommended to confirm performance, design criteria, operational requirements, and costs.

The Right-Size R2 alternative is estimated to provide compliance with the Master Plan Target until 2034, at which time SST would be brought online. Prior to implementing Right-Size R2, additional HSW characterization is recommended to confirm the nutrient load of the various waste streams and the load reduction benefits. Once SST is implemented, there will be spare TIN capacity such that various HSW wastes that were previously reduced or eliminated could potentially be brought back; however, it could take some time to build back up the customer base.

Table 4-3 summarizes the estimated timeline for the implementation of Right-Size R2 and SST. For conservative planning purposes, SST implementation was accelerated to start in 2024 and go online in 2031, three years sooner than predicted by the process model. Table 4-3 also includes a timeline for additional nutrient planning studies that include testing of innovative nutrient reduction options (i.e., HPOAS nitrification), monitoring of flows and loads in the influent and effluent, and pilot testing of SST technologies.

Table 4-3. Master Plan target implementation timeline

Project Element	Start Year	End Year	Planning/Permitting Duration (Years)	Design Duration (Years)	Construction Duration (Years)	Total Duration (Years)
Alternative Nutrient Planning Studies[a]	2021	2028	7	--	--	7
Right-Size R2	2021	2033	12[b]	--	--	12
SST	2024	2031	2	2	3	7

a. Effort includes testing alternative technologies such as HPOAS nitrification, pilot testing of SST, monitoring growth and TIN discharges, and confirming timing for project implementation.

b. Effort would include monitoring the impacts of reducing HSW streams. Right-Size R2 could be continued through the planning horizon or R2 waste streams could be increased after implementation of SST.

Figure 4-7 shows a site plan of SST facilities, assuming that new tankage is constructed. The New Dewatering Building is assumed (refer to Chapter 6 for additional details), which would minimize piping to SST. A pipeline to convey SST effluent to upstream of the secondary process would be necessary.

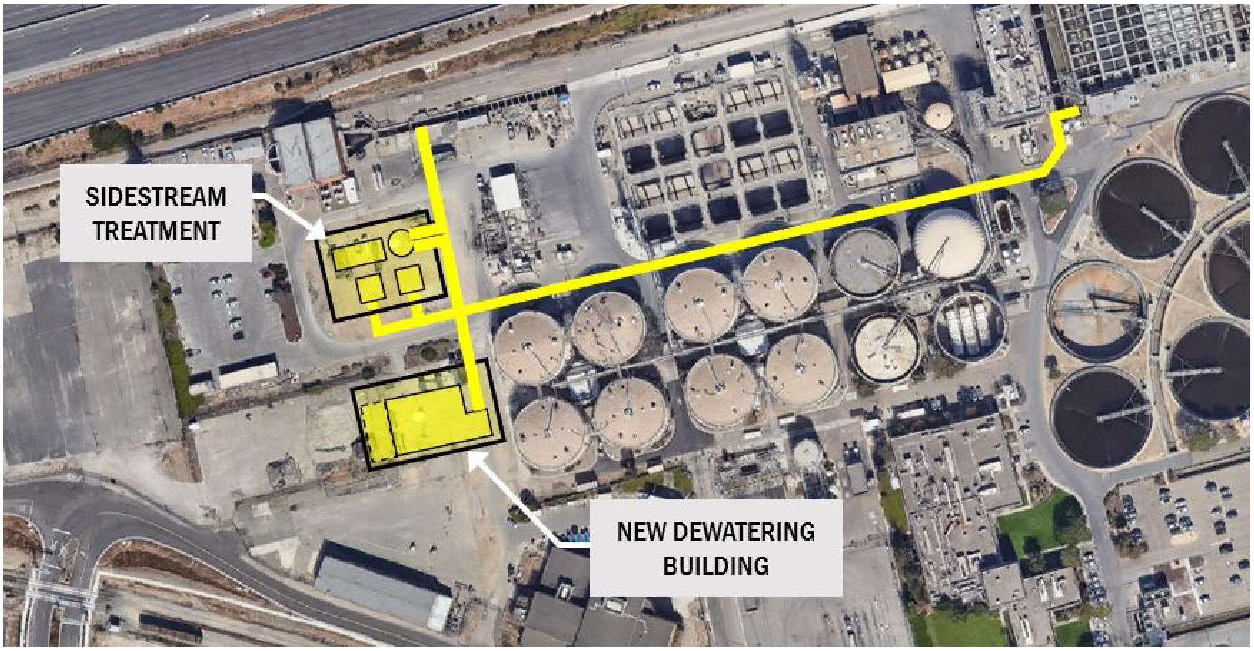

Figure 4-7. Site plan of SST facilities to meet the Master Plan Target in the planning horizon

Split Treatment

If growth continued beyond the end of the planning period, additional TIN reduction beyond SST alone would be needed by approximately 2055 to stay within the Master Plan Target. To meet this schedule, the District would need to start the planning and design of a nutrient reduction project by 2041.

For planning purposes, it was assumed this project would be split treatment. This consists of constructing new AS BNR facilities to treat 25% of the secondary influent flow and reconfiguring the existing facilities to treat the remaining 75% of the flow. Six of the existing HPOAS reactors and nine of the existing secondary clarifiers would remain dedicated to the HPOAS process to remove BOD and TSS, but not nutrients. For the new AS BNR process, two HPOAS reactors and three secondary clarifiers would be converted, and three new bioreactors would be constructed.

Split treatment was chosen for the following reasons:

- It provides the District 20 to 30 years of additional compliance with the Master Plan Target beyond the planning period.
- It is a logical bridge if a full mainstream upgrade is needed in the future. Valuable operating experience gained with operating the AS BNR process could be leveraged to optimize

criteria for a potentially larger future upgrade such as those described for the Level 2 or 3 Off-Ramps.

- AS BNR is the proposed technology for conservative placeholder reasons, i.e., it is the most established technology and has the largest footprint. As other technologies evolve, the District could pivot to a different technology such as an intensification process with a more compact footprint. A different technology may still allow the District to avoid stranding assets if the Level 2 or 3 Off-Ramp is needed in the future. Other technologies that were considered are described further in Appendix Q.

Figure 4-8 shows a site plan of the proposed facilities for the split treatment configuration. Table 4-4 summarizes the estimated timing to implement these improvements within the anticipated 10-year compliance period. As part of the design process, piloting is recommended to optimize key design parameters that are specific to the MWWTP.

Split treatment would require demolishing and relocating the Maintenance Center to the West End property. To provide adequate space for construction of the split treatment facilities, the relocation of the Maintenance Center should precede construction of the split treatment facilities by approximately five years.

Table 4-4. Implementation plan for split treatment

Project Element	Start Year	End Year	Duration (Years)			
			Planning & Permitting	Design	Construction	Total
Maintenance Center Relocation	2042	2049	2	2	3	7
Split Treatment Construction	2041	2054	3	4	6	13

Figure 4-8. Site plan for SST and split treatment to meet the Master Plan Target beyond the planning horizon

4.2.2 Level 2 Off-Ramp – Full Mainstream Treatment

The Level 2 Off-Ramp is not expected to occur within the planning horizon. If it were needed, full mainstream nutrient removal would be needed to treat 100% of the flow. AS BNR was selected because it is most established and conservative placeholder technology in terms of footprint. Other technologies that were considered are described further in Appendix Q. However, as technologies evolve over time, other technologies could become more suitable, or even advantageous, compared to AS BNR. The District will track technological development to make an informed decision if this Off-Ramp needs to be taken.

For full mainstream nutrient removal, eleven AS BNR (MLE) bioreactors would be needed to be constructed, and all of the existing secondary clarifiers would be re-purposed. Both the Maintenance Center and the Administration Building and Laboratory would be demolished and relocated to the West End property. To provide adequate space for construction of the mainstream treatment facilities, the relocation of these buildings should precede construction of mainstream treatment by approximately five years. A site plan of full mainstream nutrient removal is shown in Figure 4-9. Additional comprehensive site plans are shown in Chapter 11.

Table 4-5 summarizes the estimated timing to implement these improvements within a 10-year compliance period. Similar to the split treatment improvements, it is recommended that the District perform piloting to allow for optimization of key design parameters that are specific to the MWWTP.

Figure 4-9. Site plan for full mainstream treatment to meet the Level 2 Off-Ramp

Table 4-5. Implementation plan for full mainstream treatment to meet the Level 2 Off-Ramp

Project Element	Start Year	End Year	Duration (Years)			
			Planning & Permitting	Design	Construction	Total
Administration & Laboratory Building	2042	2049	2	2	3	7
Maintenance Center	2042	2049	2	2	3	7
AS BNR Upgrade	2041	2054	3	4	6	13

4.2.3 Level 3 Off-Ramp

The Level 3 Off-Ramp is not expected to occur within the planning horizon. If it were needed, the mainstream AS BNR process described above could be modified into a 5-Stage Bardenpho configuration by re-partitioning the compartments and modifying equipment within the bioreactors (i.e. diffusers, mixers and mixed liquor recirculation pumping), as well as adding one more aeration basin. If phosphorus limits were established, effluent filters would be required. A site plan for the Level 3 Off-Ramp is shown in Figure 4-10. Additional comprehensive site plans are shown in Chapter 11.

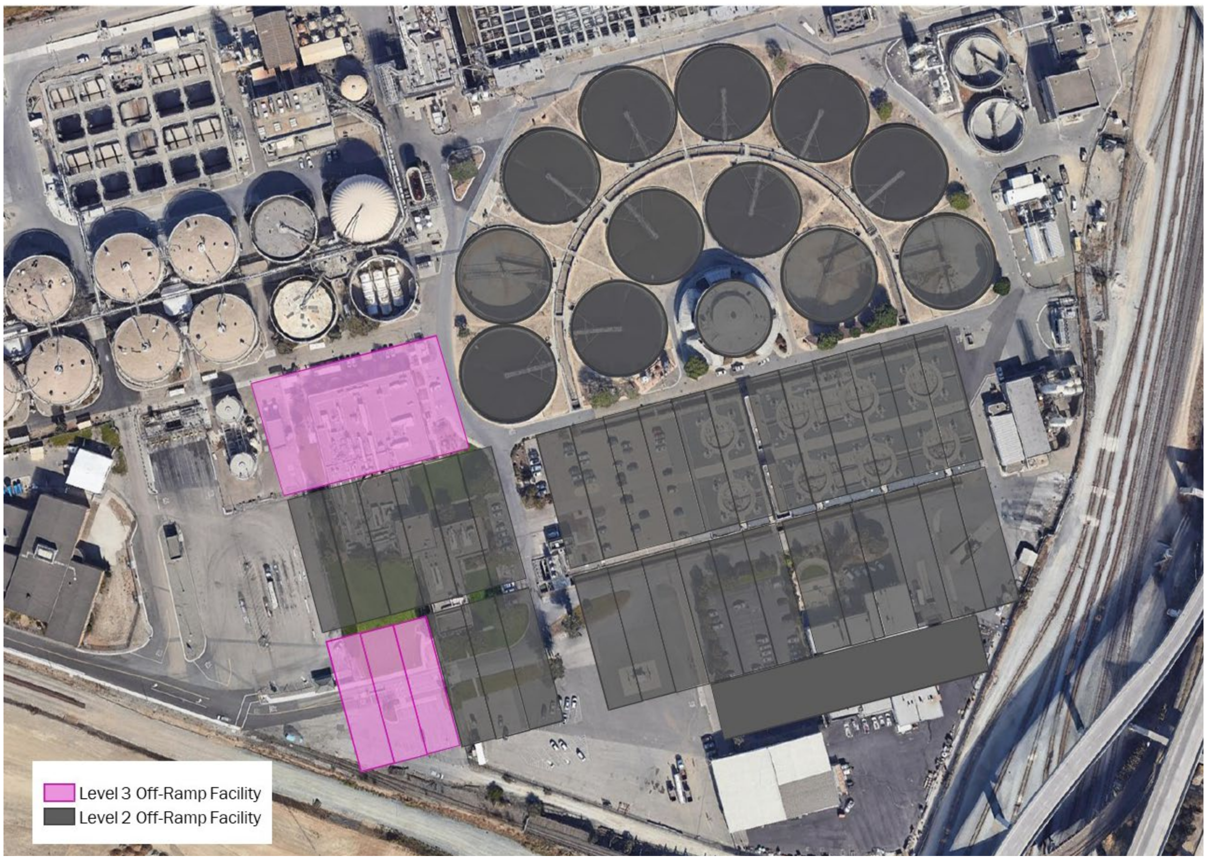

Figure 4-10. Site plan for full mainstream treatment to meet the Level 3 Off-Ramp

CHAPTER 5 BIOSOLIDS MANAGEMENT

This chapter provides a summary of biosolids management trends and the evaluation of biosolids management alternatives for near-term and long-term implementation.

5.1 Background and Economic Trends

Biosolids generated at the Main Wastewater Treatment Plant (MWWTP) have historically had three principal end uses depending on the season:

- **Land Application:** Biosolids are land applied during the dry weather season at sites in Merced County. Some land application is performed during the wet weather season at a site in Sacramento County.
- **Alternative Daily Cover:** Biosolids are used for alternative daily cover (ADC) at nearby landfills during the wet weather season.
- **Compost Facilities:** Biosolids are sent to compost facilities in Merced County during the wet weather season.

For the past five years, the District has used 3-year biosolids management contracts with the option to end the contract after each year of the contract.

Figure 5-1 shows the District's historical and projected biosolids management aggregate unit costs. Costs have been rising and will continue to rise due to the following:

- **Limited local wet weather outlets:** In recent years, solid waste regulations went into effect and have resulted in biosolids becoming less desirable for use at landfills. In some cases, landfills have stopped accepting biosolids altogether for alternative daily cover (ADC). In addition, Senate Bill (SB) 1383 "Short-Lived Climate Pollutants: Organic Waste Methane Emissions Reductions," was passed, which sets targets for diversion of organics from landfills that become enforceable in 2022. In response to this new regulation, it is anticipated that landfills or the jurisdictions where landfills reside will prohibit biosolids use at landfills, regardless of whether it is for ADC or disposal.

- **Increases in Hauling/Transportation Costs:** The Federal Motor Carrier Safety Administration published the Electronic Logging Device (ELD or e-log) rule, which requires truck drivers to maintain an electronic log of the time spent driving. ELDs facilitate compliance with rules that limit a truck driver's hours of service. The ELDs have a greater impact on biosolids routes that are longer (e.g. from the MWWTP to Merced), because a hauler may need more drivers to complete the same number of deliveries. More drivers have been required to meet this new regulation, in particular on these longer routes, and therefore overall biosolids management costs have increased.

- **Supply-demand discrepancies:** This includes the San Jose-Santa Clara Regional Wastewater Facility (RWF) and Central Contra Costa Sanitary District (Central San) entering the biosolids market for the first time, as well as the San Francisco Public Utilities Commission (SFPUC) renegotiating its biosolids contracts.

- **Standard escalation by the consumer price index (CPI):** 3% per year was assumed.

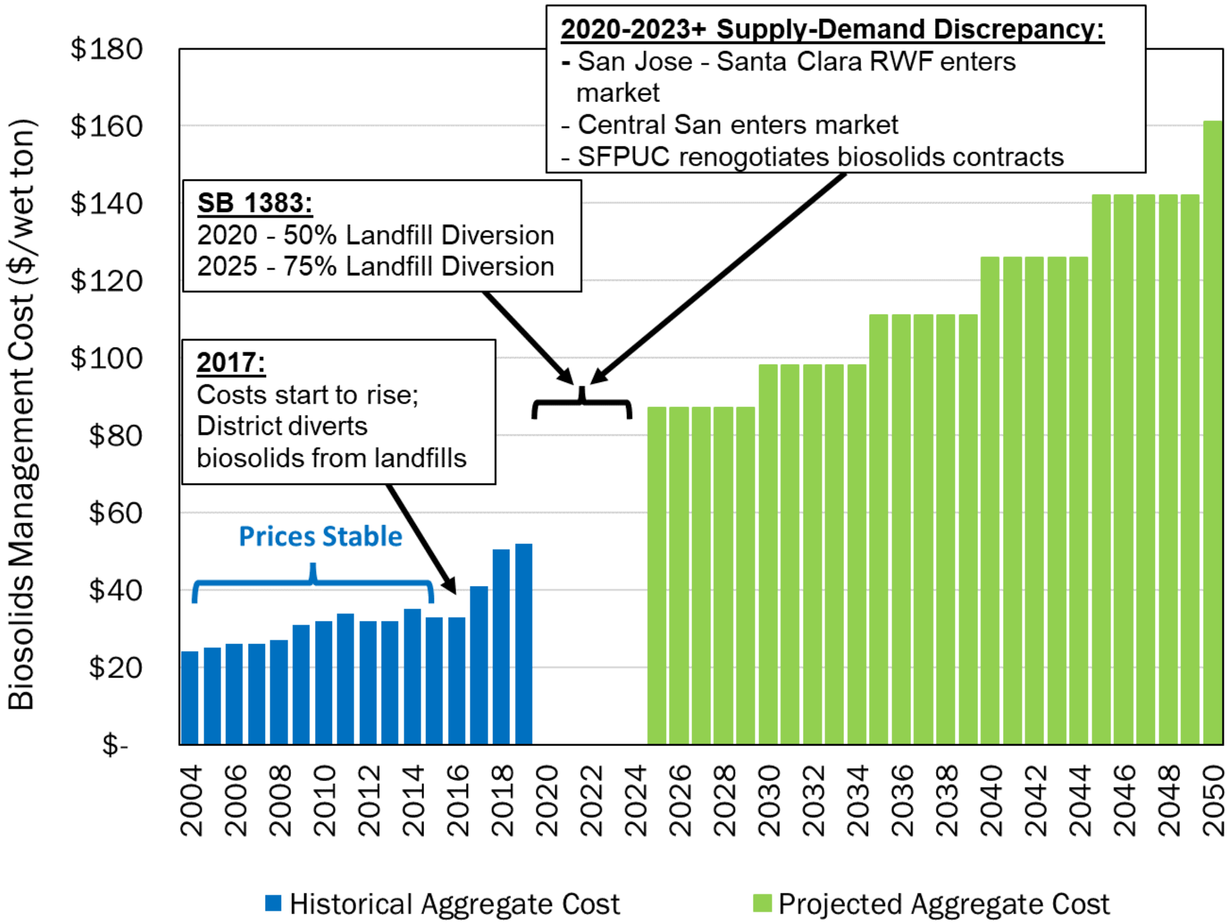

Figure 5-1. Historical and projected biosolids management costs

5.2 Biosolids Management Alternatives

Biosolids management alternatives were developed based on the following drivers and goals:

- **Produce a marketable Class A product:** Marketable products (e.g. compost, soil blends, or thermally dried products) would allow for more end uses to help develop a reliable, cost-effective, and year-round biosolids management program.
- **Increase wet weather beneficial use options:** Land application in Northern California is limited during the winter months. Proactive development of wet weather options will help stabilize costs and minimize risk over the long term.
- **Create a flexible pathway to address potential per- and polyfluoroalkyl substances (PFAS) regulations:** PFAS are a group of chemicals used to make fluoropolymer coatings and products that resist heat, oil, stains, grease, and water. It is possible that future PFAS regulations will restrict or eliminate land application as a management strategy. For this reason, the long-term plans incorporate either non-land application uses or further processing to eliminate PFAS.

The biosolids management roadmap was developed based on the following alternatives, which are described in more detail in Appendix S:

- **Status Quo:** The District would continue to rely on third-party contracts for biosolids management. Biosolids would continue to be land applied during the dry weather season and diverted to merchant facilities during the wet weather season. ADC would be used as a wet weather management option until landfills no longer accept biosolids for this use, after which merchant facilities would be used in the wet weather season. Merchant facilities are defined as facilities that are owned and operated by a third party, accept biosolids for further processing, and manage end uses of the final product. Examples of merchant facilities include storage, compost, and/or alternative post-digestion facilities.
- **Off-Site Storage:** The District would construct, own, and operate an off-site storage facility that would store biosolids during the wet weather season. Land application of the stored biosolids would be performed by a third-party contractor during the dry weather season.
- **Post-Digestion Facility:** The District would construct a post-digestion facility (thermal dryer) at the Main Wastewater Treatment Plant (MWWTP). The dried pellets would be land applied during the dry weather season, as well as diverted to new, local markets. The volume reduction achieved with thermal drying provides the ability to store the pellets at the MWWTP during the wet weather season.

These three alternatives are described in more detail below.

5.2.1 Status Quo

This alternative is referred to as "status quo" because it would not include additional biosolids processing or treatment, and would rely on a third-party contractor for biosolids management. The District would continue to land apply during the dry weather season and to divert biosolids to merchant facilities during the wet weather season. ADC would be used as a wet weather management option until landfills no longer accept biosolids for this use due to SB 1383. A solids screening facility is included under this alternative to ensure a higher-quality feedstock for merchant facilities.

Figure 5-2 illustrates the projected range of annual unit costs through 2050 for the "status quo" alternative. The lower boundary assumes that on average 50% of biosolids are land applied and 50% are diverted to a merchant facility. The upper boundary assumes that 100% of biosolids are diverted to a merchant facility. The biosolids management cost is reported in $/wet ton using two different metrics:

- **Biosolids Management Cost:** The individual unit costs at years 2025, 2030, 2040, and 2050 shown in blue and green text include costs for hauling, as well as tipping fees for land application and merchant facilities. These costs refer to the biosolids management costs incurred directly from the biosolids management contract at that point in time.
- **Total Cost:** The values along the upper and lower boundary lines (solid blue and green lines) correspond to the y-axis and include: a) the amortized capital costs of a new Dewatering Building, digester seismic rehabilitation, and solids screening facility; and b) operating costs for biosolids hauling, management fees, chemical use, rehabilitation and replacement for new capital facilities, and sale of excess energy at MWWTP.

While the future practice may not follow these exact percentages, the lines represent the upper and lower boundaries of potential management costs based upon current market trends. If the District considers new alternatives in the future, alternatives that fall within these boundaries would be considered reasonable.

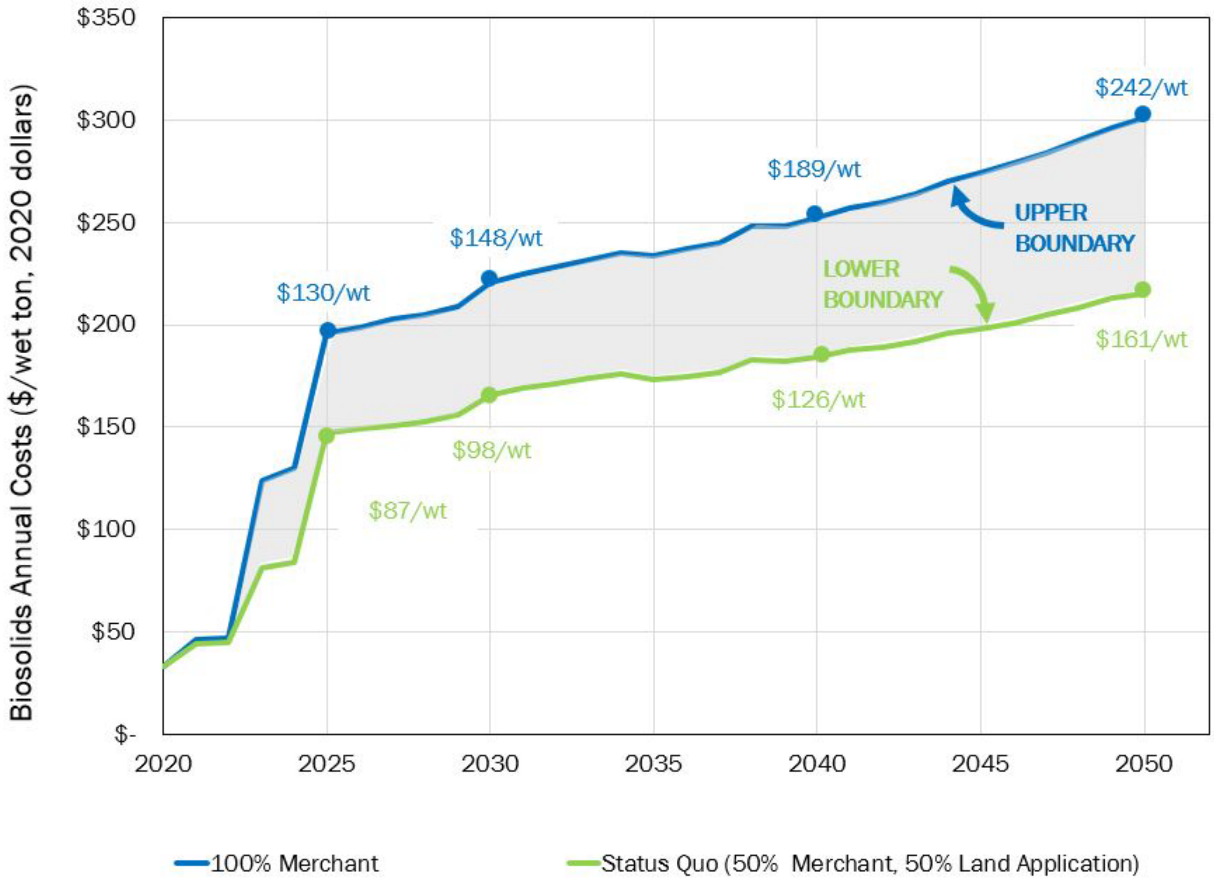

Figure 5-2. Biosolids management cost projections for the status-quo alternative

The status quo alternative minimizes capital investments at the MWWTP; however, the District will have less control over biosolids management costs and will be subject to market conditions and third-party management contract terms.

The following actions are recommended to help minimize biosolids management costs:

- Enter into long-term management contracts (5-years or greater) to provide price stability. While the District may encounter an initial increase in management costs, the longer-term contract will likely reduce price volatility while also securing biosolids outlets, particularly during the wet weather season.
- Secure capacity in existing merchant facilities for wet weather management. This may require a year-round commitment because the merchant facilities need a steady income and throughput over the year. Committing biosolids to a merchant facility year-round may increase overall management costs; however, it provides the benefit of securing an outlet for biosolids during the wet weather season.
- Continue to coordinate with third-party merchant facilities regarding the construction of new, local facilities. Early coordination with the merchant facilities can allow the District not only

to better project future costs, but also to guide the selection of location, pricing, and technology. Early commitments are needed because the third-party merchants must secure funding for the new facility. In return, the benefit to the District is a reliable outlet and stable prices for the duration of the contract. Until new outlets are developed for wet weather management, prices will continue to rise, and wet weather management will continue to be an area of high risk.

5.2.2 Off-Site Storage Facility

As shown in Figure 5-3, this alternative would include the construction of an off-site storage facility that would store biosolids during the wet weather season. During the dry weather season, the biosolids would be hauled from the storage facility to land application sites. The storage facility would need to provide a minimum of 2 months of storage for dry years, but no more than 6 months of storage for wet years. Based on the analysis described in Appendix I, off-site storage for 4 months of the year was determined to be optimal because it provides adequate flexibility during wet weather months. The estimated land requirement for the facility is 3 acres. The storage facility would include enclosed bunkers with odor control.

It was assumed that the storage facility would be owned and operated by the District, while hauling would be done by a third-party contractor. The District could consider performing hauling itself, but would need to expand staff.

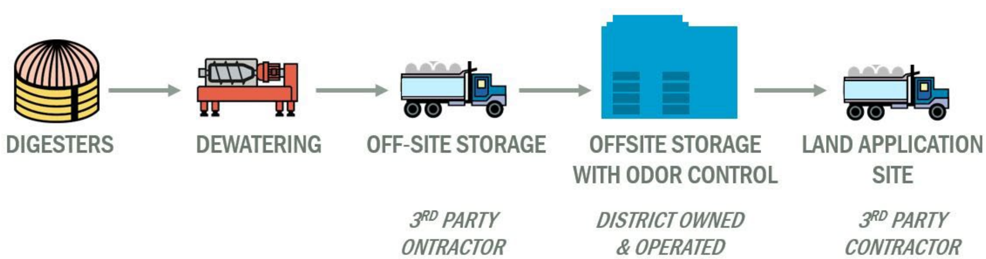

Figure 5-3. Schematic of off-site storage alternative

The location of the off-site storage facility could be located relatively near the MWWTP or near the land application sites. Multiple locations were considered:

- **District-owned Pinole property:** This property is located relatively near the MWWTP, which has the advantage of streamlining operations and maintenance (O&M). However, since the property is surrounded by residential communities, permitting and community opposition would be a significant challenge.
- **Property in Merced County**: This location would be close to land application sites, but far from the MWWTP, increasing O&M costs and complexity. The District would need to identify, purchase, and permit a site. The permitting and mitigation requirements for a site in Merced County are unknown, and additional analysis is needed to confirm the feasibility, costs, and mitigation/permitting efforts. The District would also need to staff the remote facility for approximately half the year.

- **District-owned Wet Weather Facilities:** The District's three Wet Weather Facilities do not meet the land requirements and were not further analyzed.
- **District-owned North Richmond Water Reclamation Treatment Facility**: This site does not meet the land requirements and was not further analyzed.

The economics of an off-site storage facility in Pinole or Merced County are relatively comparable. For the Master Plan roadmap, the storage facility was assumed to be located at the District's Pinole property. Table 5-1 presents planning criteria for this alternative.

Prior to implementation, additional analysis is needed to confirm feasibility, permitting requirements, and whether any mitigation would be required. Additionally, the District should evaluate whether other locations in the Bay Area or near the land application sites have emerged.

Table 5-1. Planning criteria for the off-site storage facility alternative

Criteria	Value
Duration of Storage (months)	4
Storage Building Footprint (square feet)	110,000
Total Land Requirements (acres)	3
Amount of Biosolids to Merchant Facilities	15%
Additional Full-Time Employees for Facility Operation[a]	3.5
Capital Cost[b] ($ millions)	$81
Annual Operating Costs (Year 1), ($ millions [c])	$6.2[a]
Net Present Value ($ millions)	**$417**

a. Full-time employees manage O&M of off-site storage facility and front-end loader operation for moving biosolids in and out of storage bunkers during winter months.

b. Costs are presented in 2020 dollars.

c. Facility is assumed to be operational in 2025. Annual operating costs include additional labor for off-site storage facility; operational and rehabilitation/replacement costs for the off-site storage facility; additional hauling costs to and from off-site storage; and biosolids management costs.

Figure 5-4 presents the projected biosolids annual costs of the off-site storage alternative compared to the status quo alternative. Similar to Figure 5-2, the biosolids management cost s reported in $/wet ton using two different metrics:

- **Biosolids Management Cost:** The individual unit costs at years 2025, 2030, 2040, and 2050 are shown in yellow text and include capital costs for off-site storage, hauling, and management fees for land application and merchant facilities. These costs refer to the biosolids management costs incurred directly from the biosolids management contract at that point in time.

- **Total Cost:** The values along the solid lines (blue, yellow, and green) correspond to the y-axis and include: a) amortized capital costs of new Dewatering Building, digester seismic rehabilitation, off-site storage, and solids screening facility; and b) operating costs for biosolids hauling, management fees, chemical use, rehabilitation and replacement for new capital facilities, and sale of excess energy at MWWTP.

In the near-term, the off-site storage alternative is relatively costly, i.e., near the upper bound of the status quo alternative. However, over time, the off-site storage cost stabilizes and approaches the lower bound of the status quo alternative. It would be advantageous to construct the off-site storage facility in the 2025 to 2030 timeframe (or when management costs approach $115 per wet ton) to maximize the economic benefits of an off-site storage facility.

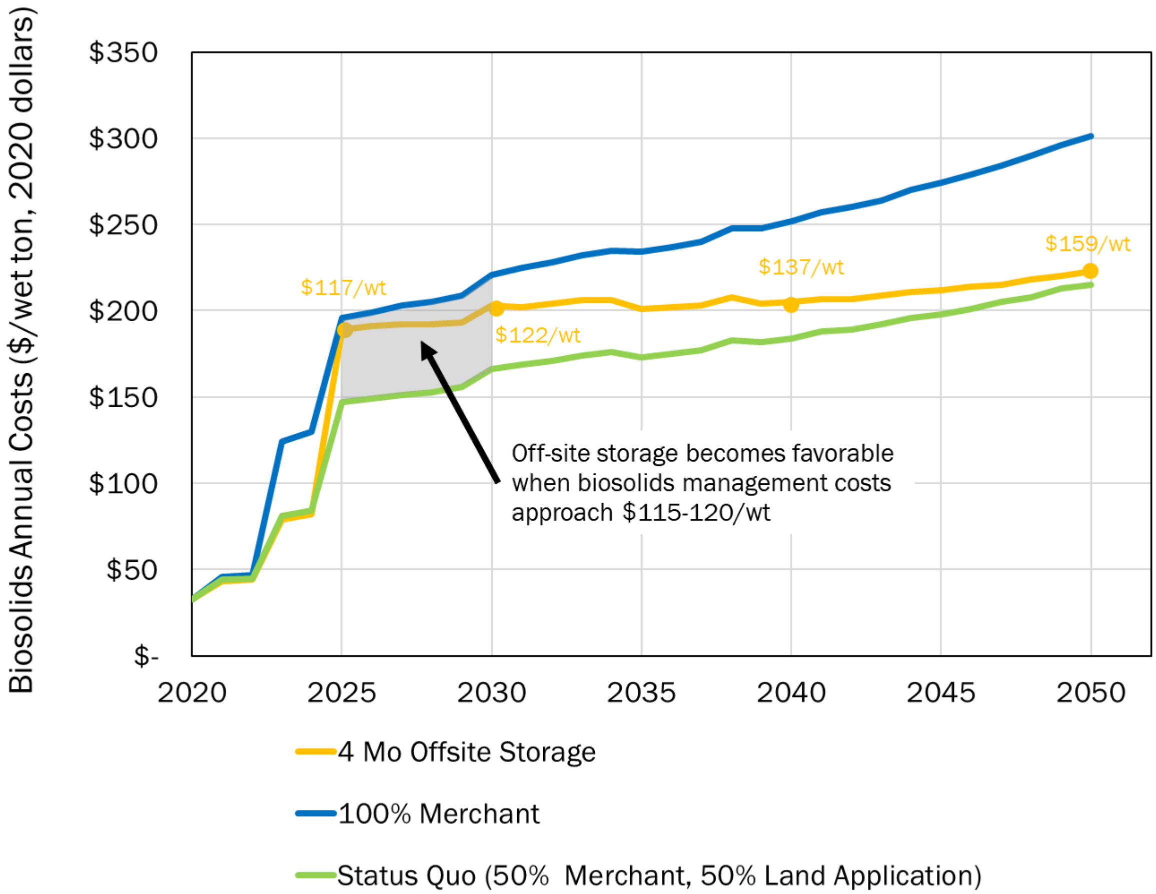

Figure 5-4. Biosolids management cost projections for the off-site storage alternative compared with the status quo

Other considerations for this alternative include:

- **Future Alternative Use:** The off-site storage facility could be converted to pellet storage in future years if a thermal dryer were constructed at the MWWTP.
- **Selling Capacity for Revenue:** Excess storage capacity at the facility could potentially be sold to other agencies and/or third-party contractors to offset the capital cost.
- **Challenges of adding a new off-site facility:** An off-site storage facility would have challenges such as permitting, potential impacts to neighbors, and staffing. There is potential for unknown challenges, as well, since the District does not currently operate an off-site storage facility.

The economics of an off-site storage facility are not currently advantageous and are not expected to improve until biosolids manage costs increase significantly. Considering the uncertainties and potential challenges to implementing such a facility, it is recommended that the District reexamine the feasibility of off-site storage as unit prices for biosolids management rise.

5.2.3 Post-Digestion Technology

This alternative includes the construction of a post-digestion technology, which would increase opportunities for biosolids beneficial use and wet weather management. Three post-digestion technologies were evaluated: thermal drying, pyrolysis, and chemical thermal hydrolysis (Lystek). Thermal drying was selected as a placeholder technology for the Master Plan roadmap, as it is an established technology that offers the benefits of volume reduction and alternative beneficial use outlets.

The thermal dryer would be enclosed within a building with odor control. One thermal dryer would be needed, but space would be reserved for a redundant thermal dryer, which could be added in the future. Two months of on-site storage at the MWWTP were included. Storage of thermal dryer product does present some risk of fire hazard, but storage facilities can be designed with fire safety features to minimize these risks.

The thermal dryer would have a heating demand for day-to-day operation of the system. Biogas would be used as fuel to generate the necessary heating demand for the thermal dryer, and would therefore reduce the amount of biogas being conveyed to the Power Generation Station to generate renewable electricity. If necessary, natural gas could be used instead to heat the thermal dryer. The electrical demand for the thermal dryer is minor because the demand is only present during system startup.

Table 5-2 presents planning criteria for this alternative. Construction of the thermal dryer was considered in three different years: 2025, 2030, and 2040. The size of the thermal dryer was not modified for the different time periods; however, in early years, the dryer would operate less than 7 days per week.

Table 5-2. Planning criteria for the thermal dryer

Criteria	Value
Design Year	2050
Average Dry Weather Total Solids Load, (lbs/day)	166,000
Building Footprint (square feet)	25,300
Total Land Requirements (acres)	0.75
Number of Thermal Dryer Units	1[a]
Operations Requirement (days/week)	7
2050 Heating Demand (Lower Heating Value) (MMBTu/h)	26
2050 Biogas Demand[b] (Higher Heating Value) (MMBTu/h)	29
2050 Electrical Demand (kWh/year)	5,700,000
Pellet Storage Duration (months)	2
Total Hopper Volume (cubic feet)	17,500
Capital Cost ($ millions)	$199
Annual Operating Costs (Year 2040) ($ millions)	$5.3
Net Present Value ($ millions)[c]	**$550**

a. No standby unit is assumed. It is assumed that routine maintenance is performed during the dry weather season when biosolids can be land applied. During emergency shutdowns, it is assumed that biosolids could be managed through emergency contracts.

b. Heating demand assumed to be primarily met with biogas. As flows and loads increase, the biogas available for the thermal dryer will increase.

c. Capital and operating costs are presented for the Medium Growth Scenario. The NPV assumes thermal dryer is online in 2040.

Figure 5-5 presents the biosolids management costs of the post-digestion alternative with the status quo alternative. Similar to Figure 5-2 and Figure 5-4, the biosolids management cost is reported in $/wet ton using two different metrics:

Biosolids Management Cost: The cost indicated in textbox callout includes capital cost for thermal dryer, biosolids hauling, management fees for land application, and revenue for pellet sales. This cost refers to the biosolids management cost incurred directly from the biosolids management contract at that point in time.

Total Cost: The values along the solid and dashed lines correspond to the y-axis and include: a) amortized capital costs of new Dewatering Building, digester seismic rehabilitation, thermal dryer, and solids screening facility; and b) operating costs for biosolids hauling, management fees, chemical use, rehabilitation and replacement for new capital facilities, and sale of excess energy at MWWTP.

Three lines are shown for the post-digestion alternative corresponding to construction in 2025, 2030, and 2040. If a thermal dryer were constructed in 2025 or 2030, the costs would be expensive and unfavorable, i.e., above the upper status quo boundary. However, if a thermal dryer were constructed in 2040, the costs would originate just below the upper boundary and gradually decrease over time, becoming more economically favorable. Accordingly, the optimal timeframe for implementing a thermal dryer is 2040, or when biosolids management costs approach $155 per wet ton.

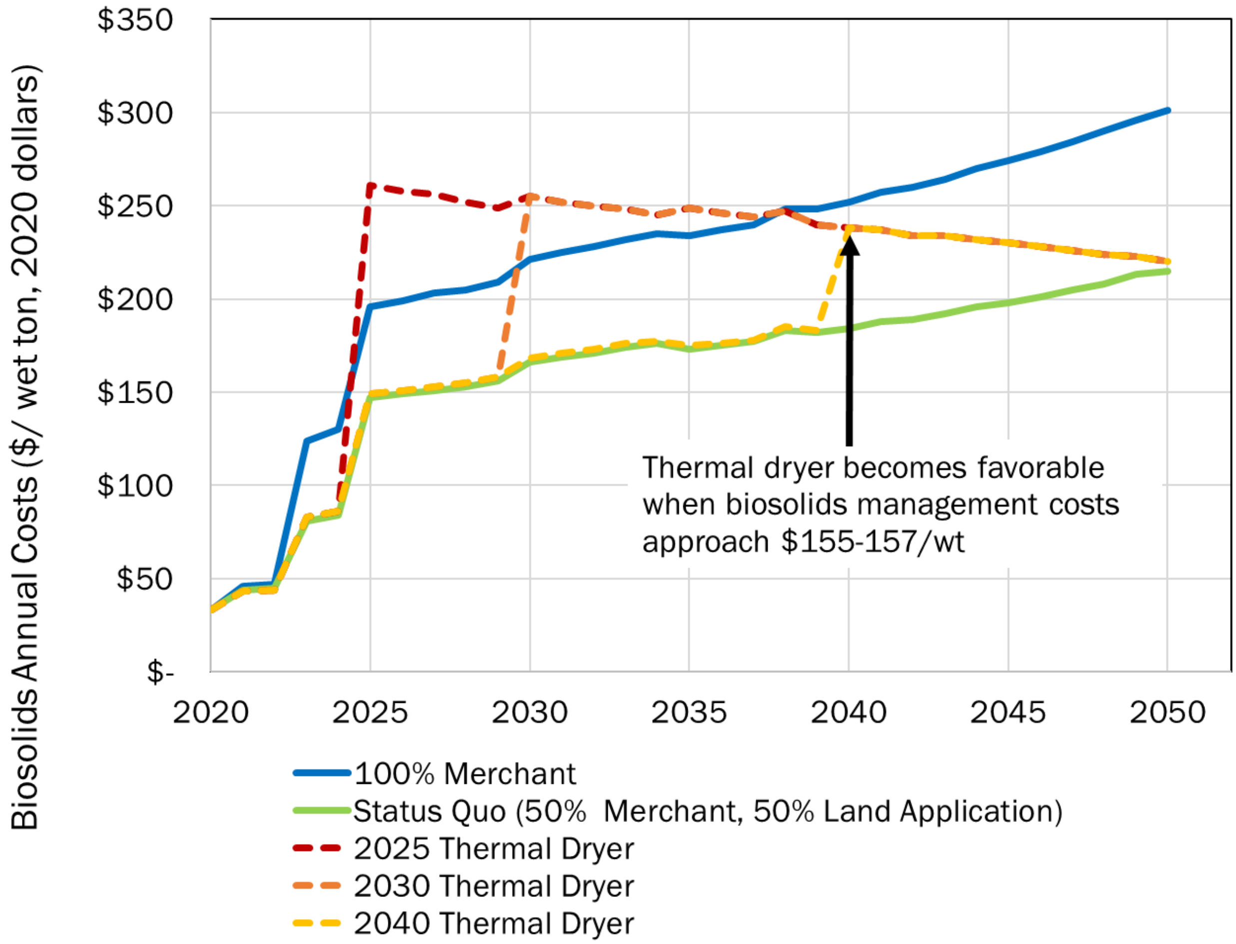

Figure 5-5. Biosolids management cost projections for the thermal dryer alternative compared with the status quo

Figure 5-6 shows a site plan of the thermal dryer. Land is reserved west of the new Dewatering Building and anaerobic digesters.

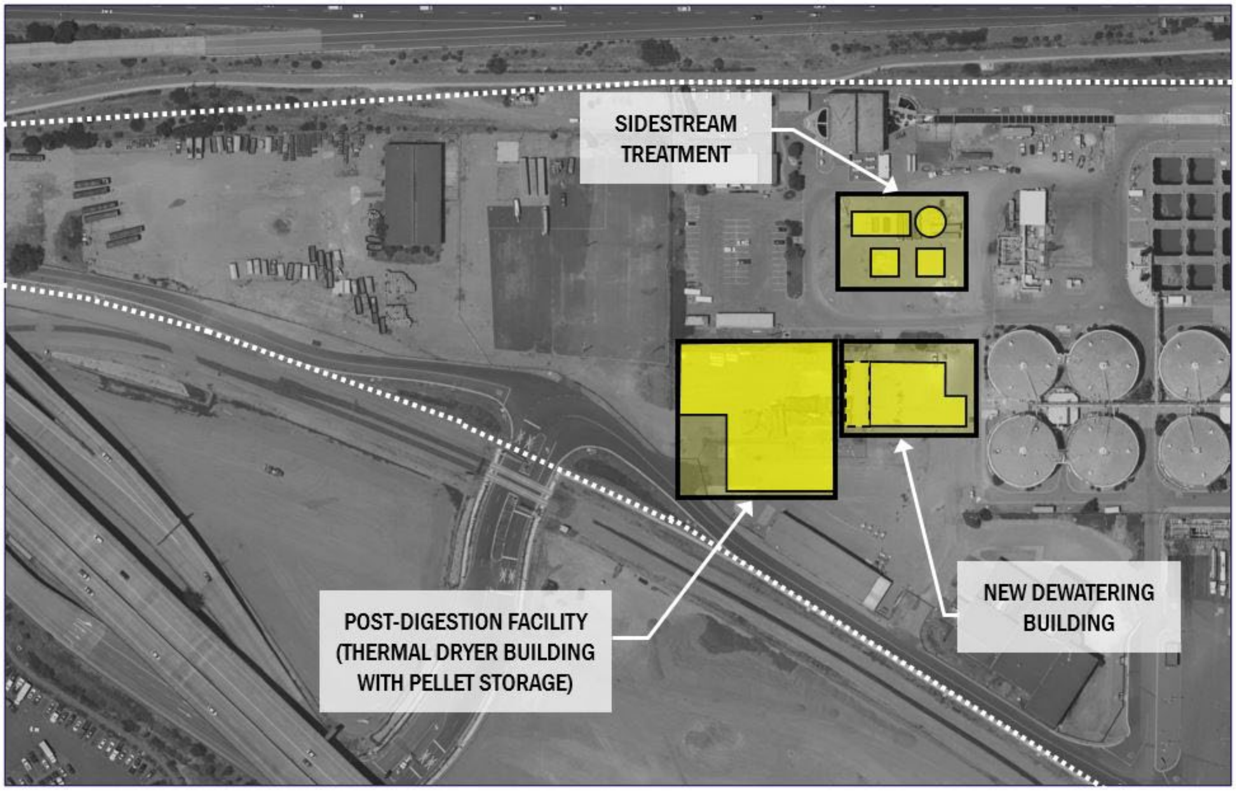

Figure 5-6. Site plan for the post-digestion technology alternative with a thermal dryer

Additional considerations for this alternative include:

- **PFAS**: The possibility of future PFAS regulations and the impact on biosolids management is unknown at this time. Post-digestion technologies such as thermal drying and pyrolysis could offer a better ability to meet potential future regulations than land application of Class B biosolids cake. If PFAS regulations limit the land application rate of biosolids, the District may be faced with longer hauling distances and higher hauling costs. Both thermal drying and pyrolysis offer the benefit of volume reduction, which can thereby reduce the economic impact of longer haul distances.

5.3 Biosolids Implementation Plan

Based on the analyses described above, the following conclusions and recommendations form the basis for the biosolids management roadmap:

- **Monitor biosolids management cost trends:** The District will continue to monitor biosolids management costs in the near-term as supply-demand conditions change.
- **Execute third-party biosolids management contracts:** Continuing with the status quo in the near-term is a feasible and reliable solution that can be easily implemented. Longer-term contracts are recommended to stabilize costs, as well as to secure wet weather and/or year-round capacity in existing merchant facilities to provide a reliable management plan.
- **Coordinate development of new merchant facilities:** The District will continue to coordinate with contractors on the development of new merchant facilities to identify timing, location, fee schedules, and required commitments.
- **Confirm feasibility of off-site storage:** Additional analysis is recommended to determine feasibility, costs, and permitting requirements of off-site storage at the District's Pinole property or in Merced County near land application sites. If off-site storage is a viable option, it should be constructed before management costs reach $115 to $120/wet ton, which is projected to occur in the 2025 to 2030 timeframe.
- **Reserve space for a post-digestion technology:** The District will reserve space for a post-digestion technology at the MWWTP. The area west of the anaerobic digesters has been identified as the preferred location for the Master Plan roadmap.
- **Monitor emerging and potential regulations:** The outcome of current efforts to regulate PFAS and its impact on biosolids management is unknown at this time. The District will continue to track the development of emerging regulations and technical issues.
- **Monitor advancement of post-digestion technologies:** The District will track the development of post-digestion technologies for number and size of installations, costs, O&M requirements, and overall feasibility.
- **Implement a post-digestion technology:** Thermal drying or other post-digestion technologies should be considered for implementation when management costs approach $155 to $160/wet ton, which is projected to occur in the 2040 timeframe.

Figure 5-7 summarizes the parallel activities of the biosolids management roadmap. The project duration for both off-site storage and thermal drying is estimated at 7 years total: 2 years for planning/permitting, 2 years for design, and 3 years for construction.

The cost triggers noted in the biosolids management roadmap do not change under various Resource Recovery (R2) reduction scenarios because the alternatives are modular, and the capital and operating costs scale based on the tonnage and cake volume. Therefore, the cost triggers can be applied to the various R2 reduction scenarios that are further described in Chapter 11.

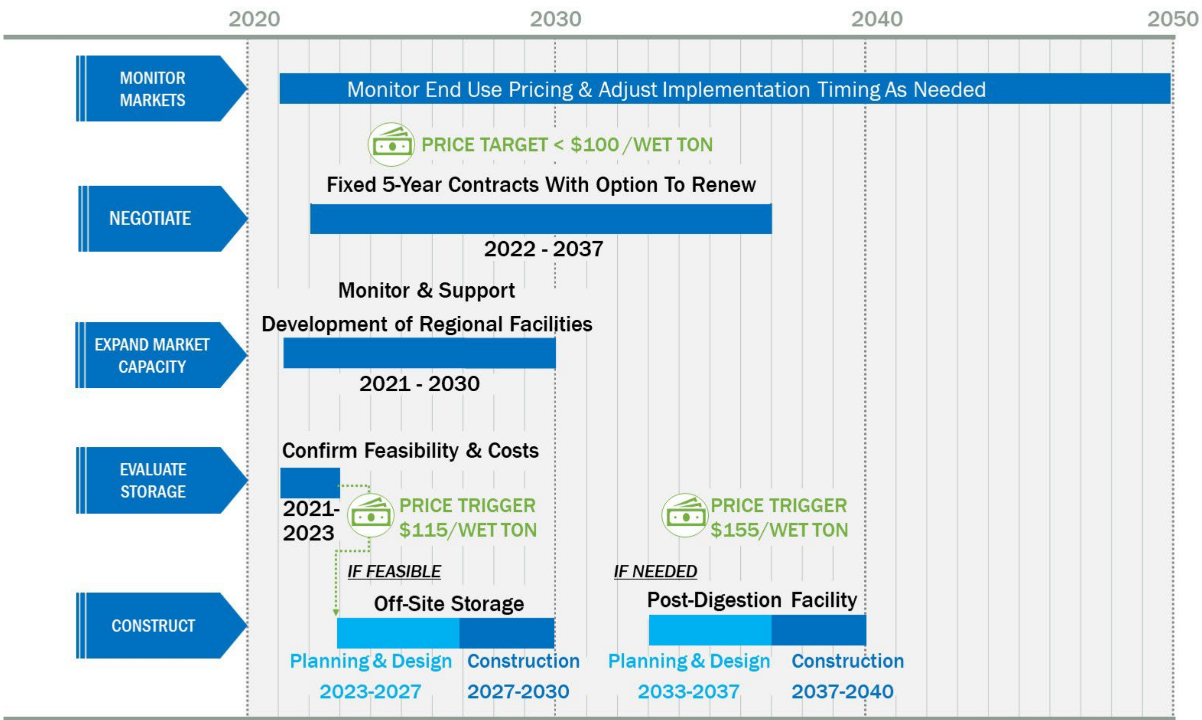

Figure 5-7. Implementation plan for biosolids management

CHAPTER 6 SOLIDS FACILITIES

This chapter provides an overview of the solids treatment process, including the dewatering system and anaerobic digesters.

6.1 Solids Dewatering

The Sludge Dewatering Building (hereby referred to as the Dewatering Building) is located in the central and northern part of the Main Wastewater Treatment Plant (MWWTP) west of the primary sedimentation tanks (refer to Figure 1-1). The Dewatering Building includes equipment for waste activate sludge (WAS) thickening, solids dewatering, and solids load out. The dewatering system includes sludge feed pumps, polymer feed pumps, centrifuges, and cake pumps. Solids loadout includes three hoppers and a truck loadout facility. Table 6-1 summarizes the solids dewatering and loadout equipment/facilities.

Table 6-1. Solids dewatering and loadout equipment

Item	Description
Sludge Feed Pumps	
Type	Moyno Progressive Cavity
Number of Units	5
Hydraulic Capacity per unit (gpm)	3 at 350 gpm and 2 at 250 gpm
Motor Size per unit (hp)	25
Centrifuges	
Type	Humboldt Model S4-1
Number of Units	3
Hydraulic Capacity per unit [a] (gpm)	125 (derated)
Solids capacity per Unit (lb/day)	468,000
Type	Flottweg Z73-4/454
Number of Units	2
Hydraulic Capacity per unit [a] (gpm)	250 (derated)
Solids capacity per Unit (lb/day)	288,000
Cake Pumps	
Type	Piston Pump
Number of Units	5
Motor Size per unit (hp)	100
Cake Hoppers	
Number of Units	3
Volume per unit (cubic yards)	155

a. Observed hydraulic capacity per Appendix I.

6.1.1 Solids Dewatering Challenges

Challenges with the solids dewatering equipment and facility include the following:

- Aging infrastructure
- Lack of reliability and operational flexibility
- Capacity limitations

Aging Infrastructure

Aging infrastructure issues associated with dewatering are discussed in detail in Appendix D and in Appendix I. The key issues are summarized as:

- **Operations and Maintenance (O&M) Issues:** The dewatering equipment is subject to frequent and spontaneous failures. District staff spend more time performing maintenance at the Dewatering Building than in any other part of the MWWTP. Failures at dewatering need to be immediately addressed due to the capacity constraints and lack of redundancy at the facility, which disrupts maintenance elsewhere. The centrifuges and cake pumps require frequent attention, but other equipment such as the sludge feed pumps, polymer feed pumps, and hopper gates experience failures, as well. Grit slugs and struvite precipitation in the equipment have been identified as common causes of equipment failure. The frequency and impact of grit slugs are expected to be reduced in the future as mixing in the second-stage digesters is implemented.
- **Obsolescence:** As the Humboldt centrifuges and Moyno cake pumps approach the end of their useful life, replacement parts are increasingly challenging to find.
- **Seismic Vulnerability:** The District's seismic assessment identified the Dewatering Building as a high-priority seismic rehabilitation to address the safety and level-of-service objectives that were established as part of the seismic evaluation.

Lack of Reliability & Operational Flexibility

The dewatering treatment process is configured in five parallel trains that are not cross connected. Major equipment in each train includes a sludge feed pump, polymer feed pump, centrifuge, and cake pump. If any piece of equipment on the train is out of service, the entire train must be taken out of service, which reduces reliability and operational flexibility.

Capacity Limitations

District staff have identified capacity limitations at the centrifuges and cake hoppers. The centrifuge capacity was de-rated from the nameplate capacity when high grit loads are present based on the manufacturer's recommendation. As noted above, grit slugs and struvite precipitation lead to equipment failure, which in turn results in dewatering capacity limitations.

A capacity assessment of the dewatering process confirmed that the hydraulic capacity (not solids capacity) is the limitation for both the centrifuges and cake hoppers (Appendix P). At peak loading, the centrifuges do not have adequate firm capacity (defined as two units out of service or N+2 configuration) under current and future conditions.

The cake hoppers were also identified to have a firm capacity limitation (defined as one unit out of service or N+1 configuration) in 2020 under peak conditions. The cake hopper capacity limitation is considered secondary to the dewatering capacity constraint because the biosolids management contract requires off-hauling services seven days per week. The contract specifies that the handler must provide the requested number of trucks each day, within the range of 6 to 14 trucks, and the contract specifies no-show penalties when the number of trucks requested do not arrive within the given day. The required responsiveness under the biosolids management contract reduces the likelihood of the hoppers reaching capacity.

6.1.2 Solids Dewatering Alternatives

To address the range of issues associated with the dewatering process, the following alternatives were considered and are described below:

- Construct a new Dewatering Building
- Rehabilitate the existing Dewatering Building
- Increase the solids concentration of digested solids with co-thickening or recuperative thickening

The co-thickening or recuperative thickening alternative is described in Appendix AB. It was not carried forward into the Master Plan roadmap because it would not on its own address the issues with the dewatering process, as described earlier. It would have to be paired with rehabilitation of the existing Dewatering Building, resulting in higher costs. Furthermore, it would likely worsen O&M by producing more struvite.

New Dewatering Building

In this alternative, a new Dewatering Building would be constructed. The new Dewatering Building would not include WAS thickening. Instead, the existing WAS thickening system would remain in the existing Dewatering Building through the planning horizon, and seismic improvements would be performed on the existing building. The new Dewatering Building would be designed to increase reliability by providing cross connections between pumps and dewatering equipment. Cake pumps could also be eliminated from the process by having the centrifuges discharge directly into cake hoppers, with screw conveyors used to distribute the cake across the hoppers. Table 6-2 summarizes the planning criteria for the new Dewatering Building and Figure 6-1 provides a site plan with an example floor plan for the facility.

Table 6-2. Planning criteria for new Dewatering Building alternative

Item	Planning Criteria
Flow and Load Scenario	2050 Medium Growth Scenario
Dewatering Feed Flow (gpm)	1,000[a]
Solids Dewatering Equipment	
Type	Dewatering centrifuge
Number of Units	6 (4 duty, 2 standby)
Capacity per Unit (gpm)	Derated: 300 Nameplate: 360
Feed Pump Motor Size (hp)	25
Dewatering Cake Transfer System	Screw conveyor to hopper
Solids Hoppers	
Number of Units	3 (2 duty, 1 standby)
Volume per Unit (cubic yards)	460
Dewatering Building Enclosure	
Building Area (square feet)	8,500
Building Height (feet)	30 (4-stories)
Implementation Timeline	
Phase 1 Duration (years)	Planning: 2 Design: 2 Construction: 3 Total: 7
Phase 2 Duration (years)	Planning: 1 Design: 1 Construction: 2 Total: 4

a. Peak 7-day flow was selected for planning level criteria. It assumes that one second-stage digester is reserved as equalization for peak day flows.

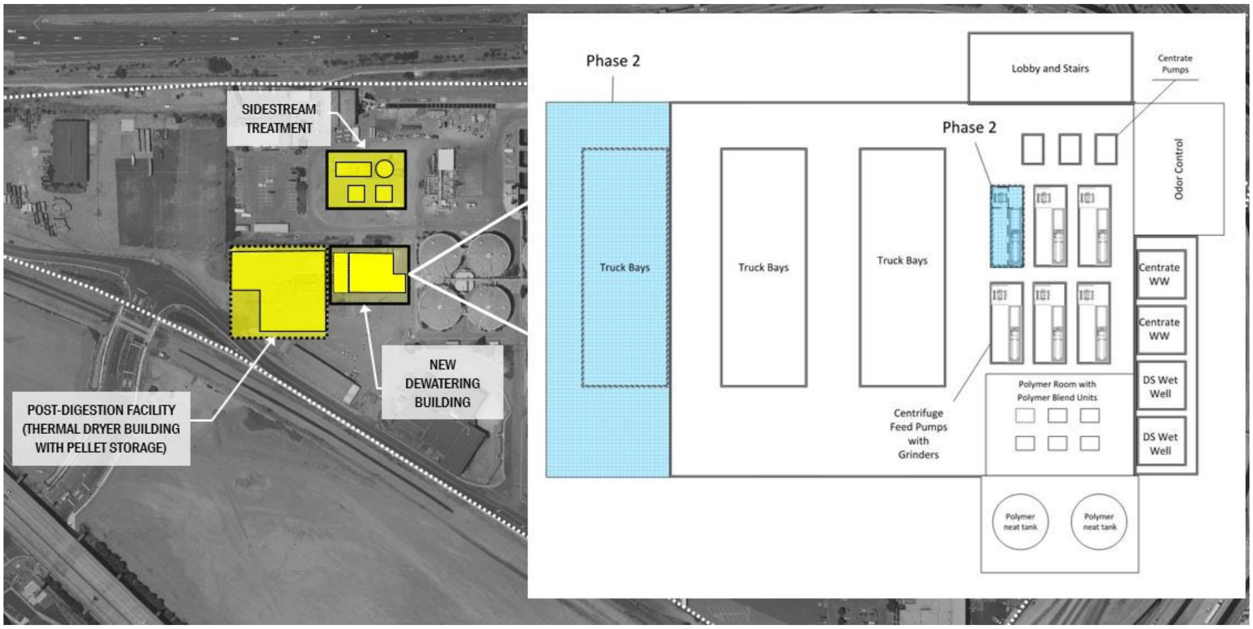

Figure 6-1. Site plan for the new Dewatering Building

The new Dewatering Building would be constructed in two phases, as shown in Figure 6-2. During Phase 1, a new Dewatering Building would be constructed with 5 centrifuges, 2 cake hoppers, and 2 truck bays. The Phase 1 facility would meet flow and load projections under the Medium Growth Scenario through approximately 2044. A second phase could be designed and constructed that would include the addition of one centrifuge and one truck bay to meet flows and loads beyond the planning horizon. The estimated capital costs for Phase 1 and 2 are $74 million and $16 million, respectively. The estimated construction duration of the new Dewatering Building was informed by recent projects implemented at the Orange County Sanitation District (OCSD) and Metro Wastewater Reclamation District (Denver, CO).

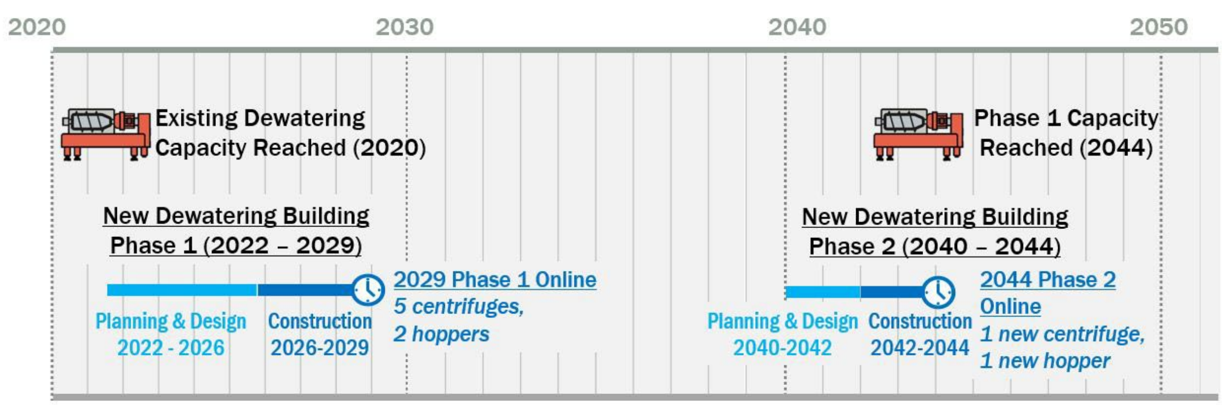

Figure 6-2. Implementation plan for the new Dewatering Building alternative

Rehabilitate Existing Dewatering Building

For this alternative, aging infrastructure at the existing Dewatering Building would be replaced and upgraded, including the centrifuges, sludge feed pumps, cake pumps, piping, and polymer system. The existing Dewatering Building would be seismically retrofitted, as well.

The existing three Humboldt dewatering centrifuges would be replaced with three, high-speed centrifuges. The analysis was based on replacing the existing centrifuges with high-speed centrifuges (e.g., Flottweg C8E) that have a nameplate capacity of 800 gpm; however, it was assumed that these new centrifuges would be de-rated to 600 gpm based on the District's historical de-rating of the centrifuges, as well as the manufacturer's recommendation. Construction would occur in two phases: Phase 1 would replace two centrifuges, and Phase 2 would replace the third centrifuge.

Other key details of this alternative include:

- Temporary dewatering equipment would be installed during construction to provide adequate dewatering capacity to minimize operational impacts. Temporary dewatering adds significant cost and complexity to this alternative. The District has previous experience with a temporary dewatering train that required significant operator attention, which was particularly challenging during swing and graveyard shifts when fewer operators are available to observe the process. The most challenging aspect was conveying the dewatered cake from the centrifuges to a relatively small-sized temporary collecting hopper and then on to the existing storage hoppers. If any step in the temporary dewatering train goes down, the entire train goes down.
- This alternative would not address reliability issues associated with having five parallel dewatering trains that cannot cross-connect.
- Expansion of the cake hoppers to the north and west of the existing hoppers was determined to be infeasible due to site constraints. Accordingly, the lack of cake storage capacity would mean that Operations staff would rely on emergency on-call biosolids trucks during future peak conditions.

Table 6-3 provides the planning criteria for this alternative. A preliminary layout of the rehabilitated Dewatering Building was developed to confirm the space needs for piping, dewatering equipment, and pumps, as shown in Figure 6-3. However, additional detailed engineering analysis is needed to confirm feasibility and refine design criteria.

Table 6-3. Planning criteria for alternative to rehabilitate the existing Dewatering Building

Item	Planning Criteria
Flow and Load Scenario	2050 Medium Growth Scenario
Dewatering Feed Flow (gpm)	1,000[a]
Solids Dewatering Equipment	
Type	Dewatering Centrifuge
Number of Replacement Centrifuges	3
Capacity per Centrifuge (gpm)	Derated: 600 Nameplate: 800
Hydraulic and Solids Loading (lbs/hr)	1,200
Feed Pump Motor Size (hp)	25
Dewatered Cake Pump Motor Size (hp)	100
Implementation Timeline	
Phase 1 Duration (years)	Planning: 2 Design: 2 Construction: 4 Total: 8
Phase 2 Duration (years)	Planning: 1 Design: 1 Construction: 2 Total: 4

a. Peak 7-day flow was selected for planning criteria. It assumes that one second-stage digester is reserved as equalization for peak day flows.

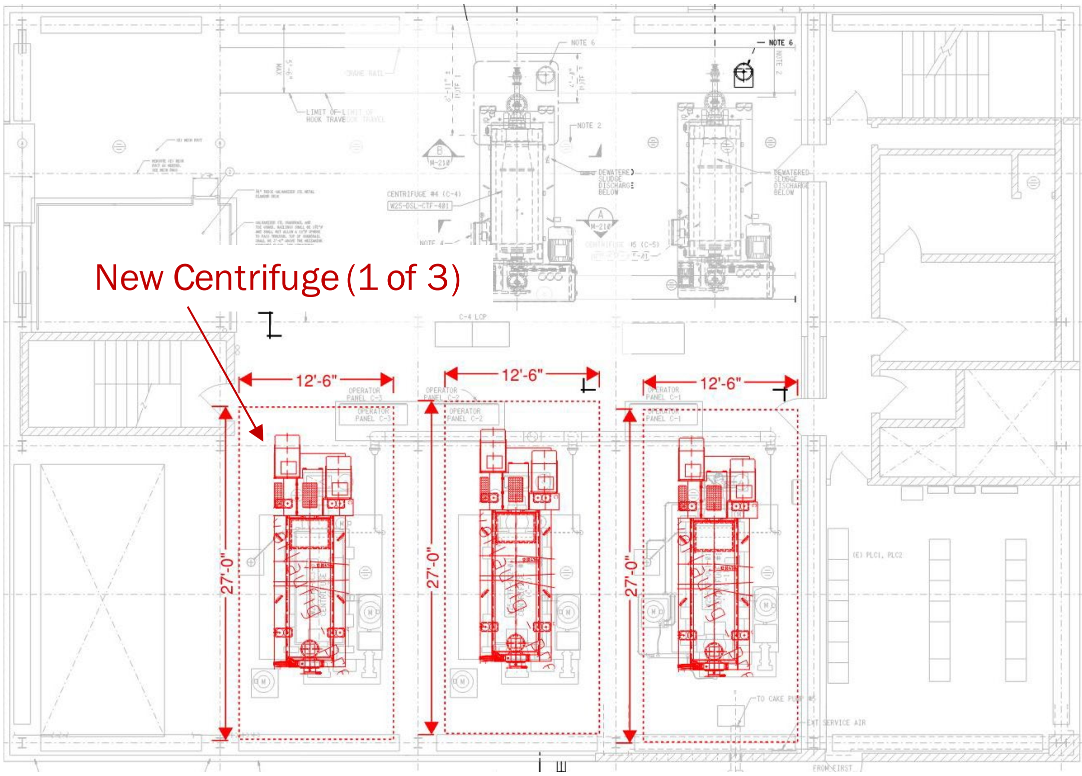

Figure 6-3. Floor plan for alternative to rehabilitate the existing Dewatering Building

Figure 6-4 shows the implementation plan of this alternative with two phases. Phase 1 would replace two centrifuges and provide firm capacity through 2047. Phase 2 would replace one centrifuge to provide firm capacity beyond 2047. Each phase of rehabilitation is estimated to have a capital cost of $15 million. The seismic rehabilitation of the Dewatering Building is estimated to be an additional $7.9 million.

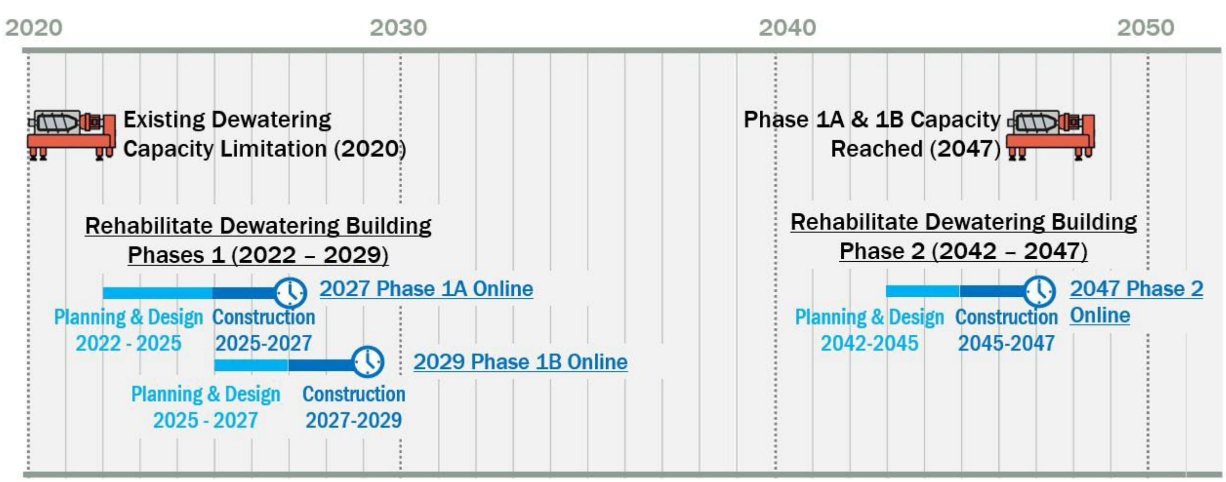

Figure 6-4. Implementation plan for the rehabilitate existing Dewatering Building alternative

6.1.3 Dewatering Alternatives Evaluation

An analysis of the two alternatives described above was performed with respect to both economic and non-economic criteria. Results are shown in Table 6-4, Figure 6-5, and Figure 6-5.

Table 6-4 and Figure 6-5 summarize the net present value (NPV), which is made up of capital costs, operating costs, and economic benefits. The operating costs of each alternative include the energy costs associated with the dewatering equipment. Rehabilitation of the existing Dewatering Building includes annual costs for emergency biosolids management that may result due to the cake hopper storage limitations. For the new Dewatering Building, economic benefits for reduced O&M were taken into account due to the elimination of cake pumps. With the exception of the dewatered cake pumps, the following items were assumed to be similar across the alternatives and therefore were not included in the NPV: labor, polymer use, and rehabilitation and replacement.

For both alternatives, most of the NPV consists of capital costs, and the economic benefits are not significant. The NPV of rehabilitating the existing Dewatering Building is $20 million less than that of the new Dewatering Building. However, rehabilitating the existing Dewatering Building has more uncertainties that could translate into higher-than-estimated costs. Additional engineering analysis is needed to determine the technical feasibility due to the limited space within the building, as well as to refine the construction duration so that cost estimates for temporary dewatering can be revised.

For the non-economic criteria, the new Dewatering Building alternative has a higher score by a significant margin. A new Dewatering Building provides the benefit of simplified construction, increased reliability, reduced O&M through the elimination of cake pumps in the treatment train, and increased operational flexibility.

While rehabilitating the existing Dewatering Building would allow the District to continue to use an existing asset, there would be some major disadvantages, including (1) the continued O&M challenges and lack of operational flexibility associated with having five parallel trains that cannot cross-connect, and (2) the challenges and uncertainty of construction costs associated with rehabilitating an existing building.

Table 6-4. Net present value comparison of dewatering alternatives in 2021 dollars

Cost ($ million)	New Dewatering Building (Phases 1 and 2)	Rehabilitate Existing Dewatering Building (Phases 1 and 2)
Capital Cost	$100	$60
Operating Cost	$12	$22
Benefits	$8	--
NPV	**$103**	**$81**

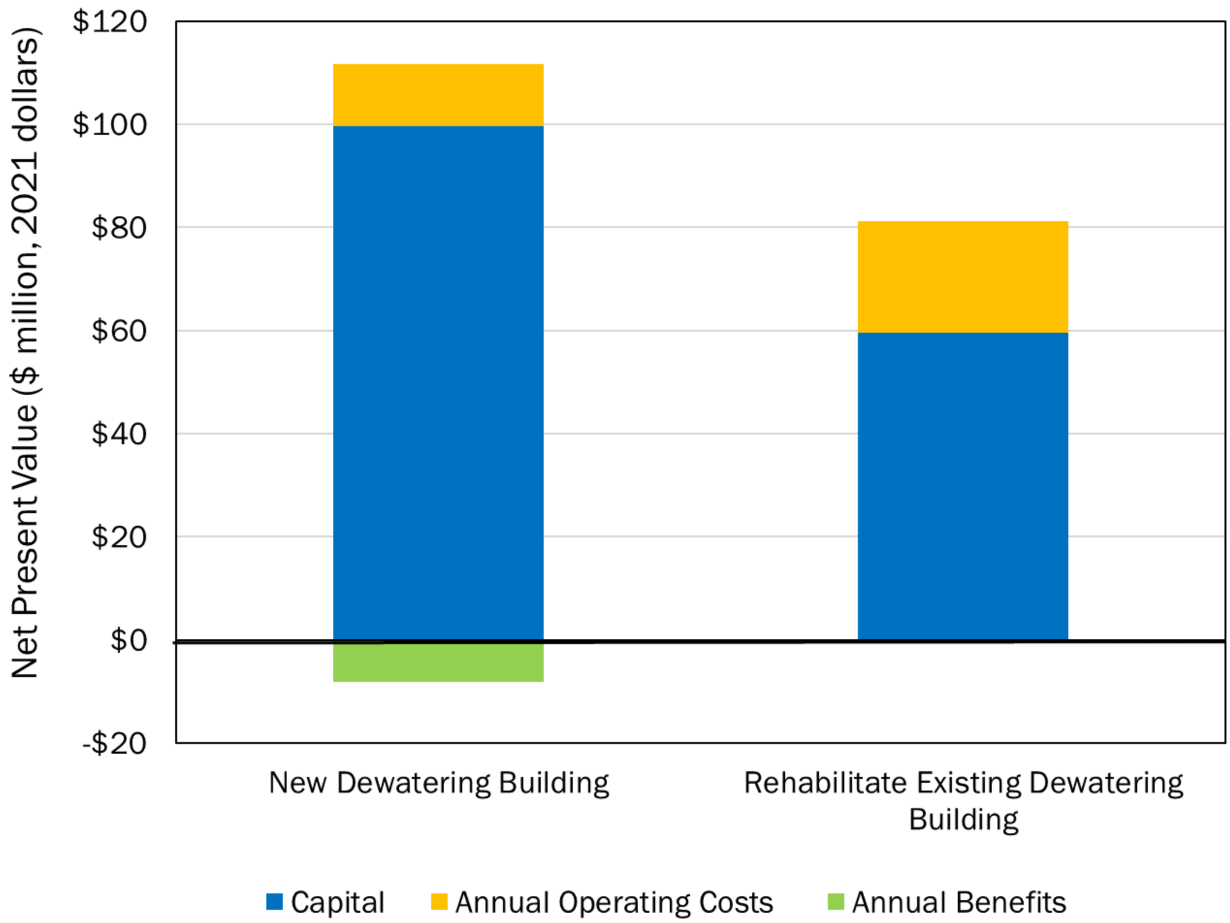

Figure 6-5. Economic evaluation of dewatering alternatives

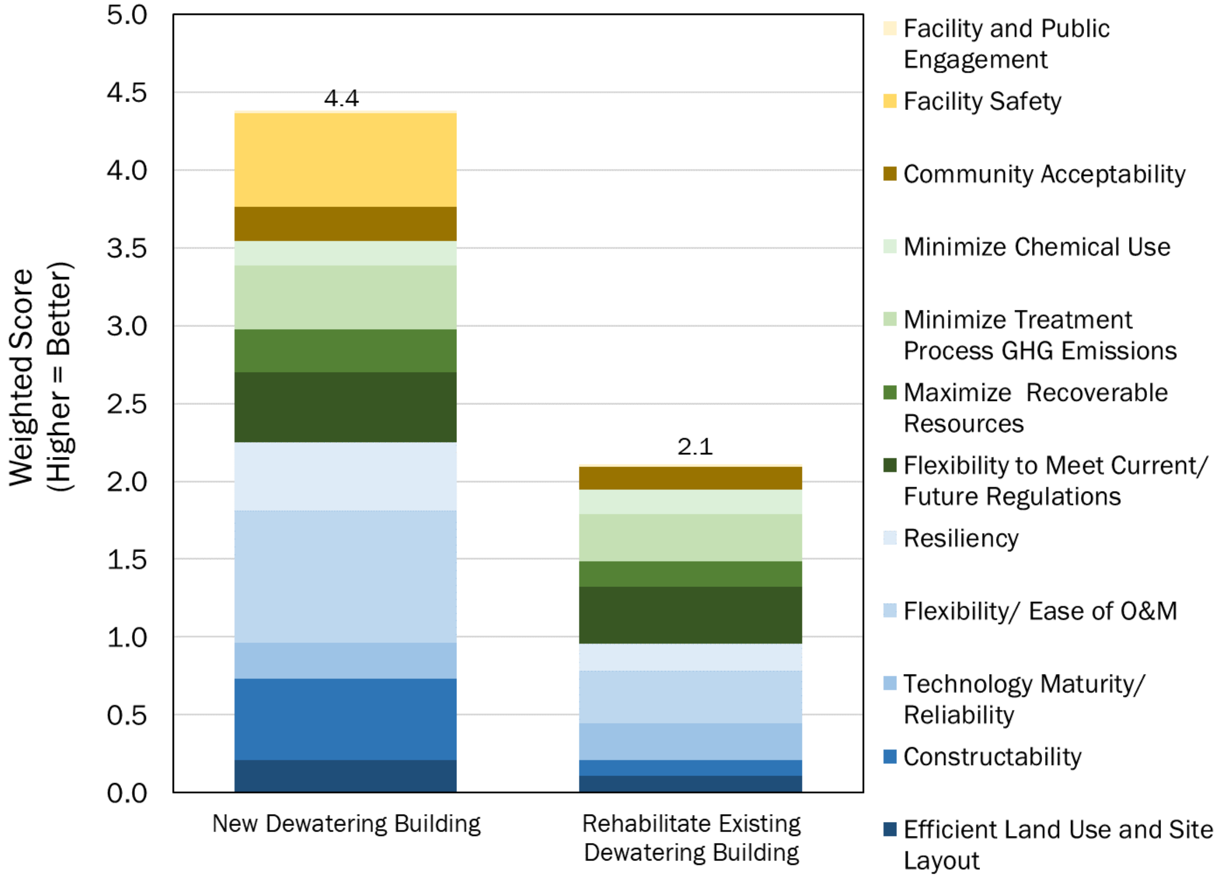

Figure 6-6. Non-economic evaluation of dewatering alternatives

6.1.4 Impact of Resource Recovery on Dewatering Capacity

The impact of R2 on dewatering capacity was evaluated for the following scenarios:

- **No Change to R2**: This alternative represents the status quo. R2 would continue to be received at the MWWTP assuming the Medium Growth Scenario.
- **Right-Size R2:** R2 would continue to be received at the MWWTP with a targeted reduction in HSW. The reduction in HSW assumes eliminating protein (i.e., blood) and dairy (i.e., dissolved air flotation) wastes.
- **No High-Strength Waste (HSW):** HSW streams would be eliminated, and the R2 program would only include LSW streams under the Medium Growth Scenario.
- **No Low-Strength Waste (LSW):** LSW streams would be eliminated, and the R2 program would only include HSW streams under the Medium Growth Scenario.
- **No R2:** All R2 wastes, including both HSW and LSW, would be eliminated. The MWWTP would only treat influent wastewater flows from the District's service area.

Results are shown in Table 6-5. Reducing and/or eliminating R2 does not address the current dewatering capacity limitation for the entire planning horizon. However, it can serve as a bridge until a dewatering project is implemented and would decrease the scope of the dewatering project.

The No HSW, No LSW, and No R2 options have the most significant impact to the dewatering system. The impact of LSW on dewatering is largely attributable to the inert solids in the streams, for example sludge from water treatment plants. The Right-Size R2 scenario has the benefit of less impact on revenue and biogas production, while still reducing the number of centrifuges needed for 2050 conditions. In the near-term, with modified redundancy criteria (N+1 redundancy), the Right-Size R2 scenario could reduce the capacity limitation at the existing Dewatering Building until approximately 2028. This would provide the District with the time to plan, design, and construct a dewatering project.

Additional information on R2 and the Master Plan roadmap is provided in Chapter 11.

Table 6-5. Impact of R2 on dewatering capacity

R2 Alternative	Year Capacity is Reached with Planning Criteria [a]	Year Capacity is Reached with Modified Planning Criteria [b]	New Dewatering Building		Rehabilitate Existing Dewatering Building
			Number of centrifuges for 2050 [c]	Number of Cake Hoppers for 2050 [c]	Number of Centrifuges for 2050 [d]
No Change to R2	2020	2020	6	3	3
Right-Size R2	2020	2028	5	3	2
No HSW	2020	2036	5	3	2
No LSW	2020	2028	5	2	2
No R2	2020	2038	5	2	2

a. Capacity criteria for dewatering assume N+2 redundancy and peak 7-day flow with second-stage digester used for flow equalization.

b. Capacity criteria for dewatering assume N+1 redundancy and peak 14-day flow with second-stage digester used for flow equalization.

c. The number of new dewatering centrifuges assumes a derated capacity of 300 gpm per unit, N+2 redundancy criteria, and processing of peak 7-day flows and loads. The number of cake hoppers is based on each hopper having a volume of 460 cubic yards and providing N+1 capacity under peak 7-day flows.

d. The number of dewatering centrifuges in the existing Dewatering Building assumes replacement of the Humboldt units with new 600-gpm units. The N+2 redundancy criteria is assumed with processing of peak 7-day flows and loads.

6.1.5 Dewatering Implementation Plan

Based on the alternatives evaluation presented above, the Master Plan roadmap is based on the construction of a new Dewatering Building in conjunction with Right-Size R2. Right-Size R2 provides capacity at the existing Dewatering Building until the new building is constructed.

The implementation timeline is shown in Figure 6-7. Phase 1 of construction will last 7 years, and the earliest time that the new Dewatering Building could come online is 2029. Five centrifuges will be needed to provide sufficient capacity through 2050, assuming Right-Size R2 is continued throughout the planning horizon. Two solids hoppers are included in Phase 1 to provide 1.5 days of cake storage under peak conditions until 2040, when a third hopper would be added in Phase 2. The capital costs for Phase 1 and Phase 2 are estimated at $74 and $12 million, respectively.

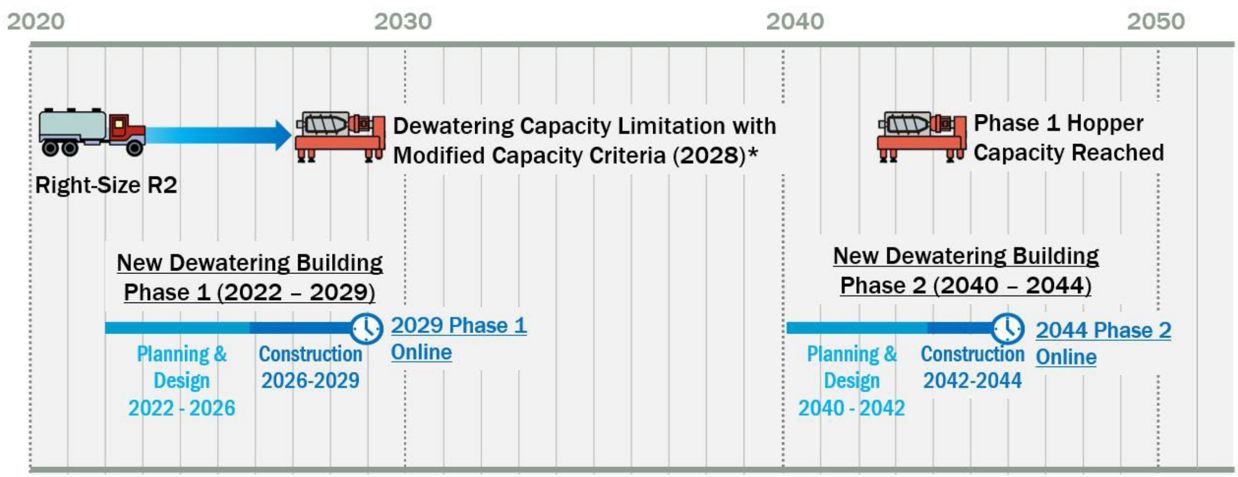

Figure 6-7. Implementation plan for the new Dewatering Building paired with Right-Size R2

Next steps for the new Dewatering Building include confirmation of the following:

- **Dewatering technology:** Confirm that centrifuges are the preferred technology for dewatering.
- **Building layout:** Perform a preliminary design of the new Dewatering Building to confirm layout, features, truck access routes, location for scales, and other ancillary features.
- **Redundancy and design criteria:** Confirm redundancy criteria, design flows and loads, number of dewatering units, and capacity per dewatering unit.
- **Project phasing:** Identify opportunities to reduce initial construction costs with strategic project management.
- **Future considerations:** Strategically plan phasing and layout of the facility to provide flexibility/expansion with post-digestion technologies.
- **WAS thickening:** Confirm that WAS thickening will remain in existing Dewatering Building.

- **Monitor struvite and sludge dewaterability:** Right-Size R2 may decrease struvite formation in the digesters and dewatering equipment, and could also improve sludge dewaterability. Monitor performance and struvite accumulation as Right-Size R2 is implemented. Incorporate findings into the design criteria for the new Dewatering Building.

6.2 Anaerobic Digesters

The capacity assessment confirmed that the anaerobic digesters have adequate total and firm capacity for the planning horizon (Appendix P).

CHAPTER 7 CLIMATE CHANGE RESILICIENCY

This chapter describes climate change resiliency considerations, including sea level rise, biogas utilization, greenhouse gas (GHG) emissions, recycled water, and sea level rise. Beneficial use of water reuse (as it relates to nutrient management) and biosolids are covered in Chapters 4 and 5, respectively.

7.1 Sea Level Rise

The District performed an extensive analysis to identify facilities at the Main Wastewater Treatment Plant (MWWTP) that are vulnerable to sea level rise (Appendix E). The analysis showed that the facilities located within the central portion of the MWWTP are expected to avoid flooding from sea level rise within the planning horizon; however, the Dechlorination Facility and Transition Structure near the shoreline of the Bay are at risk of flooding during 100-year storm surges under current and future conditions. No other facilities at the MWWTP were identified to need improvements to address sea level rise within the planning horizon. However, all projects implemented within areas known to be vulnerable to sea level rise, which includes the MWWTP, will consider the District's climate change design guidelines for any capital projects and will implement features to avoid impacts of inundation due to future sea level rise, even beyond the Master Plan planning horizon.

7.2 Biogas Utilization

Biogas generated from the solids treatment process at the MWWTP is a biogenic source of energy. Biogas is energy rich and is used to generate electricity on-site at the Power Generation Station (PGS). The PGS consists of multiple types of infrastructure, including a gas turbine, three engines, a gas conditioning system, and ancillary equipment. A simplified schematic of this process is shown in Figure 7-1.

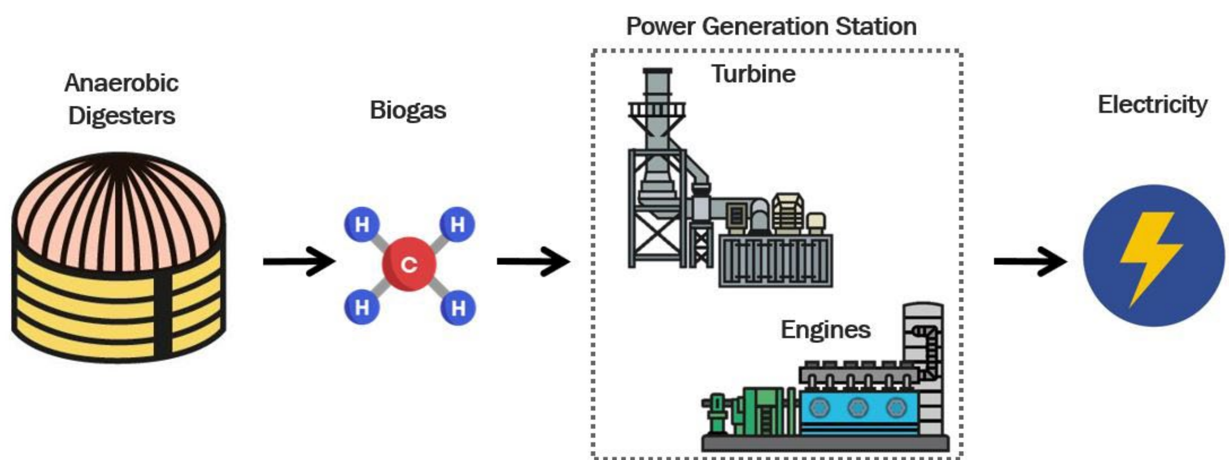

Figure 7-1. Simplified schematic of biogas production and electricity generation at the MWWTP

The District has set a goal to reduce indirect (Scope 2) GHG emissions to zero by 2040, which would require one of the following:

- Producing 100%-renewable power on-site at the MWWTP
- Purchasing 100%-renewable power
- Purchasing unbundled renewable energy certificates (RECs) or offsets to counteract the use of non-renewable power sources, if allowed by District policy

Whether biogas contributes to the District's GHG inventory depends on the circumstances. Beneficial use of biogas to generate electricity does not contribute to the District's GHG inventory; however, any biogas that is flared does contribute to the District's direct (Scope 1) GHG emissions. To align with the District's overall carbon neutrality goals and to comply with the intent of the District's air permit, the District takes all feasible measures to avoid flaring through prudent biogas utilization.

A biogas utilization study (Appendix K) was performed to evaluate the following goals:

- Characterize challenges and economics for PGS now and in the future
- Ensure that continued operation of PGS offers economic and non-economic value
- Identify opportunities to increase the value of on-site electricity generation
- Identify opportunities and challenges for new uses of biogas that are not based on electricity
- Recommend near-term steps that maintain flexibility and maximize future biogas value

A cost-benefit financial analysis for biogas utilization was performed and took into account a variety of factors, including operating expenses, tip fees, electricity sales, and offset electricity purchases. For offset electricity purchases, two options were considered: "brown power" from the Western Area Power Administration (WAPA) and "green power" from Pacific Gas and Electric (PG&E).

The analysis indicated that the cost of operating the PGS is currently greater than the value of the power produced for two principal reasons:

- **High Operations and Maintenance (O&M) Costs:** The O&M costs are driven by high fixed costs for labor to operate the facilities, maintenance costs to address the aging engines and associated infrastructure, and an extended service agreement (ESA) for the turbine.

- **Low Value of Renewable Energy**: Costs to produce power on-site are compared to avoided costs of purchasing power from WAPA, which is inexpensive. At the same time, the value of surplus renewable energy, including RECs, is much lower than forecasted due to the influx of low-cost solar and wind power in the market.

However, the economics of PGS are greatly improved if other considerations are taken into account:

- **Avoided Power Purchases:** If the costs to produce power are compared to the avoided costs of purchasing 100% green power from PG&E or a community choice aggregator, which are more expensive, then producing power at the PGS remains very cost-effective.

- **Tip Fees:** If it is assumed that high-strength wastes are accepted at the MWWTP only because of the existing cogeneration capacity and the net revenues from these tip fees are included, then the economic outlook of PGS is more favorable.

- **Back-Up Power:** Producing power on-site provides non-economic benefits such as local power distribution resiliency and an additional level of redundancy for operation of the MWWTP.

Short-term recommendations for the biogas utilization roadmap include:

- Renew the Power Purchase Agreement (PPA) with the Port of Oakland (Port) or a new party in late 2022.
- Renew the turbine ESA in late 2023.
- Consistently track PGS and R2 economics to ensure that costs don't exceed benefits.
- Strategically increase tip fees for high-strength wastes to ensure that the R2 program covers treatment costs and maximizes revenue.
- Clarify and/or establish green energy purchasing policy to meet the District's climate change goals.
- Continue to monitor the potential for credit trading through the Low Carbon Fuel Standard and Electric Renewable Identification Numbers programs; electric vehicle charging of EBMUD fleet and/or employee vehicles; and a direct power supply connection with the Port or a third party.
- Continue to monitor and influence the guidance on the implementation of California Occupational Safety and Health Administration's process safety management on-site use exception.

Mid-term recommendations for the biogas utilization roadmap include:

- Analyze the resulting economics of PGS with the new PPA, new ESA, higher tip fees, feedstock changes, and other market changes.
- When required by regulations, implement Right-Sized R2 to reduce or eliminate high-strength wastes that are high in nitrogen, as described in Chapter 11.

7.3 Greenhouse Gas Emissions

The District has established a goal for the wastewater system of reducing indirect emissions to a net zero increase and reducing direct emissions by 50% by 2040, compared to 2000 levels. At the MWWTP, indirect emissions include power use and direct emissions include combustion of fuel (i.e., natural gas), and treatment and discharge of wastewater (e.g., nitrogen content of wastewater discharges and process emissions).

The District's GHG reduction goals are challenging to meet due to the limited options to reduce nitrous oxide emissions resulting from nitrogen that reaches the MWWTP. Nitrogen in the raw wastewater primarily originates from human waste and thus cannot be prevented or source controlled. Further, changes to the biological treatment processes at the MWWTP can shift where the nitrous oxide emissions emanate from, but according to guidance that the District uses to calculate its GHG inventory, those changes will only marginally decrease overall Scope 1 emissions, not to the level necessary to get to 50% reduction in direct emissions.

Nitrogen contained in trucked wastes from the R2 program can be targeted for strategic removal ("Right-Size R2"); however, there are some tradeoffs. For example, some trucked wastes that contain high nitrogen content also have significant benefits for both economics and biogas generation.

As a result of these challenges, the District's approach to reducing direct emissions is strategic and focused. The most effective measures the District can take in the near term are:

- **Replace all diesel with renewable diesel:** The District must use diesel fuel for pilot fuel in the engines (i.e., to start them up), which results in approximately 10,000 gallons of diesel fuel use per year. The District also uses diesel for emergency generators, which is a negligible amount, except during extended outages. Replacing this fossil-fuel diesel with renewable diesel has been successful on the Water side of the District's business, as renewable diesel is functionally identical to fossil-fuel diesel.
- **Right-Size R2:** Reducing or eliminating trucked waste that is high in nitrogen will have immediate benefits to reduce nitrogen and therefore nitrous oxide. The District has identified protein (i.e., blood) wastes as the best opportunity to reduce nitrogen, while minimizing the impact to benefits such as tip fees and biogas generation. Another option is to eliminate dairy (i.e., dissolved air flotation) wastes; however, the benefits of dairy wastes are significant and the nitrogen content is less well understood, so the District will further characterize dairy wastes to better understand the potential impact. The District also plans to characterize other potentially high-nitrogen wastes such as low-strength septage to determine further targets for reduction and to maximize GHG reduction benefits.
- **Electrify building and water heating**. The District currently heats personnel buildings and domestic water at the MWWTP with natural gas. Replacing these natural gas heaters with electric options will reduce direct GHG emissions. This option could be challenging and expensive, so the District will further explore the details of implementing this option, including specific modifications and cost estimates in the near-term.

- **Commit to purchasing 100% renewable electricity**: The District generates renewable electricity on-site at a cost that is currently significantly cheaper than purchasing renewable electricity. However, over time the cost of renewable electricity is expected to decrease. The District will track the changing economics to inform future decision making.

- **Explore GHG credits for carbon sequestration and fertilizer offsets:** Currently, the District contributes to a reduction in GHG emissions globally through the land application of biosolids, which sequesters carbon in the soil and offsets the use of fossil-fuel-based fertilizer. However, the District does not receive credit for these benefits in its GHG inventory because the biosolids are land applied by a third party, and therefore outside the District's direct control. The District is exploring how these benefits could be included in the District's inventory by creating contractual requirements in future biosolids management contracts.

In addition to these measures to reduce the District's GHG emissions, the District will explore the possibility of monitoring nitrous oxide and methane emissions directly from the MWWTP. The inventory methodology that the District currently uses is a broad-brush method, originally intended to estimate GHG emissions for geographic areas—cities, states, and nations—rather than specific treatment plants. Sampling and analysis of the MWWTP itself could provide a more precise understanding of the emissions from the plant, including not only estimates of annual emissions, but also the variation over days, weeks, and seasons. Doing so could further inform the District's ability to make targeted reductions and better understand how future changes to the MWWTP processes could affect the District's emissions inventory.

7.4 Recycled Water

The District's Recycled Water Master Plan Update in 2019 identified a suite of both non-potable and potable reuse projects that could be implemented to achieve the District's goal of producing a total of 20 mgd of recycled water by 2040. Recycled water projects that relate to the Master Plan are described below.

East Bayshore Recycled Water Facility

The East Bayshore Recycled Water Facility (EBRWF) is an existing recycled water facility located at the MWWTP (refer to Figure 1-1). The District evaluated options to improve recycled water quality from the EBRWF and to increase deliveries to new customers, and is moving forward with additional studies that will guide the implementation of improvements and expansion of the EBRWF.

As noted in Chapter 4, increased recycled water deliveries from EBRWF would have a minimal impact on discharges of total inorganic nitrogen (TIN) to the Bay, and therefore are not considered as a strategy for nutrient reduction. However, future plans for the EBRWF should be coordinated with overall planning efforts for the MWWTP because new treatment processes that could potentially be added to EBRWF such as reverse osmosis or a membrane bioreactor (MBR) would require additional land (refer to Chapter 11). Additionally, pilot testing of MBRs could be coordinated with mainstream nutrient removal studies and pilot testing.

Pt. Isabel Water Recycling Facility

A new potential recycled water facility located at the Pt. Isabel Wet Weather Facility (WWF) – referred to as the Pt. Isabel Water Recycling Facility – would treat raw wastewater and produce recycled water that is suitable for unrestricted non-potable reuse. If the District moved forward with implementation of this new facility, there would be a 5% TIN load reduction to the Bay that would provide the District with approximately 5 years of compliance with the Master Plan Target. The Pt. Isabel Water Recycling Facility would not require land at the MWWTP, as all treatment facilities would be located at the Pt. Isabel WWF.

Potable Reuse

Potable reuse at the MWWTP was identified as a potential long-term project. As part of the Recycled Water Master Plan Update, various recycled water production options were considered, and approximately 4.5 acres of land was identified for a potable reuse facility located at the MWWTP. Potable reuse is not expected to be implemented within the planning horizon of the Master Plan; however, to provide flexibility for the future, land was reserved for a potable reuse facility, as described in Chapter 11.

CHAPTER 8 PUMPING SYSTEMS

Key pumping systems at the Main Wastewater Treatment Plant (MWWTP) include the influent, mid-plant, and effluent pump stations. The influent pump station (IPS) and effluent pump station (EPS) were identified to currently have capacity limitations at peak flows, as described in Appendix P. This chapter describes the plan to address the capacity limitation along with other related projects in the Capital Improvement Program (CIP). Detailed information such as design criteria and historical operating experience are located in Appendix I.

8.1 Influent Pump Station

The IPS has five influent pumps with a rated capacity of 85 mgd per pump (425 mgd total). The total and firm capacity are defined as five and four pumps, respectively. The peak hourly influent flow rate is defined as 425 mgd.

Pump testing and rebuilds are routinely performed by the District. It has been observed that, after a pump rebuild, the flow rate gradually decreases over time due to pump degradation such as worn impellers. As a result, the actual influent pump capacity varies year to year and is determined during pump testing. Additional pump testing, condition assessment, and engineering analysis are needed to identify potential improvements to consistently maintain the IPS total capacity of 425 mgd. This additional work may also include pump rehabilitation and replacement.

The CIP includes projects at the IPS for aging infrastructure improvements and seismic rehabilitation. To address capacity limitations at IPS, the near-term roadmap includes additional engineering analysis to identify improvements and/or pump replacement that are needed to provide reliable capacity. IPS projects in the CIP assume that the improvements to address capacity will be performed at the same time as the aging infrastructure improvements and seismic rehabilitation.

8.2 Effluent Pump Station

The EPS has four effluent pumps with a rated capacity of 107 mgd per pump (428 mgd total). The total and firm capacity are both defined as three pumps. There are four pumps installed, with one as a standby; however four pumps cannot run simultaneously without overflowing the surge chamber immediately downstream of the pump discharge. The EPS discharges into an outfall pipe into the San Francisco Bay, and the hydraulic capacity is impacted by tidal conditions. The maximum outfall capacity assuming a 10-year high tide level (but no sea level rise) was recently de-rated from 320 mgd to 278 mgd due to hydraulic bottlenecks at the surge chamber and downstream of the EPS.

Dynamic hydraulic modeling, including a surge analysis, needs to be performed to identify and confirm improvements to address the hydraulic bottlenecks at the EPS to increase the total capacity back to 320 mgd. The near-term roadmap includes this analysis to address the hydraulic bottlenecks and capacity limitations. It is assumed that the analysis would be performed as part of the EPS project included in the CIP, which will address aging infrastructure and seismic rehabilitation in addition to capacity limitations.

8.3 Implementation Plan

The 10-year CIP includes projects at both the IPS and EPS to address aging infrastructure, seismic rehabilitation, and capacity limitations. Additional engineering analyses are planned to start in the near-term to confirm pump and/or hydraulic improvements to address the capacity limitations. The improvements would be designed and constructed following the engineering analyses.

CHAPTER 9 LIQUIDS FACILITIES

This section provides an overview of projects identified for the liquids treatment facilities at the Main Wastewater Treatment Plant (MWWTP), including:

- **Primary treatment:** Covering of primary sedimentation tanks (PSTs) for odor control.
- **Secondary treatment:** Four alternatives were considered to increase the capacity of the secondary treatment system, including chemically enhanced primary treatment (CEPT), step-feed configuration of high-purity oxygen activated sludge (HPOAS) reactors, upgrade of surface aerators, and upgrade of return activated sludge (RAS) pumps. Although CEPT would occur at the PSTs, it is discussed in the secondary treatment section with the other alternatives.
- **Disinfection:** Disinfection alternatives were evaluated to identify feasible alternatives to chlorination/dechlorination. A key objective of the study was to confirm if dechlorination could be eliminated. Based on the analysis, alternatives to chlorination and dechlorination were not identified in the near-term, thereby confirming the need to implement improvements to the Dechlorination Facility.

9.1 Covering of Primary Sedimentation Tanks

Covering the PSTs for odor control was identified for the roadmap, and planning criteria are shown in Table 9-1.

Table 9-1. Planning criteria for covering the PSTs

Item	Planning Criteria
Number of Tanks	16
Air Changes per Hour	12
Cover Material	Aluminum or Fiberglass Reinforced Plastic
Odor Control System Type	Chemical Scrubber
Construction Costs	$37 million
Planning, Engineering, and Construction Management	$13 million
Contingency (30%)	$15 million
Total Capital Costs	**$66 million**

Figure 9-1 illustrates the implementation plan, with 2031 selected as the potential start date for planning purposes. There are three distinct phases to minimize construction impacts to operations and maintenance (O&M). The first phase would cover the first 6 PSTs and install an odor control system. The second and third phases would cover the remaining PSTs and connect the ductwork to the odor control system. Prior to implementation of this project, it is recommended that additional engineering analysis be performed during preliminary design to confirm odor control system technology, as well as selection of PST cover type (aluminum versus fiberglass reinforced plastic).

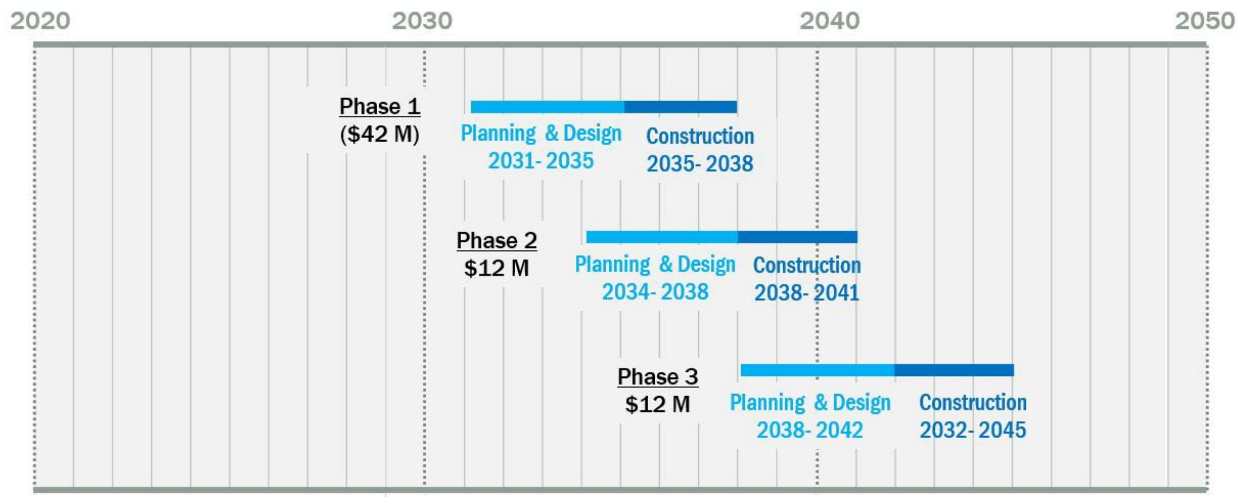

Figure 9-1. Implementation plan for covering the PSTs

9.2 Secondary Treatment System Capacity Improvements

Capacity limitations under specific rare circumstances were identified for the HPOAS reactors in 2040 and for the secondary clarifiers in 2020 (Appendix P).

High-Purity Oxygen Activated Sludge Reactors

The HPOAS reactors have four stages in series. Stage 1 is anaerobic, while Stages 2-4 are aerobic. The HPOAS were rated based on the oxygen transfer performance into the aerated stages under peak day conditions. Two limiting conditions were considered:

- A low Stage 4 vent oxygen purity (<40%)
- A low dissolved oxygen (DO) concentration (<2 mg/L) in the first aerobic zone (Stage 2) due to high oxygen uptake rates and insufficient oxygen transfer.

Low DO concentration in Stage 2 was found to be the limiting factor in year 2040. To address this limitation, secondary system upgrades are needed to either decrease peak day loading or increase oxygen transfer efficiency in Stage 2.

Secondary Clarifiers

The secondary clarifiers were determined to be capacity-limited in 2020 during peak flow and loading conditions. Peak conditions were assumed to be the following simultaneously:

- Peak week organic loading
- Peak flow (150 mgd for firm capacity, 168 mgd for total capacity)
- 90th percentile sludge volume index (SVI)

The secondary clarifiers were rated based on maximum acceptable solids loading ratesi.e., a maximum HPOAS reactor mixed liquor suspended solids (MLSS) concentration for peak firm (13.6 mgd/clarifier) and total (14 mgd/clarifier) flows based on 2-dimensional computational fluid dynamics modeling for a historical 90th percentile SVI of 133 mL/g. The maximum MLSS values were obtained from steady-state BioWin model simulation results at peak week or peak month loading conditions, whichever was more limiting to capacity.

Maximum week loading was found to be the limiting factor, requiring secondary system upgrades to decrease the maximum solids loading rate to the clarifiers during peak firm and total flow conditions.

9.3 Secondary Treatment System Capacity Alternatives Analysis

To address secondary system capacity constraints, the following alternatives were considered:

- **Chemically Enhanced Primary Treatment:** CEPT consists of adding ferric chloride ($FeCl_3$) and polymer upstream of the PSTs, which would improve the removal of total suspended solids (TSS) and biological oxygen demand (BOD) in the PSTs. In turn, this would decrease loading to the secondary treatment system, lowering peak-day loading to the HPOAS reactors, as well as peak-week MLSS and solids flux to the secondary clarifiers. CEPT could be performed intermittently or as needed when capacity-limited conditions arise.
- **Step-Feed:** Routing up to 50% of secondary influent flow directly to Stage 3 of the HPOAS reactors (skipping Stages 1 and 2 entirely) would decrease the MLSS concentration and reduce the solids flux to the secondary clarifiers.
- **Upgrade Return Activated Sludge Pumps:** Installing higher capacity RAS pumps would allow for a higher solids flux rate to the secondary clarifiers, extending secondary clarifier capacity.
- **Upgrade Surface Aerators:** Upgrading surface aerators in Stage 2 would increase the oxygen transfer efficiency and provide sufficient aeration capacity for peak day demands.

Table 9-2 shows how these alternatives would address the secondary treatment system capacity limitations. No alternative is effective enough on its own to address all the secondary treatment capacity limitations; accordingly, the last two rows in Table 9-2 show combined alternatives.

Table 9-2. Secondary treatment system improvement alternatives

Alternative	HPOAS Reactors		Secondary Clarifiers	
	Firm Capacity (7 Reactors)	Total Capacity (8 Reactors)	Firm Capacity (13.6 mgd/clarifier)	Total Capacity (14 mgd/clarifier)
Capacity Study Findings (Medium Growth Scenario)[a]	2040	2050	2020	2022
CEPT	2045	2050+	2033	2040
Step-Feed	2040	2050	2050 +	2050+
Upgrade Surface Aerators	2050+	2050+	2020	2022
Upgrade RAS Pumps	2040	2050	2027	2032
CEPT + Upgrade RAS Pumps	2045	2050+	2042	2050+
Step-Feed + Upgrade Surface Aerators	2050+	2050+	2050+	2050+

a. Refer to Appendix P for detailed findings from capacity assessment.

Chemically Enhanced Primary Treatment

The use of CEPT to increase HPOAS reactor and secondary clarifier capacity was evaluated using the same BioWin model developed for the capacity assessment with the following assumptions:

- Ferric chloride dose of 30 mg/L at the headworks
- Polymer dose of 0.5 mg/L at the inlet of each PST
- TSS removal efficiency across the PSTs as follows:
  - 71% TSS removal for wet weather flows and loads
  - 74% TSS removal for dry weather flows and loads

Figure 9-2 shows a conceptual site plan of CEPT. New ferric chloride tanks would be added adjacent to the existing ferric chloride tanks. Ferric chloride would be added upstream of grit removal and polymer would be added at the inlet of each PST. Figure 9-2 shows CEPT for 16 PSTs; this assumption should be revisited if 2 to 3 PSTs are dedicated to sidestream treatment (SST).

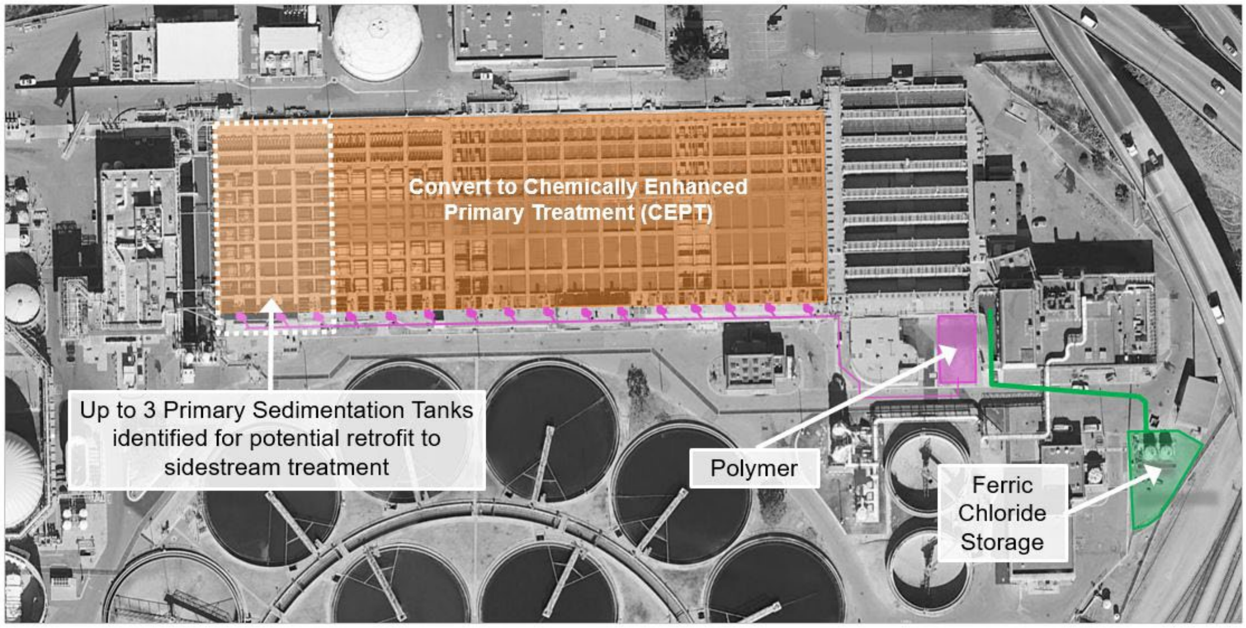

Figure 9-2. Conceptual site plan of CEPT

Implementing CEPT alone would extend the firm capacity of the HPOAS reactors from 2040 to 2045 and the secondary clarifiers from 2020 to 2033. The secondary clarifier capacity would still be the limiting condition for the secondary treatment system, and an additional improvement would be required to unlock additional secondary clarifier capacity during peak flow events (i.e., upgrades to RAS pumps).

CEPT would have several benefits, including improving the removal of TSS and BOD and reducing struvite precipitation in the digesters. In addition, it would allow for operation at higher surface overflow rates (SORs), which could allow for up to three PSTs to be re-purposed for SST (Appendix V). For the capacity assessment, a maximum SOR of 3,000 gpd/ft^2 was assumed for the existing conventional PSTs to represent a condition with no thickening in the PSTs to handle peak day flows. With CEPT, the peak day SOR could increase to 3,700 gpd/ft^2 for 13 PSTs (total capacity) and 4,400 gpd/ft^2 for 11 PSTs (firm capacity).

Intermittent CEPT could serve as a bridge to mitigate capacity limitations in the interim while providing time for the implementation of other alternatives such as step-feed and/or RAS upgrades. CEPT could be implemented as needed when SVIs are high (HPOAS reactor limitation) and/or when peak flows are anticipated (PST limitation).

Step-Feed

Step-feed consists of routing up to 50% of secondary influent flow directly to Stage 3 of the HPOAS reactors (skipping the Stages 1 and 2 entirely), as illustrated in Figure 9-3. In this configuration, the MLSS concentration in Stages 3 and 4 is diluted so that solids loading on the secondary clarifiers is reduced, thereby increasing treatment capacity.

The use of step-feed to increase secondary clarifier capacity was evaluated using the BioWin model developed for the capacity assessment. A maximum of 50% step-feed split flow to Stage 3 of the HPOAS reactors was assumed. Both an eight train (full step-feed) and four-train (half step-feed) conversion were considered. For the four-train conversion, the firm capacity was assumed to be three step-feed trains and four status-quo trains in service. For total capacity, four step-feed trains and four status-quo trains were assumed to be in service. For this alternative, new feed pipes and valves would be necessary.

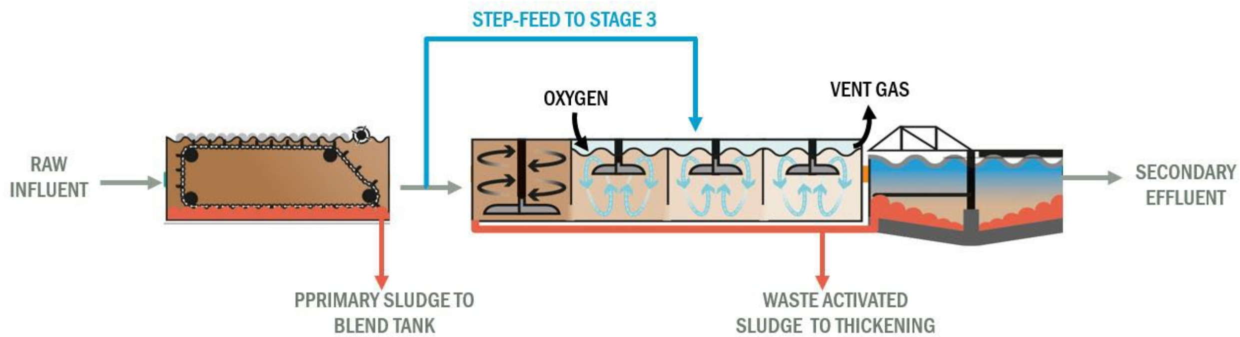

Figure 9-3. Schematic of step-feed configuration

Step-feed was determined to increase secondary clarifier capacity to 2032 with half conversion and beyond the planning horizon with full conversion. However, step-feed would not address the HPOAS reactor capacity limitation, and new surface aerators in Stage 2 would be needed by 2040.

Upgrade Return Activated Sludge Pumps

Upgrading the RAS pumps from 6 to 8.5 mgd/clarifier at peak flow would extend secondary clarifier capacity from 2020 to 2027 for firm capacity and from 2022 to 2032 for total capacity. If RAS pump upgrades were implemented with CEPT, secondary clarifier capacity would be extended to 2042 for firm capacity and 2050 for total capacity. The RAS improvements assume adequate capacity to pump from the existing wet well at the rate specified in this section to handle wet weather flows. This analysis is based on the computational fluid dynamics modeling results presented in Appendix P.

Upgrade Surface Aerators

HPOAS reactor total capacity is sufficient through the planning period; however, firm capacity is limited in 2040 due to insufficient oxygen supply and/or oxygen transfer to maintain a DO of 2 mg/L in the first aerobic zone (Stage 2). Maintaining vent purities of 40% or higher will not be a limitation.

Installing new surface aerators in the first aerobic zone would improve oxygen transfer efficiency in the existing HPOAS reactors and extend the HPOAS reactor firm capacity from 2040 to the end of the planning horizon. A new surface aerator would also be required for CEPT or step-feed to satisfy oxygen uptake rates for a peak one-day loading condition during summer flow and temperatures. The new aerator efficiency was assumed to be 3.2 pounds oxygen per horsepower per hour (lb O_2/hp-hr).

9.4 Economic Evaluation

An evaluation of the net present value (NPV) was performed to compare the following combinations of alternatives:

- **Chemically Enhanced Primary Treatment and Upgrade Return Activated Sludge Pumps:** This alternative assumes that CEPT and RAS pump upgrades would be implemented by 2024. The NPV takes into account as a benefit that the oxygen demand would be lower, resulting in energy savings. Additional costs incurred include higher energy for feed and RAS pumps, chemical costs for ferric chloride and polymer, and rehabilitation costs for RAS pumps.
- **Step-Feed and Upgrade Surface Aerators:** This alternative assumes that step-feed is implemented by 2024 and that upgrades to aerators in the first aerobic stage (Stage 2) are implemented by year 2040. No benefits are claimed in the NPV analysis. Costs incurred include rehabilitation and replacement for valves needed in the step-feed configuration.

The results of the economic analysis are shown in Figure 9-4. Both alternatives have similar capital costs; however, the operating costs and benefits are significantly different, largely due to CEPT being a chemical treatment. While CEPT could be utilized year-round, it was conservatively assumed to be a wet weather operation (7 months of the year) to address secondary clarifier capacity limitations. The duration of CEPT could be further optimized to minimize chemical use during the year. If CEPT were only used for 2 months of the year, the NPV would be similar to the step-feed alternative; this limited CEPT operation would require more monitoring and operator attention for assessing the timing of turning CEPT on and off.

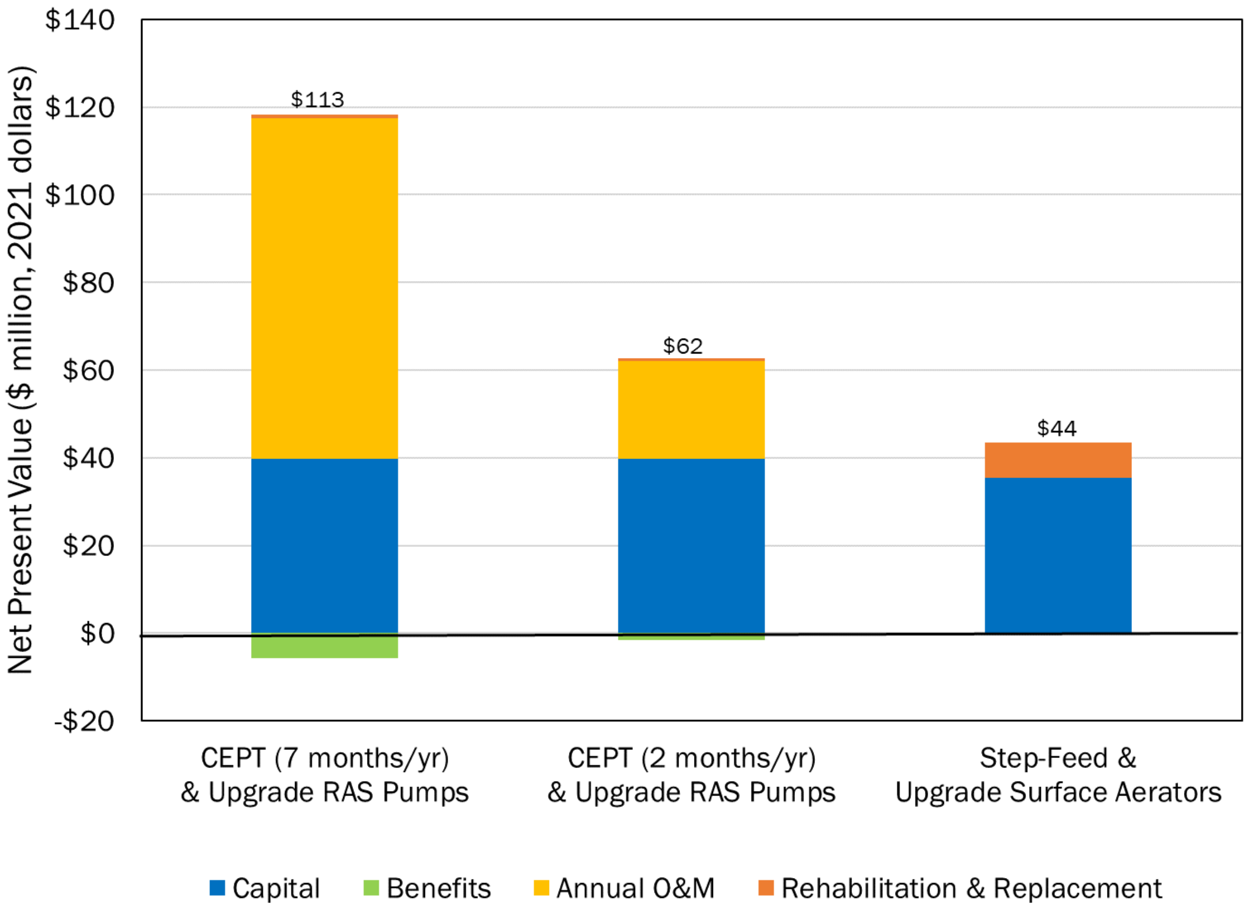

Figure 9-4. Net present value analysis of secondary treatment capacity alternatives in 2021 dollars

9.4.1 Impact of Resource Recovery on Secondary Treatment Capacity

An evaluation was performed to determine how R2 waste streams impact the secondary treatment system capacity, and results are shown in Table 9-3. A more thorough description of the R2 roadmap is presented in Chapter 11.

Table 9-3. Secondary treatment capacity for different R2 scenarios

Scenario	Firm Capacity		
	HPOAS Reactors	Secondary Clarifiers	Overall Secondary System
No Change to R2 (Medium Growth Scenario)	2040	2020	2020
Right-Size R2	2040	2020	2020
No HSW	2040	2020	2020
No LSW	2045	2040	2040
No R2	2045	2041	2041

Eliminating HSW would have a negligible impact on the secondary treatment system capacity since HSW is discharged to the Blend Tanks and then to the anaerobic digesters. The only connection between HSW and the secondary treatment process is the recirculation of dewatering centrate to the PSTs.

Right-Sizing R2 involves reducing HSW only to reduce nutrients. Accordingly, this option has a negligible impact on the secondary treatment system capacity.

Eliminating LSW has a significant impact on the secondary clarifier capacity and a minor impact on the HPOAS reactor capacity. In terms of influent loading, eliminating LSW would result in an 11-13% reduction in TSS, a 32 to 35% reduction in inert suspended solids (ISS), and a 12% reduction in BOD. The reduction in solids, particularly the ISS, would increase secondary clarifier capacity during peak flows, and the reduction in BOD would increase HPOAS reactor capacity during peak summer loads.

9.5 Secondary Treatment Capacity Implementation Plan

The secondary treatment roadmap is to implement step-feed, as this alternative provides a cost-effective approach to addressing secondary system capacity limitations without increasing chemical use at the MWWTP. Based on the findings of the capacity assessment, step-feed should be implemented in the 2020 to 2025 timeframe. However, due to the large number of CIP projects scheduled to occur in this timeframe, an alternative approach was developed for step-feed implementation as described below and shown in Figure 9-5:

- **Implement Chemically Enhanced Primary Treatment as Early as 2022**: CEPT would provide the District with the ability to reduce loads to the secondary system during peak flow and high-SVI events. CEPT could be used intermittently and would serve as a bridge to address secondary system capacity limitations until step-feed can be implemented.

- **Implement Step-Feed in Two Phases**: Phase 1 would implement step-feed in half of the HPOAS reactors to provide adequate secondary clarifier capacity until approximately 2040. Step-feed Phase 2 would implement step-feed at the remaining half of HPOAS reactors.

- **Replace Stage 2 Aerators**: The HPOAS aerators in Stage 2 would be replaced as part of the Step-Feed Phase 2 project.

Before implementing Step-Feed Phase 2, the District will confirm if more stringent nutrient regulations are forthcoming. Implementing Phase 2 may no longer be a "no regrets" investment if split treatment or mainstream nutrient removal are needed within a short timeframe.

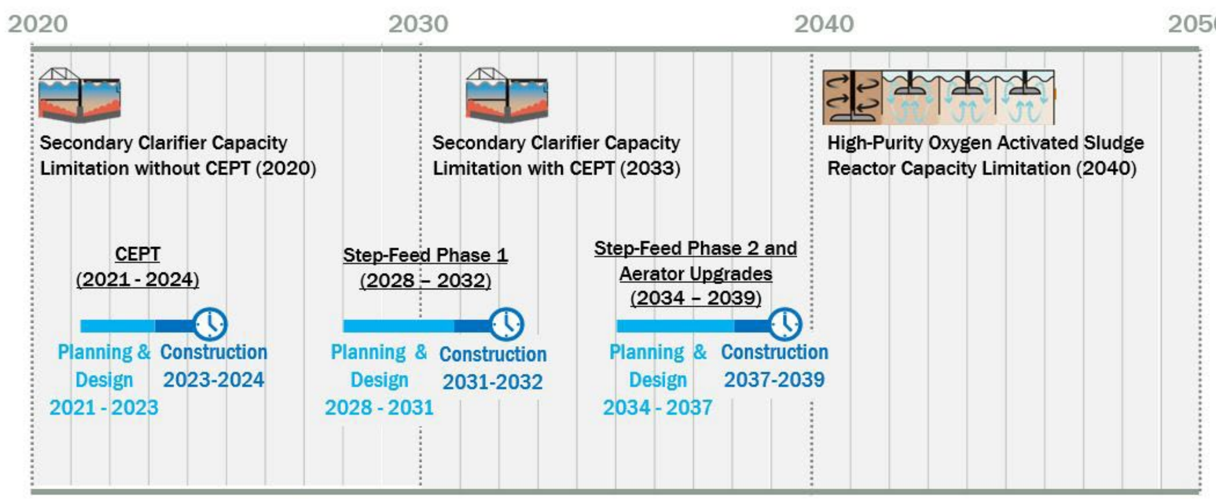

Figure 9-5. Implementation schedule for step-feed

The following studies and testing are recommended to support step-feed implementation, as well as optimization of the PSTs and secondary system:

- **Jar Testing:** Prior to implementing CEPT, jar testing is recommended to: (1) confirm TSS and BOD removal with CEPT and to (2) verify the chemical doses and operating costs of CEPT.

- **Reduced Low-Strength Waste Testing**: Additional CEPT jar testing could be performed to confirm PST removal efficiencies under a reduced LSW or no LSW scenario. LSW streams were identified as increasing inert solids, and targeted reductions of streams could provide capacity benefits at the secondary clarifiers. If jar testing indicated that reducing LSW does not negatively impact the performance of the PSTs, then the District could consider turning down or off LSW for a short period of time when capacity-limiting conditions arise.
- **Flocculation Testing:** Jar testing is recommended to verify flocculation and TSS removal performance at predicted MLSS levels and solids retention times.
- **PST Stress Testing:** After CEPT is implemented, stress testing of the PSTs is recommended to verify performance at peak flow rates, which would help characterize whether some PSTs could be repurposed for sidestream treatment.

The implementation plan described above is contingent upon how influent flows and loads grow over time. If influent flows and loads grow more slowly than projected in Chapter 2, then implementation could be delayed, depending on the extent of the flows and loads.

9.6 Disinfection

Disinfection at the MWWTP is performed with sodium hypochlorite (chlorination). Prior to discharging the treated wastewater to the Bay, the disinfectant is removed using sodium bisulfite. The Dechlorination Facility is located offsite and requires upgrades to address aging infrastructure and sea level rise. Additionally, the Dechlorination Facility presents O&M challenges due to the off-site and remote location.

The District performed an evaluation of disinfection alternatives that could effectively meet current/future disinfection regulations and eliminate the need for the off-site dechlorination or a similar quenching step. A total of 6 alternative disinfection technologies were evaluated. Based on the analysis that was performed, it was determined that chlorination and dechlorination is the optimal alternative for the near-term.

The near-term roadmap for disinfection is based on continuing the current practice of chemical disinfection with sodium hypochlorite followed by sodium bisulfite. Improvements to the Dechlorination Facility are included in the 10-year CIP to address aging infrastructure and sea level rise. The long-term roadmap for disinfection includes continued monitoring of drivers and re-evaluation of potential alternative disinfection technologies. If mainstream nutrient removal were ever implemented, the quality of the secondary effluent would be improved, potentially allowing for alternative disinfection technologies to become more cost competitive.

CHAPTER 10 PROCESS IMPROVEMENTS

This chapter describes process improvements that were identified for the Main Wastewater Treatment Plant (MWWTP), including grit improvements, struvite management, and sludge screening. Process improvements are defined as projects that can provide economic benefits through the reduction of operations and maintenance (O&M), improved process performance, and enhanced reliability. The projects could be implemented at any time when capital funding is available. These projects are not driven by regulations, capacity, aging infrastructure, or climate change resiliency.

10.1 Grit Improvements

Grit is removed using vortex grit tanks during the dry season and aerated grit tanks (AGTs) during the wet season. A capacity assessment was performed and identified the following limitations (Appendix P):

- **Vortex Grit Tanks:** The dry weather capacity (70 mgd maximum) is sufficient until 2040, assuming a 15% maximum diurnal peaking factor with average daily dry weather flows.
- **Aerated Grit Tanks:** For the peak hourly flow, the firm capacity (6 AGTs) is insufficient in 2020. The total capacity (8 AGTs in service) is sufficient through the planning period.

The District has observed that the AGTs do not achieve the desired helical mixing pattern for adequate grit removal; accordingly, fine sand has been observed in the primary sedimentation tanks (PSTs) and has damaged the PST chain and flight system.

The AGTs were rated against typical criteria for coarse grit removal according to the Water Environment Federation Manual of Practice Number 8, 6th Edition (WEF, 2010), as shown below in Table 10-1. While the air-to-length ratio and hydraulic retention are satisfactory, the width-to-depth ratio is larger than the recommended value. The AGTs are designed for a single-pass roll instead of a typical helical roll pattern. Inverting the width-to-depth ratio to account for the atypical roll pattern would reduce the ratio from 1.8 to 1.0 ft/ft, which is still higher than the recommended value of 0.9 ft/ft.

Table 10-1. Comparison of AGTs with industry recommendations

Parameter	Recommended Value	Aerated Grit Tanks
Air to Length Ratio (cfm/ft)	> 10	14
Hydraulic Retention Time (min)	> 3	7 at 345 mgd
Roll Pattern Width:Depth ratio (ft/ft)	< 0.9	1.0 (Single-Pass)

Improvements to the AGTs were evaluated, including lamella -ssisted vortex design, modified aerated grit system with a helical roll, and baffling upgrades. Sketches for each AGT improvement alternative are included in Appendix Y. The estimated capital costs for each alternative are presented in Table 10-2 below.

Table 10-2. Capital cost estimates for AGT improvements

AGT Improvement	Capital Cost ($ million)
Lamella-Assisted Vortex Design	$40
Modified Aerated Grit System with Helical Roll Design	$16
Baffling Upgrades Design	$8

It is recommended that AGT improvement projects include the conceptual design for the items listed in the table above, a detailed review of the grit dewatering system, and a detailed analysis of capture efficiency for both the AGTs and grit dewatering units. A capture efficiency analysis of the grit dewatering equipment would identify if improvements such as dedicated cyclones to grit pumps or upgrading the size of the grit classifiers would enhance capture performance and overall grit removal.

Grit removal discussed in this section was based on the performance evaluation at the headworks of the MWWTP. Grit intrusion has also been identified at the HSW receiving station, which is primarily associated with FOG waste. Grit removal at the HSW receiving station is identified in the 10-year CIP.

10.2 Struvite Management

As part of the Sidestream Treatment Report (Appendix R), the following four alternatives were evaluated to mitigate struvite formation in the digesters, dewatering equipment, and centrate lines:

- Chemical (ferric chloride) addition at the headworks
- CalPrex system
- Airprex system
- Ostara with WASSTRIP®

The capital cost of the alternatives ranges from $30 to 110 million. While ferric chloride addition at the headworks requires a low capital investment, the operating costs are approximately $1 million per year. Due to the high capital and operating costs of the alternatives and other higher-priority projects, the alternatives listed above would not likely be implemented during the planning horizon.

An emerging technology (the Elo-Vac technology) was also considered (Appendix Y). The system has both a lower capital cost ($30 million) and a lower operating cost. It is an emerging technology with limited installations in the United States. Given the limited operational history, pilot testing is recommended to confirm performance at the MWWTP. In the near-term, if the District has the CIP budget and staff, it is recommended that additional studies and/or pilot testing be performed to confirm system performance.

10.3 Sludge Screening

Sludge screening was identified as a potential improvement that would reduce debris accumulation in the digesters. Sludge screening may also be required to expand into new biosolids end use markets and new merchant facilities.

Sludge screening was not identified as a near-term improvement. It is recommended that the need for sludge screening be confirmed as new biosolids management contracts are negotiated, after grit removal at the Blend Tanks is implemented, and after mixing in the second-stage digesters comes online. These factors and projects will further inform the District on the need for sludge screening.

The Master Plan roadmap does identify sludge screening occurring in parallel with a post-digestion facility because it would likely be needed upstream of a thermal dryer or pyrolysis system. The sludge screening facility was assumed to be located inside a building with odor control. The location of sludge screening was assumed to be upstream of the digesters and downstream of the Blend Tanks to avoid the potential for screen blinding due to post-digestion struvite formation. The District has also identified sludge screening downstream of the first-stage digesters. The location of the screening system should be confirmed during planning and preliminary design of the facility to optimize costs and to facilitate O&M. The capital cost of an enclosed sludge screening system was estimated to be $16 million.

CHAPTER 11 INTEGRATED ROADMAP

This chapter synthesizes the drivers, triggers, and projects identified in the previous chapters into a 30-year integrated roadmap Main Wastewater Treatment Plant (MWWTP). The roadmap is presented in a variety of ways, including verbal descriptions, summary tables, visual diagrams, and site plans.

The concept of a roadmap is to set the path for the future based on the best information available now, and to illustrate how that path can be altered by various triggers, which divert the District's course onto off-ramps, as shown in Figure ES-1. The roadmap is "integrated" because it holistically considers all of the District's competing priorities and synthesizes them into a plan for capital improvements over the next 30 years. Due to uncertainty, it is unknown if and when triggers will occur. Accordingly, the roadmap is not a recipe for immediate implementation. Many of the necessary next steps are largely out of the District's control, such as regulatory development, evolution of flows and loads to the plant over time, economic factors that change over time, and other unknowns that can't be anticipated. Even as those uncertainties are resolved over time, the District will still need to perform more detailed engineering analyses to confirm and refine the analyses performed and conclusions made as part of this Master Plan.

11.1 Impact of Resource Recovery on Project Alternatives

Several projects in the roadmap are impacted by changes in the Resource Recovery (R2) program, including:

- Chapter 4: Sidestream treatment (SST) to reduce effluent total inorganic nitrogen (TIN) discharged to the Bay
- Chapter 5: Post-digestion (thermal dryer)
- Chapter 6: Dewatering
- Chapter 9: Secondary system capacity (step-feed and aerator upgrades)

Since these projects are interrelated, an alternatives analysis is presented below to confirm the path forward for the R2 program and the basis of the roadmap.

11.2 R2 Alternatives

Five R2 alternatives were considered as described below:

- **No Change to R2**: This alternative represents the status quo. R2 would continue to be received at the MWWTP assuming the Medium Growth Scenario.
- **Right-Size R2:** R2 would continue to be received at the MWWTP with a targeted reduction in HSW. The reduction in HSW assumes eliminating protein (i.e., blood) and dairy (i.e., dissolved air flotation) wastes.
- **No High-Strength Waste (HSW):** HSW streams would be eliminated, and the R2 program would only include LSW streams under the Medium Growth Scenario.
- **No Low-Strength Waste (LSW):** LSW streams would be eliminated, and the R2 program would only include HSW streams under the Medium Growth Scenario.
- **No R2:** All R2 wastes, including both HSW and LSW, would be eliminated. The MWWTP would only treat influent wastewater flows from the District's service area.

11.2.1 Net Present Value Evaluation

This section provides an overview of the R2 alternatives analysis in terms of the net present value (NPV). The detailed NPVs are provided in Appendix X, and the NPV assumptions are summarized in Appendix M. For all alternatives, the following assumptions were made:

Included in NPV

- Secondary treatment would be upgraded with new aerators in Stage 2 and converted to step-feed.
- SST would be constructed to meet the Master Plan Target.
- A new Dewatering Building would be constructed in phases.

Not Included in NPV

- Split treatment or full mainstream nutrient removal were not included in the NPV because the capital investment is the same for the various R2 alternatives, and the timing for these projects is uncertain.
- Off-site biosolids storage was not included in the NPV because the feasibility and costs are uncertain.
- Chemically enhanced primary treatment (CEPT) and aging infrastructure projects, such as those at the Influent and Effluent Pump Stations (IPS and EPS), were not included because the capital investment is the same for the various R2 scenarios.

Table 11-1 summarizes the annual operating costs and benefits that were included in the NPV analysis. Figure 11-1 summarizes the timing of capital projects according to the various R2 alternatives.

Table 11-1. Summary of annual operating costs and benefits for R2 NPV analysis

Item	Annual Operating Cost and Benefit Assumptions
Sidestream Treatment (SST)	Costs: • Labor, energy, and rehabilitation/replacement using Anammox process Benefits: • SST effluent containing nitrate will be routed to IPS to partially offset chemical addition (sodium hypochlorite) for odor control
Dewatering Facility	Costs: • Energy costs associated with new centrifuges and dewatering feed pumps in a new building Benefits: • Avoided costs of operations and maintenance (O&M) and energy for cake pumps
Secondary Treatment System	Costs: • Rehabilitation and replacement for step-feed, aeration valving, and flow meters Benefits: • No economic benefits were included
Thermal Drying	Costs: • Natural gas use for thermal dryer • Labor, energy (for startup), and rehabilitation/ replacement • Biosolids hauling and management Benefits: • Revenue for pellet sale included as an offset to biosolids management costs
R2 Marginal Revenue[a]	Costs: • No costs were included Benefits: • Marginal revenue of reduced R2 streams was taken as a negative benefit for the Right-Size R2, No HSW, No LSW, and No R2 alternatives

a. Marginal revenue was developed for each waste stream and takes into account: tipping fees for each waste stream, cost of treatment, cost of residuals handing, and the benefits of biogas production/reduced energy purchase. Refer to Appendix G for additional details.

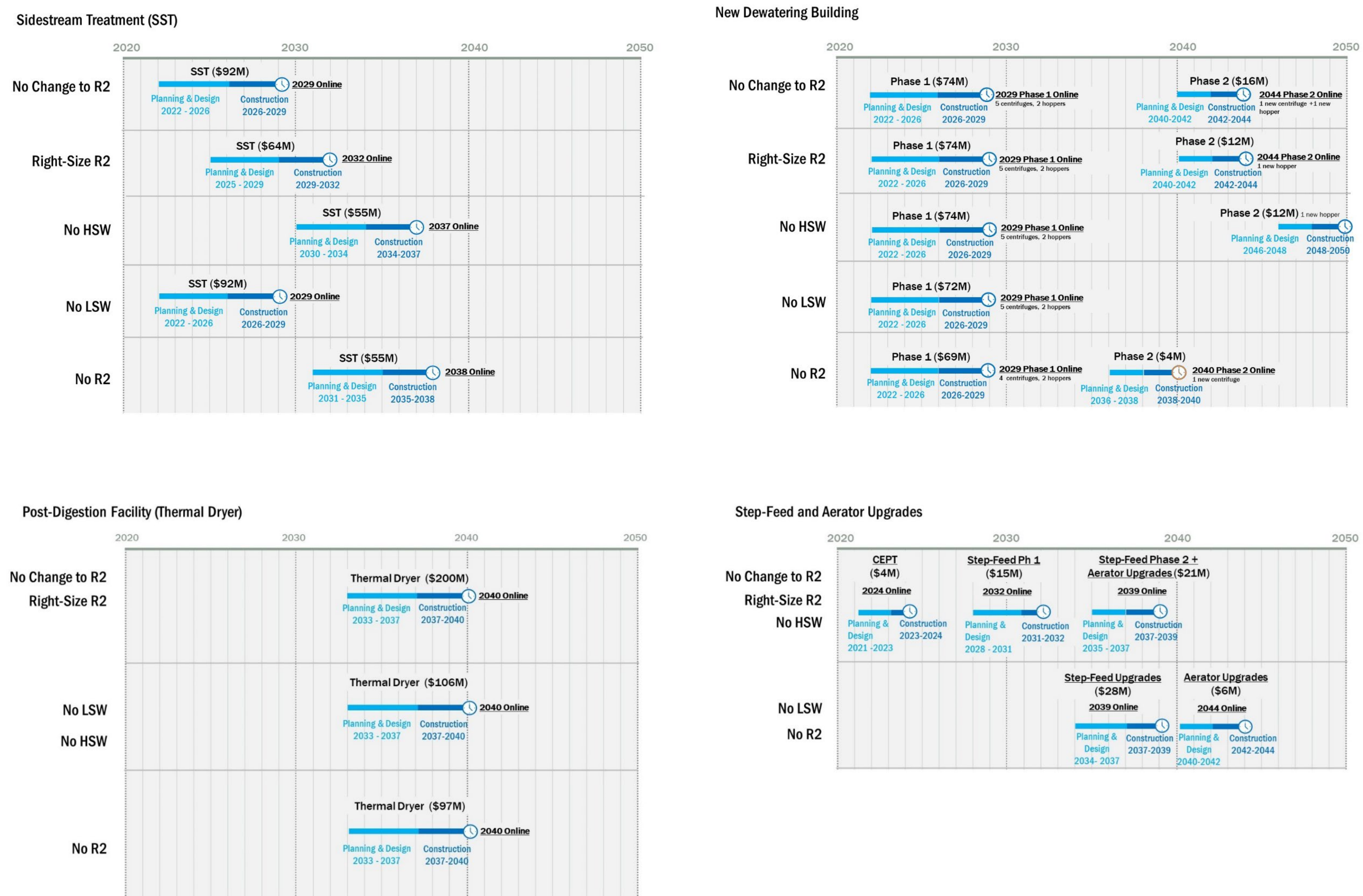

Figure 11-1. R2 alternatives and capital outlay schedule (in 2021 dollars)

Figure 11-2 presents the capital costs for the projects according to the R2 alternative. Capital costs decrease according to the extent of reduction in R2 streams. As such, the "No Change to R2" has the highest total cost, while the "No R2" alternative has the lowest total cost.

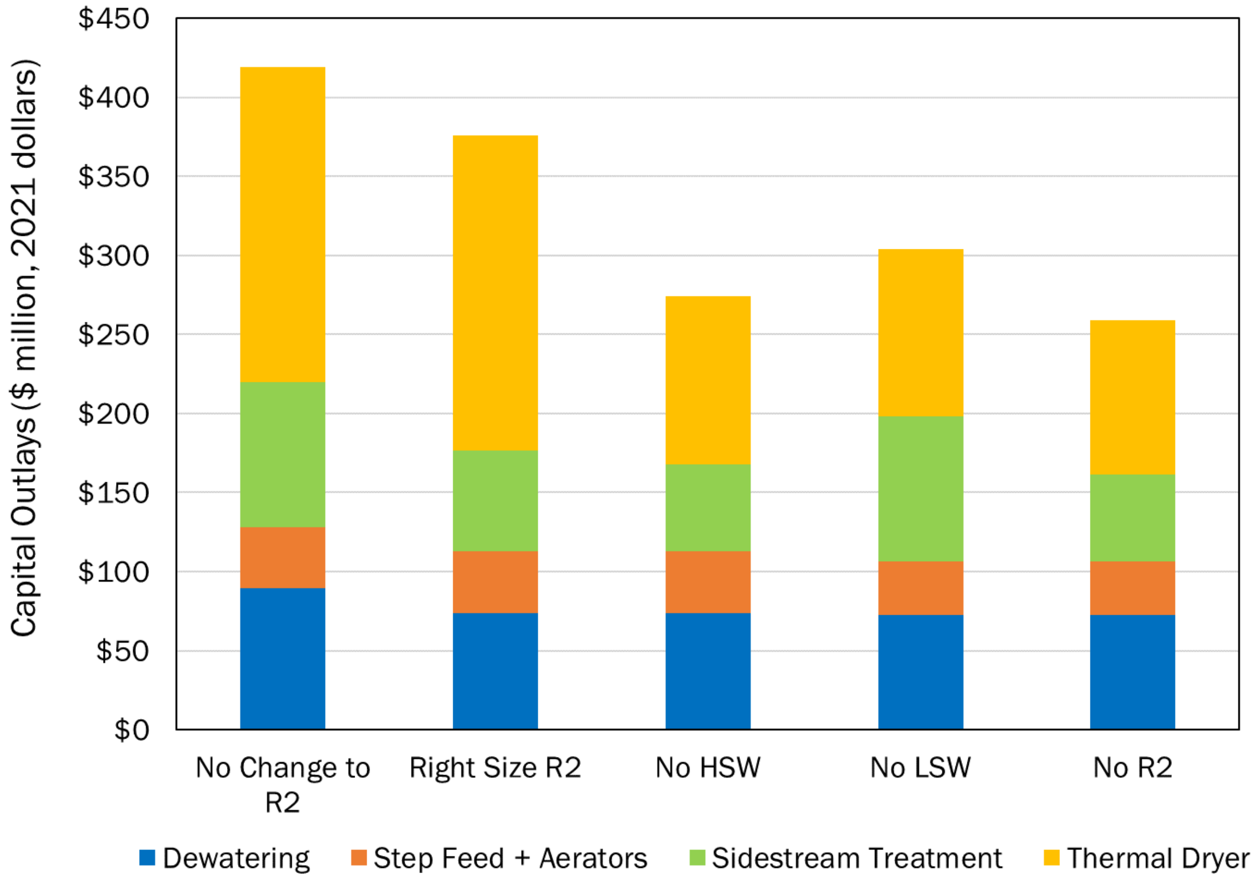

Figure 11-2. Capital costs of the R2 alternatives in 2021 dollars

Figure 11-3 summarizes the NPV for the R2 alternatives. The "No LSW" and "No R2" alternatives have the highest NPVs, indicating that they are not economically favorable. The "No HSW" alternative has the lowest NPV, while the "No Change to R2" and "Right-Size R2" and alternatives have relatively similar NPVs.

Although "Right-Size R2" does not have the lowest NPV, it was selected as the basis for the integrated roadmap because it has the following benefits:

- Provides the District with time to plan, pilot test (as needed), and construct large CIP projects such as a new Dewatering Building and SST.
- Offers the ability to incrementally phase out targeted HSW streams to stay below a future nutrient load target.
- Enables the District to continue its practice of generating renewable electricity on-site.

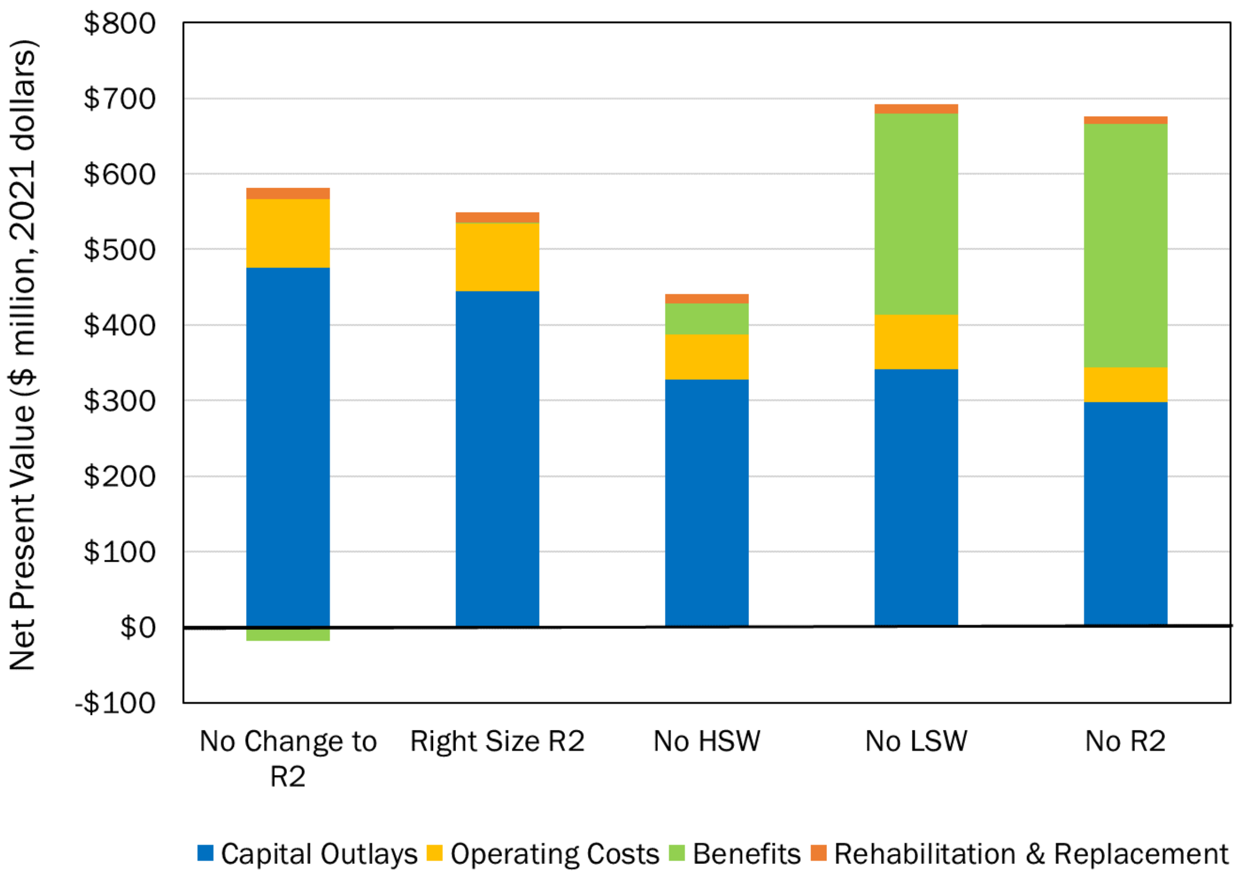

Figure 11-3. NPV of the R2 alternatives

Due to the benefits noted above, the "Right-Size R2" alternative serves as the basis for the roadmap. Before implementation, the following steps are recommended:

- Perform additional characterization and nutrient profiling of HSWs to confirm the impact that HSW reduction would have on TIN load discharges and solids dewatering.
- Perform additional characterization of LSWs to confirm the impact that LSW reduction would have on TIN load discharges as well as secondary system capacity, solids handling capacity, and overall performance of the PSTs.

11.3 Implementation Plan

Based on the analyses presented in previous chapters and the R2 alternatives analysis described above, an integrated roadmap was developed with "Right-Size R2" as the basis. The roadmap includes projects to address new regulations, aging infrastructure, capacity limitations, and climate change resiliency. Optimization projects are included; however, the timing for these projects is flexible and can be shifted as needed.

The integrated roadmap is illustrated in Figure 11-4. These figures illustrate the roadmap as a decision tree diagram with various regulatory, economic, and growth-induced triggers.

A summary of the roadmap projects is provided below. Appendix Z provides detailed tables of the early action, near-term, and long-term Master Plan projects.

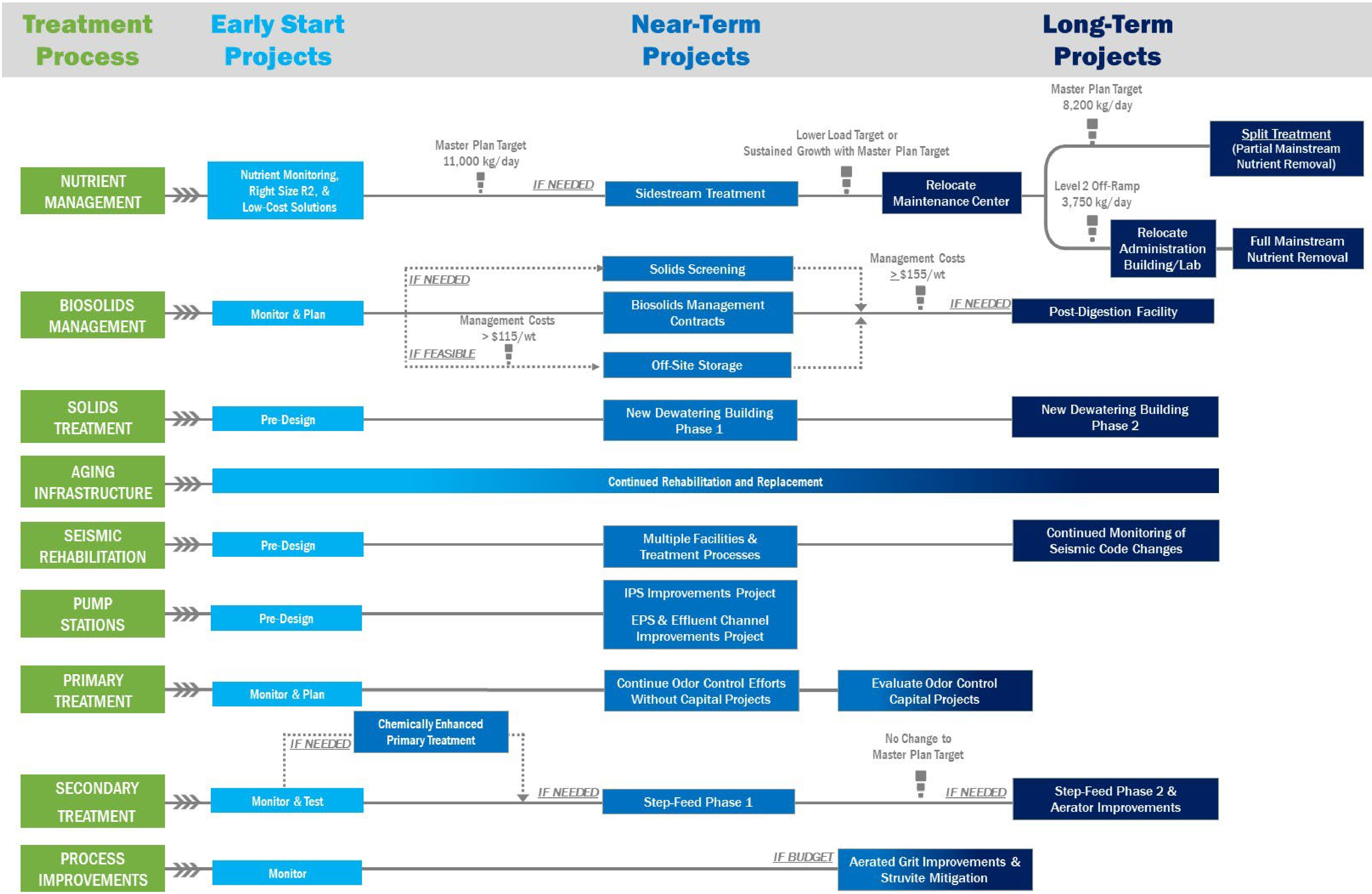

Figure 11-4. Near- and long-term integrated roadmap

Aging Infrastructure Roadmap

Infrastructure at the MWWTP is aging and in need of continued renewal. The District has forecasted the need for a minimum of $40 million per year on average for the next 30 years in order to replace in-kind the existing infrastructure currently in place before it fails. Infrastructure renewal projects only rehabilitate or replace the structures, equipment, piping, and other facilities in their current form and function without improvements in performance, safety, or other benefits. The following projects were identified as priorities for the near-term CIP:

- Influent Pump Station (IPS): Electrical, seismic, and select equipment repair/replacement
- Grit Removal System: Concrete rehabilitation and select equipment replacement
- Oxygen Production Plant: Select improvements to address safety and extend useful life
- High-Purity Oxygen Activated Sludge (HPOAS) Reactors: Concrete rehabilitation of reactors and ancillary improvements
- Secondary Clarifiers: Continued rehabilitation of all clarifiers
- Effluent Pump Station (EPS) and Effluent Channel: Concrete rehabilitation and mechanical rehabilitation
- Dechlorination Facility: Piping replacement, emergency generator replacement, concrete rehabilitation and other reliability improvements
- Anaerobic Digesters: Seismic improvements, equipment upgrades, and coating rehabilitation
- Electrical System: Continued motor control center replacements, seismic retrofits, and other reliability improvements
- Power Generation Station: Replacement of aging equipment and piping, upgraded cooling equipment, improved heat exchangers
- Plant Utilities and Support Buildings: Miscellaneous equipment repairs

The complete details of aging infrastructure capital projects are in the District's Biennial CIP. Renewal of aging infrastructure will remain the primary near-term focus of capital projects for the District. The New Dewatering Building project will replace the dewatering and biosolids cake storage function of the existing Dewatering Building, and as a result, will eliminate the need for a major rehabilitation project for that existing building. No other major project was identified that would eliminate the need for previously identified infrastructure renewal projects in the CIP.

Chapter 3 describes the aging infrastructure roadmap in more detail.

Resource Recovery Roadmap

The near-term roadmap for R2 includes the opportunistic reduction or elimination of protein (i.e., blood) and dairy (i.e., dissolved air flotation) waste streams, which is referred to as "Right-Size R2." Elimination of these waste streams reduces TIN loads discharged to the Bay and provides solids dewatering capacity benefits to give the District time to plan, design, construct, and finance new dewatering and sidestream treatment (SST) facilities. The near-term roadmap for R2 includes further characterization of the R2 wastes to determine more precisely the sources and quantities of TIN in R2 wastes, as well as to identify other waste streams that could be reduced or eliminated to provide near-term benefits to capacity, nitrogen reduction, and biogas production.

The long-term roadmap for R2 assumes that the select waste streams would be reduced or eliminated over the course of the planning horizon. The long-term roadmap should be continuously updated as the mix of R2 wastes evolves, as nutrient and biosolids regulations become more defined, and as the District implements CIP projects (i.e., SST and a New Dewatering Building) that would influence the MWWTP's nitrogen loading to the Bay.

Chapter 11 describes the R2 roadmap in more detail.

Nutrient Roadmap

The near-term nutrient roadmap involves the implementation of the "Right-Size R2" strategy followed by SST. In parallel, the District will continue to investigate low-cost, innovative nutrient reduction solutions such as split battery testing to utilize existing infrastructure and forestall the need for new nutrient removal infrastructure. The timeline for SST is dependent on multiple factors, including the timing and details of new regulations, growth of influent flows and loads, observed effluent nitrogen loads discharged to the Bay, and the status of recycled water projects that can reduce nutrients sent to the MWWTP. Pilot testing of SST is necessary to confirm feasibility, refine design criteria, and more precisely define the cost.

The long-term roadmap for nutrients is based on the implementation of mainstream nutrient removal if regulations shift to a lower TIN load target or effluent concentration limits.

Chapter 4 describes the nutrient roadmap in more detail.

Biosolids Management Roadmap

The near-term biosolids management roadmap is based on a combination of parallel activities, including negotiating longer-term management contracts that secure wet weather beneficial uses; monitoring local price trends and the status of new merchant facilities; and considering early commitments to new merchant facilities. Further evaluation of the feasibility and cost of off-site storage in the Bay Area and/or Merced County is recommended. If feasible, off-site storage should be implemented when biosolids management costs approach $115/wet ton.

The long-term biosolids management roadmap is based on implementation of a post-digestion facility (i.e., thermal dryer) when biosolids management costs approach $155/wet ton.

Chapter 5 describes the biosolids management roadmap in more detail.

Solids Dewatering Roadmap

The near-term solids dewatering roadmap includes the planning, design, and construction of the New Dewatering Building project. The new building can be phased such that the first phase would provide capacity for projected flows and loads until 2040.

The long-term roadmap includes the second phase of the new building, which would include the installation of additional centrifuges, a new hopper, and a truck bay if flows and loads continue to increase.

Chapter 6 describes the solids dewatering roadmap in more detail.

Climate Change Resiliency Roadmap

The roadmap for climate change resiliency considers sea level rise, biogas utilization, GHGs, and recycled water as described below. Chapter 7 describes the climate change resiliency roadmap in more detail.

Sea Level Rise

The District will continue to implement its climate change design guidelines on capital projects in areas that are vulnerable to sea level rise. The near- and long-term roadmap does not identify any projects specifically for sea level rise.

Biogas Utilization

The biogas utilization roadmap is the least prescriptive within the overall Master Plan roadmap. The District continually explores options for biogas utilization and will continue to do so after this Master Plan. Current economic and regulatory conditions are not favorable to alternatives to the District's current practice of generating renewable electricity through a turbine and three engines. While operations and maintenance of the turbine and engines are an ongoing challenge, the benefits outweigh the costs and challenges.

However, current conditions can and will change, and there are several potential avenues for increasing the value of the electricity that the District will pursue in the near-term. Specifically, the District will explore a competitive request for proposals for a new PPA after the current PPA with the Port of Oakland expires in 2024. In addition, the District is currently piloting a program for on-site electric vehicle charging at the MWWTP, which can take advantage of State of California incentives through the Low Carbon Fuel Standard program and will be expanded if the pilot is successful.

There are several other considerations in the Master Plan that may potentially change biogas utilization, including future nutrient regulations, near-term dewatering capacity challenges, and GHG emissions reduction goals. These considerations aren't expected to force any changes to the existing renewable energy production scheme at the MWWTP in the near term, but could and likely will over a longer time frame. In addition, there are factors outside the District's control that could result in more positive conditions for the expansion of biogas utilization. State and federal policies, as well as technological innovation could improve the outlook for biogas utilization benefits. The District will continue to re-evaluate new opportunities, engage with regulators on a proactive basis, and reach out to potential project partners.

Greenhouse Gases

The near-term roadmap includes continued coordination with The Climate Registry to guide the calculation of the District's GHG emissions. Based on the District's recently adopted GHG emission policy for the wastewater system (Policy 7.07), the roadmap includes strategies to minimize emissions at the MWWTP that include:

- Reducing TIN discharges to the Bay with Right-Size R2, low-cost innovative nutrient management solutions, and SST.
- Eliminating diesel use by switching to 100% renewable diesel.
- Consideration of eliminating natural gas use by converting building boiler systems to electric systems.
- Obtaining fertilizer offset credit and carbon sequestration for biosolids beneficial uses.
- Prioritizing biogas use to a post-digestion facility to further minimize use of natural gas.

Recycled Water

The roadmap for all recycled water projects originates in the District's Recycled Water Master Plan Update (EBMUD 2019). The near-term roadmap includes continued coordination for the potential expansion of EBRWF and evaluation of a potential Pt. Isabel Water Recycling Facility.

The long-term roadmap provides flexibility and land for a potential potable reuse facility at the MWWTP, although it is not currently anticipated to occur prior to 2050.

Influent and Effluent Pump Station Roadmap

The near-term roadmap for the IPS and EPS includes aging infrastructure rehabilitation, seismic rehabilitation, and capacity improvements. Chapter 9 describes the IPS and EPS roadmap in more detail.

Primary Sedimentation Tank Roadmap

The near-term roadmap for the primary sedimentation tanks (PSTs) includes seismic retrofits. If flows and loads increase as projected in the Master Plan analysis, then chemically enhanced primary treatment (CEPT) could be implemented to address secondary system capacity limitations on an intermittent or as-needed basis. Testing would be necessary to confirm design criteria for CEPT prior to implementation. To track how flow and load projections develop over time, water quality will continue to be monitored.

The long-term roadmap for the PSTs includes potentially covering the PSTs and providing foul air treatment. The District continually investigates low-cost operational changes to proactively manage odors. Prior to implementation, a full evaluation of the best overall approach to controlling odors will consider pre-chlorination and sludge blanket control optimization, among others.

Chapter 9 describes the PST roadmap in more detail.

Secondary Treatment Roadmap

If flows and loads increase as projected in the Master Plan analysis, the near-term roadmap for the secondary system includes performing targeted flocculation testing to define design criteria for the step-feed configuration, implementation of CEPT, and phased conversion to the step-feed configuration. Improvements to the Stage 2 aerators are identified for Phase 2 of step-feed conversion.

The timing of these projects is highly dependent on actual influent loads. The projections used in the Master Plan analysis are likely conservative based on the most recently collected influent data, and the roadmap projects for the secondary treatment system are not likely to be needed immediately. As a result, the primary effort of the near-term roadmap for the secondary system is to routinely monitor flow and load trends to determine if the capacity trigger has been met.

If nutrient regulations are stricter than anticipated (e.g. effluent TIN concentration limits), then early implementation of mainstream nutrient removal would be required. As a result, Phase 2 of step-feed conversion would not be needed.

Chapter 9 describes the secondary treatment roadmap in more detail.

Disinfection Roadmap

The near-term roadmap includes the implementation of previously identified CIP projects to address aging infrastructure in the hypochlorite dosing system and at the Dechlorination Facility. Alternative disinfection technologies have been evaluated by the District, and no technologies were determined to be suitable.

The long-term roadmap includes continued monitoring and re-evaluation of alternative disinfection technologies. If mainstream nutrient removal were implemented, the secondary effluent water quality would be improved, potentially allowing some alternative disinfection technologies to be more suitable.

Chapter 9 describes the disinfection roadmap in more detail.

Process Improvements Roadmap

Process improvements identified for the roadmap include grit removal improvements at the Blend Tank and the aerated grit tanks; struvite mitigation projects; and screening of solids. These projects could improve operational performance, but are optional. Given other infrastructure renewal needs, these projects would only be implemented when CIP funds are available. Chapter 10 describes the process improvements roadmap in more detail.

Aesthetics and Function Roadmap

It is recommended that a program be developed to integrate aesthetics and function at the MWWTP. Currently, facilities vary in architectural style, colors, and materials, and as a result, lack a unifying theme. Standardization of architectural and aesthetic guidelines will create a cohesive style. In addition to aesthetics, the overall site plan of future facilities must be functional. This includes considerations such as vehicle/truck routing, pedestrian travel, parking, and the ability to secure off certain areas for O&M or construction staging. These considerations will be developed further as part of the New Dewatering Building project, which is a large-scale, prominent new building that will require additions and modifications to existing vehicle routing, and will influence future planned facilities such as SST.

11.3.1 Master Plan Timeline and Project Costs

Table 11-2 summarizes the Master Plan project capital costs with the anticipated implementation timeline. The implementation timeline is illustrated in Figure 11-5.

The projects identified in Table 11-2 were developed to address all the Master Plan drivers, including aging infrastructure, seismic vulnerability, new regulations, climate change resiliency, capacity, and process improvements. The implementation timeline is subject to change as the District monitors growth, regulations, and economic conditions.

Table 11-2. Summary of Master Plan costs and implementation timeline

Master Plan Project	Description	Capital Cost (2021 Dollars)	Implementation Timeline
Nutrients			
Right-Size R2	Reduce or eliminate select R2 waste streams (protein and dairy wastes) to reduce TIN discharges and provide time for the District to plan, design, construct and finance nutrient removal projects. Reduction in R2 streams can also be balanced with biogas production to minimize flaring	No Capital Cost	2021 - 2050
Sidestream Treatment	Implement sidestream treatment for compliance with Master Plan Target for nutrient discharges. Assumed new tankage.	No Change to R2: $92 million Right-Size R2: $64 million	2024 - 2031
Split Mainstream Treatment (Split Treatment)	Implement split treatment (HPOAS + AS BNR) if regulations require meeting a lower TIN load target. Includes relocation of Maintenance Center.	$420 million	2041 - 2054
Mainstream Nutrient Removal	Convert to mainstream nitrogen removal if regulations require meeting Level 2 TIN target (Level 2 Off-Ramp). Includes relocation of Maintenance Center and Administration and Laboratory Building.	$1,330 million	2041 - 2054
Biosolids Management			
Off-site Storage	Construct off-site storage, if determined to be feasible and when biosolids management costs approach $115/wet ton.	$81 million	2023 - 2030
Post-Digestion Facility	Construct on-site post-digestion facility (thermal dryer) when biosolids management costs approach $155/wet ton.	$199 million	2033 - 2040
Solids Facilities			
New Dewatering Building Phase 1	Construct New Dewatering Building to address aging infrastructure and capacity limitations.	$74 million	2022 - 2029
New Dewatering Building Phase 2	Expand New Dewatering Building to include one additional hopper and truck bay when District approaches 2040 "Right-Size R2" flows and loads.	$12 million	2040 - 2044
Pumping Systems			
Influent Pump Station and Effluent Pump Station	Implement improvements to address capacity limitations in addition to aging infrastructure improvements.	$77 million	2022 - 2030
Liquids Facilities			
Cover the Primary Sedimentation Tanks	Evaluate the effectiveness of covering the PSTs to provide treatment of foul air for improved odor control. Implementation occurs only after seismic retrofit construction. Includes cost of cover all PSTs.	$66 million	2035 - 2045
Chemical Enhanced Primary Treatment (CEPT)	Implement CEPT as a bridge for addressing secondary treatment capacity limitations until step-feed is implemented.	$4 million	2021 - 2024
Step-Feed Phase 1	Implement step-feed for half of high-purity oxygen activated sludge (HPOAS) reactors to address secondary clarifier capacity limitations.	$15 million	2028 - 2032
Step-Feed Phase 2 and Aerator Upgrades	Implement step-feed at remaining HPOAS reactors and replace Stage 2 aerators to address capacity limitations, assuming that full mainstream treatment will not be necessary.	$21 million	2034 - 2039
Process Improvements			

Master Plan Project	Description	Capital Cost (2021 Dollars)	Implementation Timeline
Aerated Grit System Improvements	Implement improvements to enhance grit removal.	$30 million	2039 - 2046
Struvite Management	Implement struvite mitigation technology to address O&M challenges at dewatering equipment and centrate pipelines.	$30-50 million	2035 - 2041
Sludge Screening	Implement sludge screening as needed, based on O&M challenges, end use requirements and/or post-digestion facility requirements.	$16 million	2034 - 2040

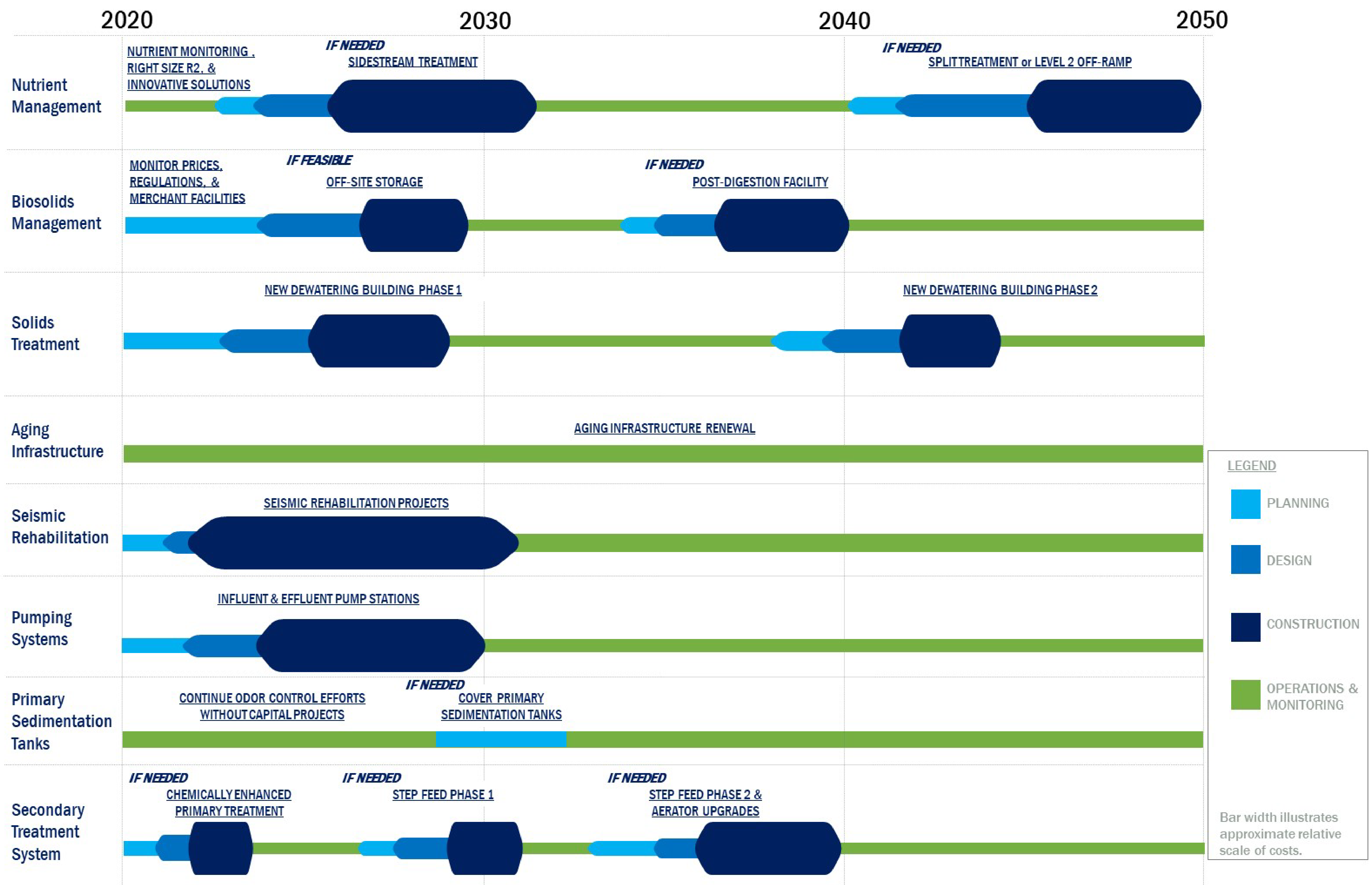

Figure 11-5. Implementation timeline for the integrated roadmap

11.3.2 Master Plan CIP Annual Operating Projections

The Master Plan roadmap projects identified above will result in modified energy use, biosolids management, revenue, labor, and chemical use. The following sections provide an overview of these categories.

Energy Use

Average annual energy demand projections are summarized in Table 11-3. The projections take into account projected growth and new treatment processes. For existing facilities that will continue to operate over the planning horizon, energy demands were increased from current conditions proportional to the projected flows or loads. Diversion of biogas to a post-digestion facility (thermal dryer) was assumed in 2040. Natural gas would not be needed for the thermal dryer, and no other new natural gas demands were identified.

The annual energy demand in 2050 is estimated to be approximately 7 MW. The capacity of the MWWTP's Pacific Gas and Electric (PG&E) primary service connections is 5.7 MW for Line 1 and 4.8 MW for Line 2. Both connections together provide adequate capacity for average energy demands and potentially for peak demands as long as both lines, or one line and PGS, are available. An evaluation of electrical capacity at the MWWTP did not identify power distribution limitations in the near-term (Appendix J). If biogas is diverted to a post-digestion facility in the future, the District will need to rely more on external power. The District is currently evaluating improvements to power supply capacity and reliability in tandem with the biogas utilization roadmap.

Table 11-3. Projected annual average power demand at the MWWTP[a]

Treatment Process/Facility	Power Demand (MW)				
	2020	2030	2040	2050	
	-	-	-	Master Plan Target (HPOAS + SST)	Level 2 Off-Ramp
Pumping Facilities and Grit[b]	0.8	0.9	1.0	1.0	1.0
Existing Secondary Treatment[c]	2.5	2.8	3.0	3.3	0 [d]
Solids Handling and R2 Facilities[d]	0.6	0.6	0.6	0.7	0.7
Buildings & Miscellaneous[e]	1.0	1.0	1.2	1.3	1.3
Subtotal Existing Facilities	4.9	5.3	5.8	6.3	3.0
Sidestream Treatment	--	0.2	0.2	0.2	0.2
Mainstream Nutrient Removal (Level 2 Off-Ramp)[f]	--	--	--	--	3.3
Thermal Dryer[g]	--	--	0.6	0.7	0.7
Subtotal New Facilities	--	0.2	0.8	0.9	4.2
Total Existing and New Facilities	**4.9**	**5.5**	**6.6**	**7.2**	**7.2**

a. Assumes "Right-Size R2" flows and load conditions. Refer to Appendix J for power distribution and demands.

b. IPS, EPS, primary sludge pumping, and Mid-Plant Pump Station

c. Oxygen Production Plant, HPOAS aerators, secondary clarifier drivers, and RAS/WAS pumping

d. WAS thickening, TWAS pumps, dewatering feed and cake pumps, centrifuges, SLW receiving station pumps, FOG receiving station pumps, and Blend Tank recirculation pumps

e. Digester feed pumps, Operations Center, Administration and Laboratory Building, and EBRWF

f. Secondary clarifier drives and RAS/WAS pumping

g. Assumes turbine and engines are online, and energy production is maximized through 2040. In 2040, biogas utilization is prioritized to maximize energy production with the engines and to meet the biogas demands of the thermal dryer. As a result, on-site power generation is reduced in 2040 and natural gas use for the thermal dryer is avoided.

Biosolids Management

Costs for biosolids hauling and management are summarized by decade in Table 11-4. The status quo alternative is assumed through 2040. A thermal dryer is assumed to be online in 2040 with 66% of pellets being land applied and 33% being distributed as a product for other end uses. The projected costs do not account for pellet revenue. Due to the uncertainty of off-site storage, the management costs do not assume that off-site storage is constructed. Chapter 5 further describes the biosolids management alternatives.

Table 11-4. Projected annual average biosolids management costs

Item	2020	2030	2040	2050
Biosolids Hauling and Management ($ million)[a]	$4.2	$8.6 - $12.9	1.0	1.5

a. Year 2020 assumes current biosolids management contract costs. Starting in 2023, the upper range of costs assumes 100% of biosolids are diverted to a merchant facility, while the lower range assumes 50% to a merchant facility and 50% to land application. In 2040, a thermal dryer is assumed with 66% of pellets going to land application and 33% to other markets.

Revenue

Future revenue sources are projected to differ from the status quo as follows:

- A loss of R2 marginal revenue is projected due to the elimination of protein and dairy waste streams (Right-Size R2).
- A loss of excess power sale is projected based on the redirection of biogas to a thermal dryer in 2040.
- A new revenue source may be recognized through biosolids pellet sales.

Table 11-5 summarizes the projected revenue modifications by decade.

Table 11-5. Projected annual average revenue modifications

Item	2020	2030	2040	2050
Right-Size R2 Marginal Revenue Loss ($ million)[a]	--	($0.5)	($0.5)	($0.5)
Biosolids Pellet Revenue ($ million)[b]	--	--	$0.1	$0.1

a. Right-Size R2 revenue loss is based on elimination of protein and dairy wastes. Marginal revenue is $0.02/gallon.

b. Revenue assumes 33% of solids produced are sold as a product. The remaining 66% are land applied or distributed with no revenue.

Labor

Table 11-6 presents additional labor/positions that would be required as new unit processes are brought online. Projects that upgrade or improve existing treatment processes were assumed to not require additional labor. Table 11-6 does not include additional labor for mainstream nutrient removal because it was assumed that the current O&M staff would operate the mainstream treatment facility. As the District further develops mainstream nutrient removal, this assumption should be confirmed, particularly with respect to maintenance and instrumentation and controls.

Table 11-6. Projected additional labor requirements (as full-time equivalent positions)

Item	2020	2030	2040	2050
Nutrient Reduction – Sidestream Treatment	--	1.75	1.75	1.75
Off-site Storage	--	3.5	3.5	3.5
Thermal Dryer	--	--	5	5

Chemical Use

Chemical use projections are based on new treatment processes that require additional or new chemical use, as well as opportunities for reductions in chemical use. Table 11-7 summarizes projected chemical use by decade. Although CEPT is a recommended project in the CIP, CEPT is not anticipated to be used for long durations. CEPT is assumed to be used intermittently during periods of peak flows/loads and high sludge volume index (refer to Chapter 9). Therefore, CEPT is not expected to increase chemical use on an annual average basis.

Table 11-7. Projected annual average chemical costs

Item	2020	2030	2040	2050
Odor Control – Cover PSTs ($ millions)	--	--	$0.4	$0.4
Odor Control – IPS ($ million)[a]	--	($0.5)	($0.5)	($0.5)
Split Treatment ($ million)	--	--	--	$0.6
Level 2 Off-Ramp – Methanol Addition ($ millions)	--	--	--	$2.2

a. Savings are based on reduction of sodium hypochlorite use at IPS; reduction in chemical use would be recognized if sidestream treatment effluent and/or nitrate rich secondary effluent is returned to IPS.

11.4 Site Plans

Site plans of new and demolished facilities by decade are shown in Figures 11-6 through 11-8.

A site plan with all the off-ramps considered in the planning horizon is shown in Figure 11-9, including:

- **Level 3 Off-Ramp**: If mainstream nutrient removal for the Level 3 Off-Ramp were ever needed, both the Administration/Laboratory Building and the Maintenance Center would need to be demolished and relocated.
- **Relocation of Staff Buildings**: Staff buildings would be relocated to the western edge of the property. The location of the relocated buildings should be further developed to confirm the need/desire to locate the buildings in a more central location. The Field Services Building was assumed to be consolidated with the new Administration/ Laboratory Building to provide adequate space for the potable reuse facility.
- **Potable Reuse Facility:** A new potable reuse facility would require approximately 4.5 acres of land. The potable reuse facility is shown on the West End asphalt cap, as this location is ideal from the standpoint of flow and waste stream diversion. However, additional considerations for the location of the potable reuse facility include the location of relocated staff buildings, traffic flow, and public access for tours.

All of the potential off ramps fit within the District's property lines; however, there is no buffer land available. The District will continue to track the development of nutrient removal technologies. Compact technologies may become more cost competitive and established, allowing for further optimization of site planning.

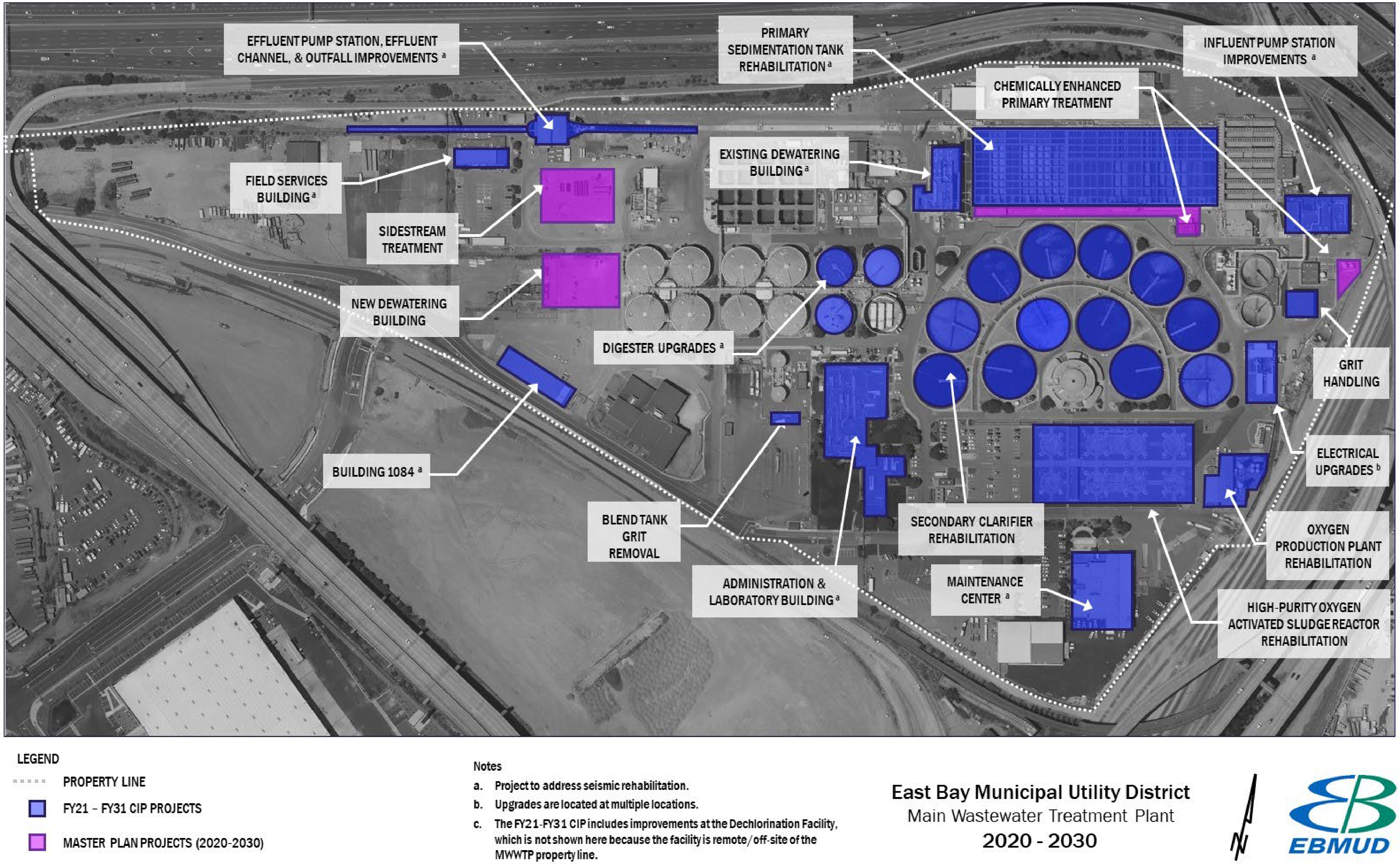

Figure 11-6. Master Plan site plan for years 2020 to 2030

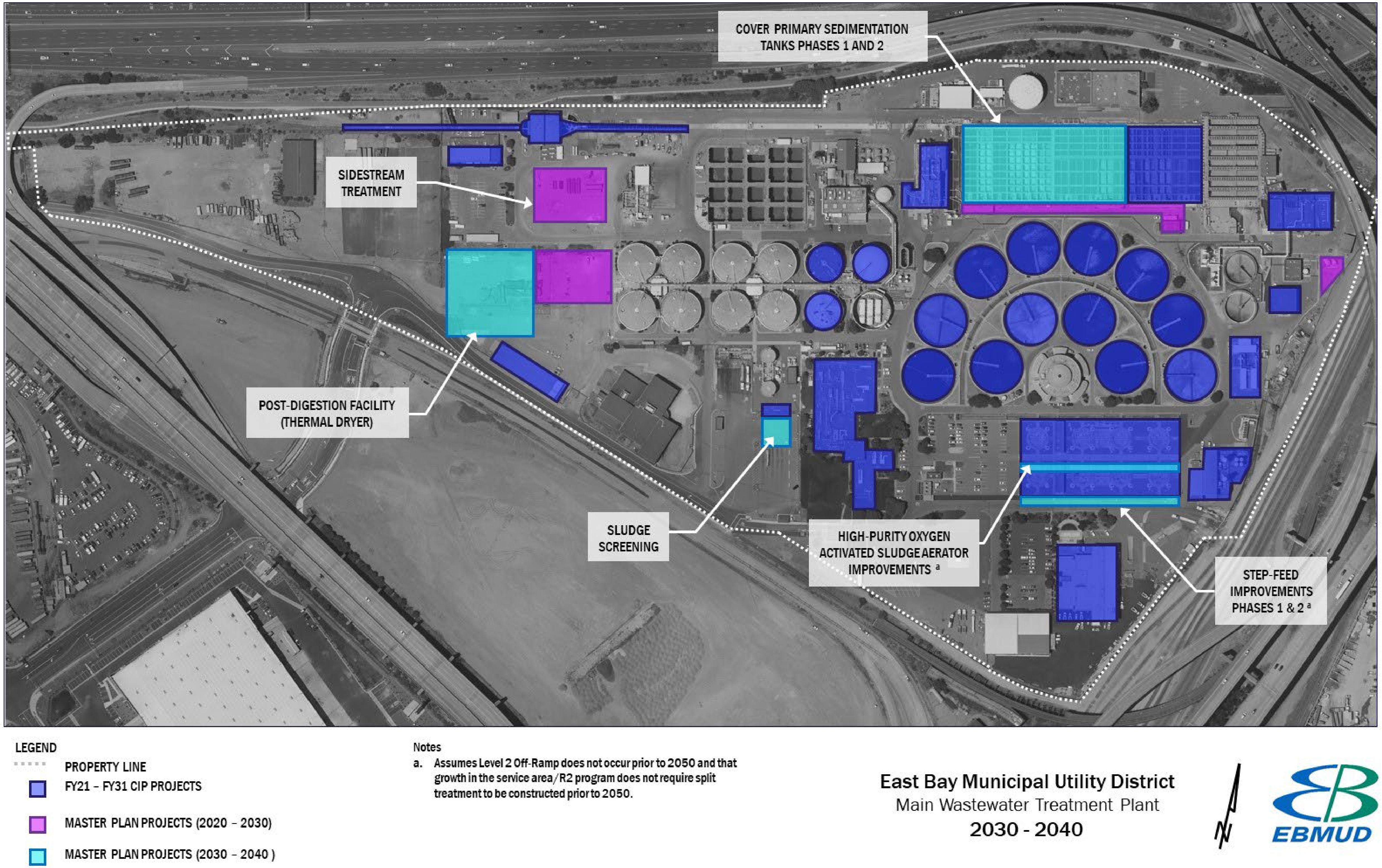

Figure 11-7. Master Plan site plan for years 2030 to 2040

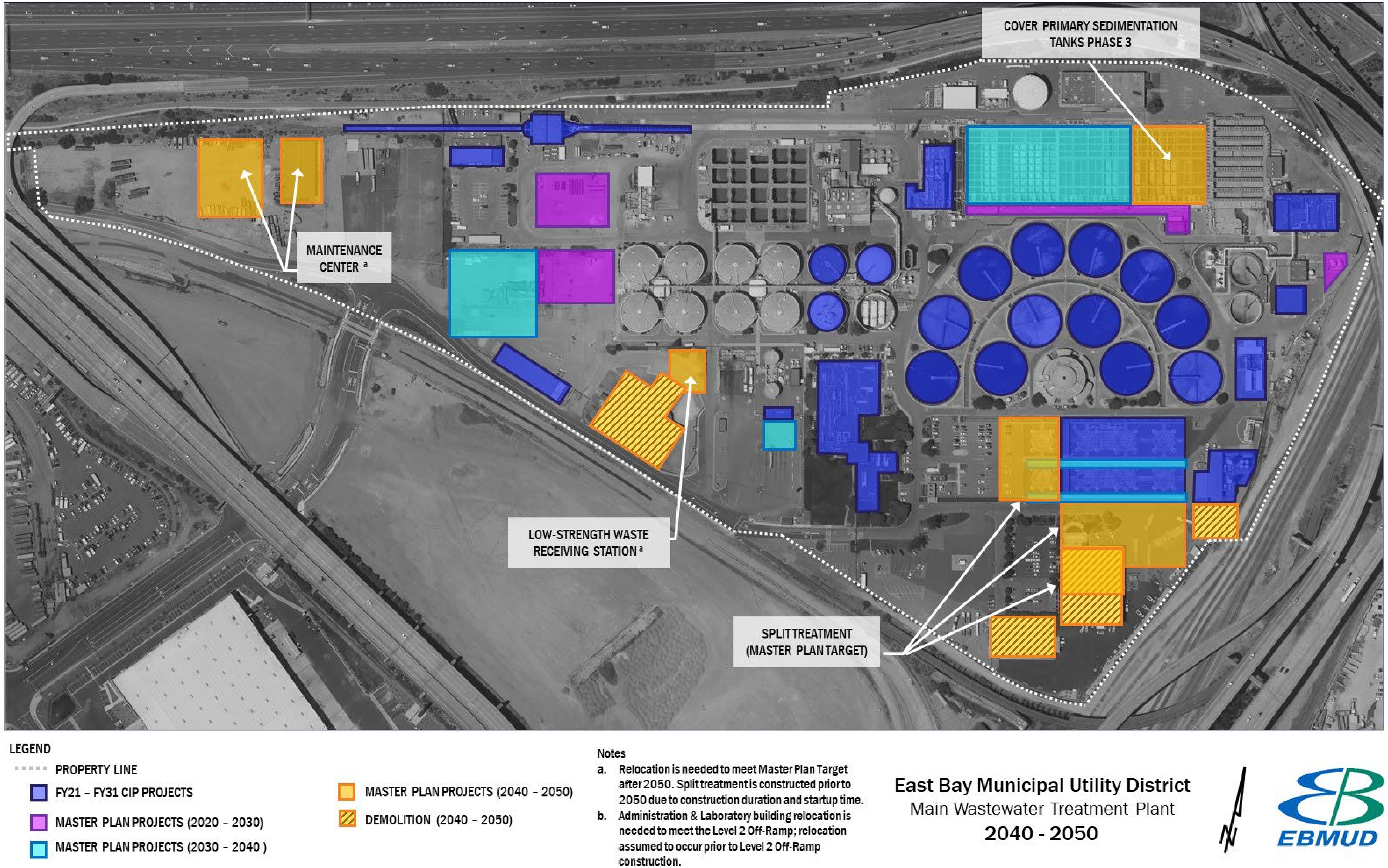

Figure 11-8. Master Plan site plan for years 2040 to 2050

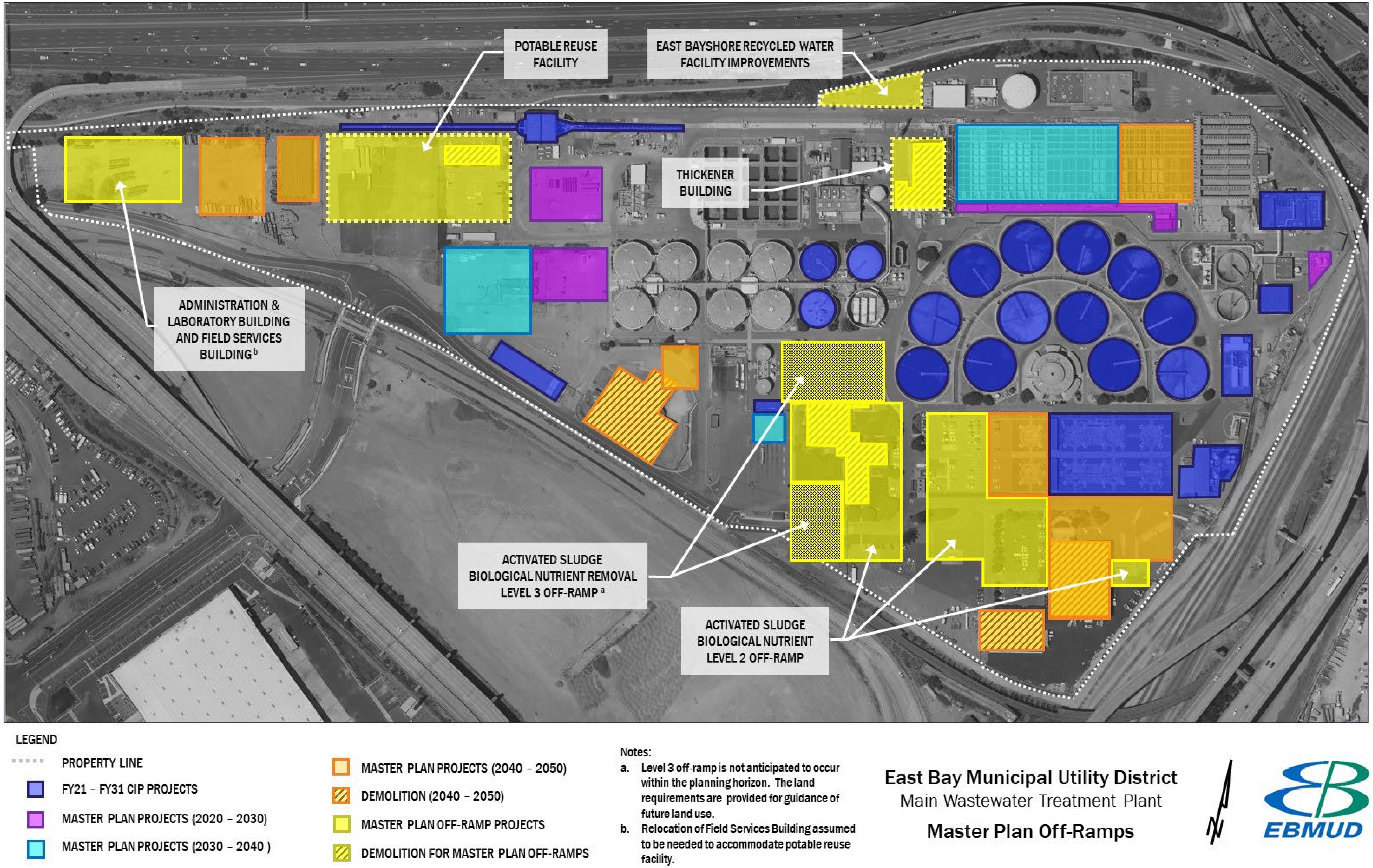

Figure 11-9. Master Plan site plan off-ramps

CHAPTER 12 REFERENCES AND APPENDICES

Brown and Caldwell, Draft Blended Sludge and Fats, Oils, and Grease Screening and Degritting Pilot Study Report, 2020).

Brown and Caldwell, Final EBRWF Water Quality Improvements Study, 2018

East Bay Municipal Utility District, Recycled Water Master Plan Update, 2019.

InfaTerra, Main Wastewater Treatment Plant Seismic Structural Evaluation and Conceptual Design Project Report – Draft, 2020.

Woodard & Curran & Brown and Caldwell, Final Recycled Water Master Plan Update, 2018

Appendix A – E00: Wastewater System Overview
Appendix B – E10: Previous and Ongoing Studies Summary
Appendix C – E20: MWWTP Regulatory Requirements
Appendix D – E30: Condition Assessment and Seismic Study
Appendix E – E40: Climate Action and Sustainability Plan
Appendix F – E50: MWWTP Master Plan Goals and Objectives
Appendix G – E60: Resource Recovery Summary and Projections
Appendix H – E70: Influent Flows and Loads Projections
Appendix I – E80: Existing Plant Performance
Appendix J – E90 Electrical Capacity Study
Appendix K – E100: Biogas Utilization Report
Appendix L – C30: Market Assessment
Appendix M – C40: Basis for Cost Estimate
Appendix N – C50: Evaluation Criteria
Appendix O – C60: Plant-Wide Process Model Report
Appendix P – C70: Capacity Assessment
Appendix Q– C80: Nutrient Reduction Alternatives Report
Appendix R – C80.1: Sidestream Treatment Report
Appendix S – C90: Biosolids Management Report
Appendix T – Workshop Materials and Meeting Minutes
Appendix U – High-Purity Oxygen Activated Sludge Nitrification Analysis
Appendix V – Primary Sedimentation Tank Evaluation
Appendix W – Reduce R2: Scenarios: Flow and Loads and Process Model Results
Appendix X – R2 Scenario Net Present Value
Appendix Y – Process Improvement Details
Appendix Z – Details Table of Near-Term and Long-Term Master Plan Projects
Appendix AA – Integrated Master Plan in Brief
Appendix AB – Co-thickening and Recuperative Thickening