BACWA Meeting with Regional Board: Review of the Nutrient Reduction Study

17 September 2018

HDR

Brown AND Caldwell

BACWA BAY AREA CLEAN WATER AGENCIES

Agenda

1. Watershed Permit Requirements
2. Scoping and Evaluation Report
3. Study Limitations
4. Nutrient Reduction Findings
5. Reduction by Other Means
6. Sea Level Rise
7. Key Observations
8. Summary

Watershed Permit Requirements

Watershed Permit

CALIFORNIA
Water Boards

EDMUND G. BROWN JR.
GOVERNOR

MATTHEW RODRIQUEZ
SECRETARY FOR
ENVIRONMENTAL PROTECTION

San Francisco Bay Regional Water Quality Control Board

ORDER No. R2-2014-0014
NPDES No. CA0038873

WASTE DISCHARGE REQUIREMENTS FOR NUTRIENTS FROM MUNICIPAL WASTEWATER DISCHARGES TO SAN FRANCISCO BAY

The following dischargers are subject to waste discharge requirements (WDRs) set forth in this Order, for the purpose of regulating nutrient discharges to San Francisco Bay and its contiguous bay segments:

Table 1. Discharger Information

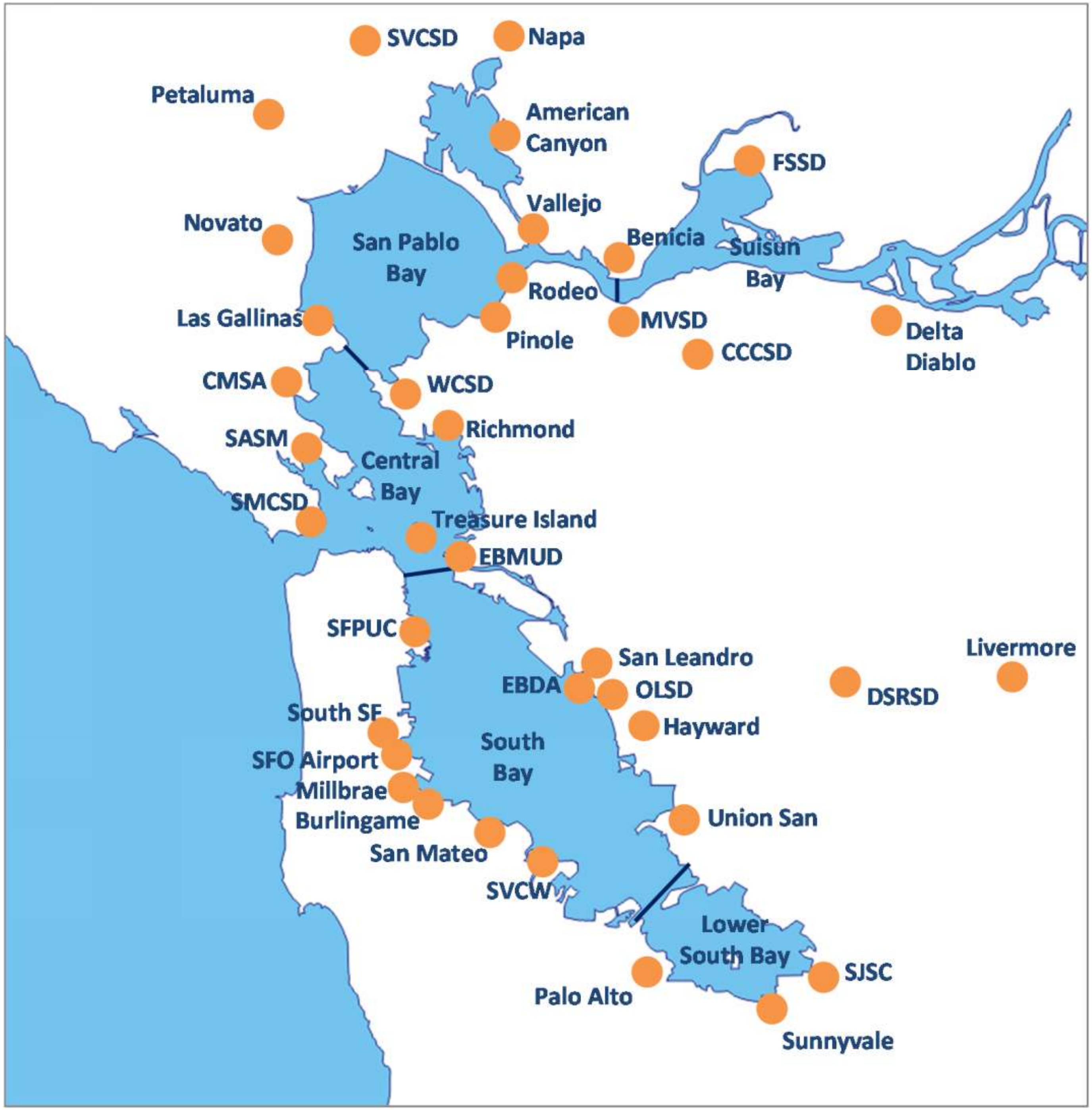
Discharger	Facility Name	Facility Address	Minor/ Major

April 9, 2014

Watershed Permit Requirements

- Issued April 9, 2014 – Regional Water Board Order No. R2-2014-0014
- Requirements:
  - Scoping and Evaluation Plan (Accepted first quarter of 2015)
  - July 2018: Task 1 - Conduct treatment plant optimization and sidestream treatment evaluation for nutrient load reductions (Submitted before July 2018 deadline)
  - July 2018: Task 2 - Conduct treatment plant upgrades and analysis of removal by other means for nutrient load reductions (Submitted before July 2018 deadline)
  - Annual Reporting (Annual submittal in October from 2015 through 2018)

37 Participating Agencies



Scoping and Evaluation Report

Scoping and Evaluation Report (Accepted February 2015)

- Established nutrient levels
- Presented the approach for all 37 plants:
  - o Data collection and prelim. assessment
  - o Site visits
  - o Site visit reports
  - o Nutrient reduction report for each plant
  - o GHG emissions
  - o Removal by other means
  - o Sea level rise

Treatment Levels

Level	Study	Ammonia	TN	TP
Level 1 *	Optimization	--	--	--
Level 2 *	Upgrades	2 mg N/L	15 mg N/L	1.0 mg P/L
Level 3 *	Upgrades	2 mg N/L	6 mg N/L	0.3 mg P/L

* Seasonal impacts considered for all three treatment levels:
  - Dry Season = May 1 to September 30
  - Wet Season = October 1 to April 30

Data Collection

Questions to Understand Plant:	Value	Units/Comments	
PLANT BACKGROUND:	INFO FROM POTW		Comments from POTW (optional)
Plant Footprint, acres or square feet =		Ball park; provide units	
Submit a Plant Process Flow Diagram and mark off areas planned for future projects =		As a separate file (marked up scan is OK)	
SERVICE AREA DESCRIPTION:			
Number of Service Connections =			
Area covered by the Discharger =			
Prior Reports:			
Provide any planning reports on nutrient removal (**send separately**)		Example, master plan	
Provide information on Capital Improvement Projects planned for nutrient removal (**send separately**)		Example, aeration basin expansion for nitrification	
Provide any reports completed related to By Other Means (**send separately**)		Example, nutrient trading, water recycling, wetlands treatment, biosolids export, source control, and non-point source	
Provide any reports completed related to Sea Level Rise and Climate Change (**send separately**)			
FLOW LIMITS:			
Permitted Flow (ADWF), mgd =			
Permitted Flow (Peak Flows), mgd =		If listed on NPDES Discharge Permit	
Rated Capacity (ADWF), mgd =		If known	
Current ADWF Flows, mgd =			

Sent to Plants in Dec 2014 to Better Understand each Plant and Perform Pre-Engineering before each Site Visit

Site Visits

Objectives:

- Review data with lab staff
- Review permit requirements
- Develop treatment concepts to satisfy the permit requirements
- Walk the plant to confirm viability of developed concepts
- Produce a site visit report that confirms the concepts developed during the site visit

Data Review and Site Visits

BACWA BAY AREA CLEAN WATER AGENCIES

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Potential Nutrient Reduction by Treatment Optimization and Treatment Upgrades

Facility Information	
Facility Name	
Address	
Facility Contact	
Date of Visit	
Facility Attendees	
Consultant Mgmt Group Attendees	
Consultant Process Engineer	
Consultant Operations Expert	
Describe Existing Nutrient Limits *(if any)*	Ammonia = 170 mg N/L AMEL and 220 mg N/L MDEL
Permitted Capacity	19.5 mgd ADWF; 31.1 mgd PWWF

Current Conditions		
Flow	**Summer**	**Winter**
Annual Average Flow, mgd	13.0	13.1
Peak Month, mgd	13.3	13.7
Max Day, mgd	14.3	17.0
Peak Hour Flow, mgd	19	31.5
TSS Loads (Marginal seasonal impacts)		
Annual Average, lb/d	38,500	38,900
Peak Month, lb/d	42,500	43,400
Max Day, lb/d	58,500	60,500
BOD Loads (Marginal seasonal impacts)		
Annual Average, lb/d	35,700	37,400
Peak Month, lb/d	38,700	41,700
Max Day, lb/d	42,300	54,300
Ammonia Loads (Marginal seasonal impacts)	**Summer**	**Winter**

BACWA BAY AREA CLEAN WATER AGENCIES

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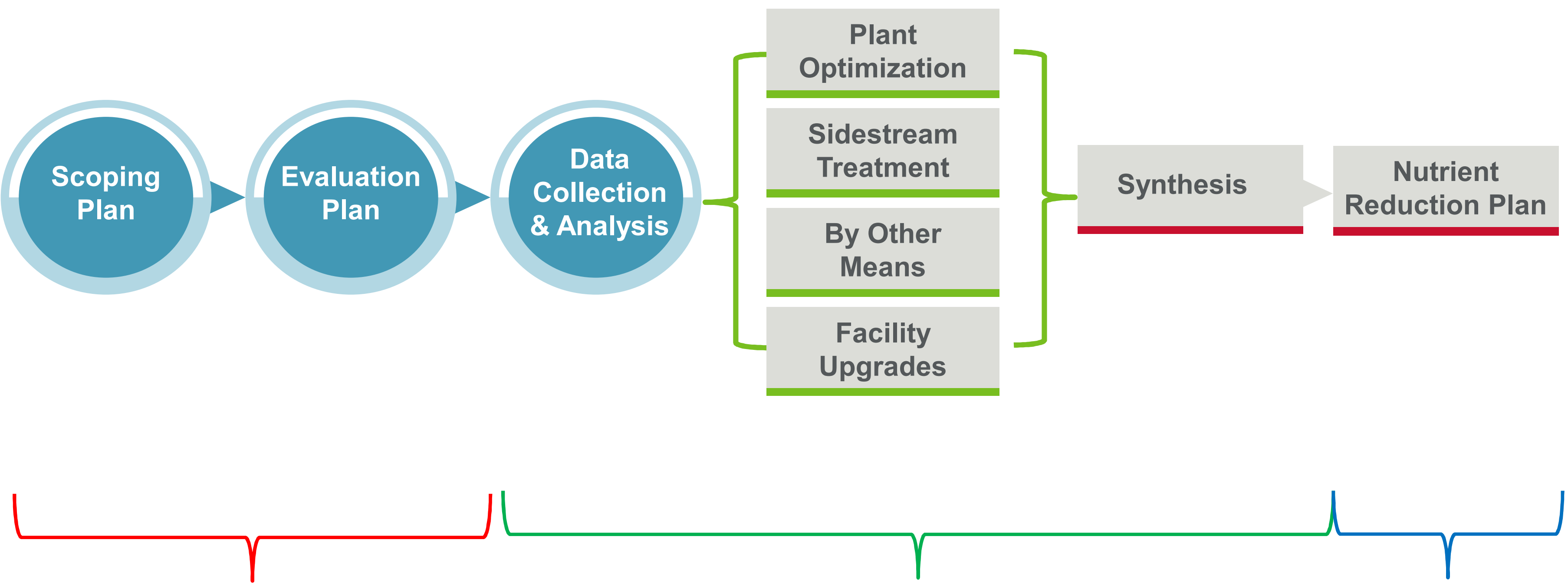
Current Conditions		
Annual Average, lb/d	3,500	3,800
Peak Month, lb/d	3,800	4,100
Max Day, lb/d	3,800	4,400
TKN Loads (Marginal seasonal impacts)		
Annual Average, lb/d	5,400	5,700
Peak Month, lb/d	6,000	6,200
Max Day, lb/d	6,500	6,300
Ortho-P Loads (Marginal seasonal impacts)		
Annual Average, lb/d	360	370
Peak Month, lb/d	420	490
Max Day, lb/d	430	610
Total P Loads (Marginal seasonal impacts except for Max Day)		
Annual Average, lb/d	690	700
Peak Month, lb/d	760	780
Max Day, lb/d	2,100 High due to solids from water recycling return streams	900

- The current flows and loads are in-line with the Master Plan historical and projected flows and loads. The current flows and loads show marginal seasonal impacts on flows and loads.
- The max day summer total P loads are high due to phosphorus in the solids return stream from the Recycled Water Facility (RWF). Delta Diablo adds ferrous chloride (FeCl2) to their sewer at the Pittsburg and Antioch pump stations (PS) and alum at the ActiFlo® process located at the RWF.

Documentation (check all available documents)	
☒	Current Master Plan
☒	PFD
☐	Facility Plan
☐	Sea Level Rise Report

Project Approach Summary



Approved in Feb 2015

Data Collection: Spring 2015
Site Visits: Spring – Fall 2015
Draft / Final Plant Reports: 2016-2018

Summer 2018

Study Limitations

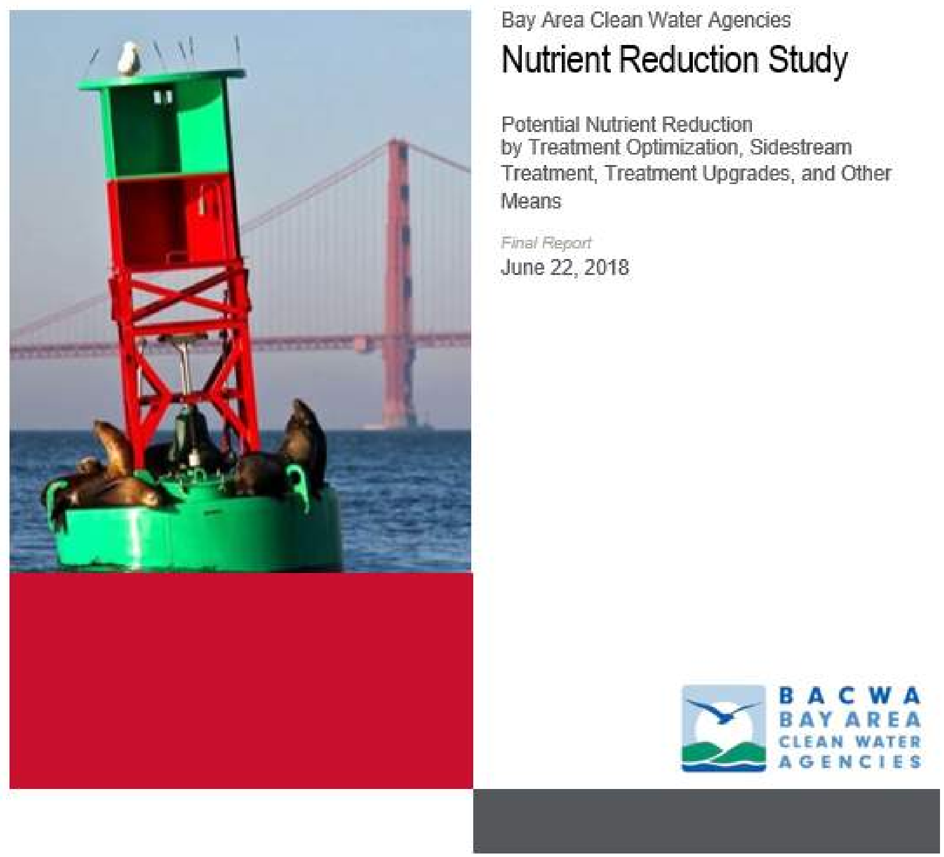
Study Limitations

1. The Study's treatment levels DID NOT consider water quality objectives. Rather, they were based on a tipping point in facilities needed to achieve Level 2 versus Level 3 (e.g., filters, chemicals, etc.).
2. Treatment levels were based on ammonia, TN and TP versus individual species (impacted technology selection)
3. Planning level effort that was limited to data exchange and a single site visit (i.e., not a detailed facilities planning report)
4. Projected flows/loads were typically not site specific
5. Used parametric cost estimating (excluded site specific constraints)
6. Findings (including costs and space requirements) were based on established, conventional technologies.

Nutrient Reduction Findings

Nutrient Reduction Findings (Submitted June 2018)

- Individual plant reports and sign-off letters for all 37 plants
- Optimization
- Sidestream treatment
- Plant upgrades
- Summary comparison of Opt./Sidestream/ Upgrades



Individual Plant Reports and Sign-Off Letters (Appendix in the Main Report for all 37 Plants)

HDR

Bay Area Clean Water Agencies
Nutrient Reduction Study

Oro Loma/Castro Valley Wastewater Treatment Plant

San Lorenzo, CA

February 9, 2018
Final Report

ORO LOMA SANITARY DISTRICT

February 12, 2018

Mr. Bruce Wolfe
Executive Officer
San Francisco Bay Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 94612

Subject: Acceptance of Plant-Specific Findings for the Nutrient Reduction Report

Dear Mr. Wolfe

On behalf of Oro Loma Sanitary District, I have reviewed the individual plant report prepared for Oro Loma that is included as an appendix to the Potential Nutrient Reduction by Treatment Optimization, Sidestream Treatment, Treatment Upgrades, and Other Means Report (Nutrient Reduction Report). The plant report was prepared by the HDR consulting team under a contract with Bay Area Clean Water Agencies (BACWA). This report represents the Oro Loma facility in 2017 and outlines a methodology and costs to obtain selected levels of nutrient treatment.

I agree that the recommended approach and cost estimates for reducing nutrients at our facility are reasonable with respect to the context of the overall report. Furthermore, in accordance with the Watershed Permit requirement for report certification, I certify, under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. The Nutrient Reduction Report is, to the best of my knowledge, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Thank you,

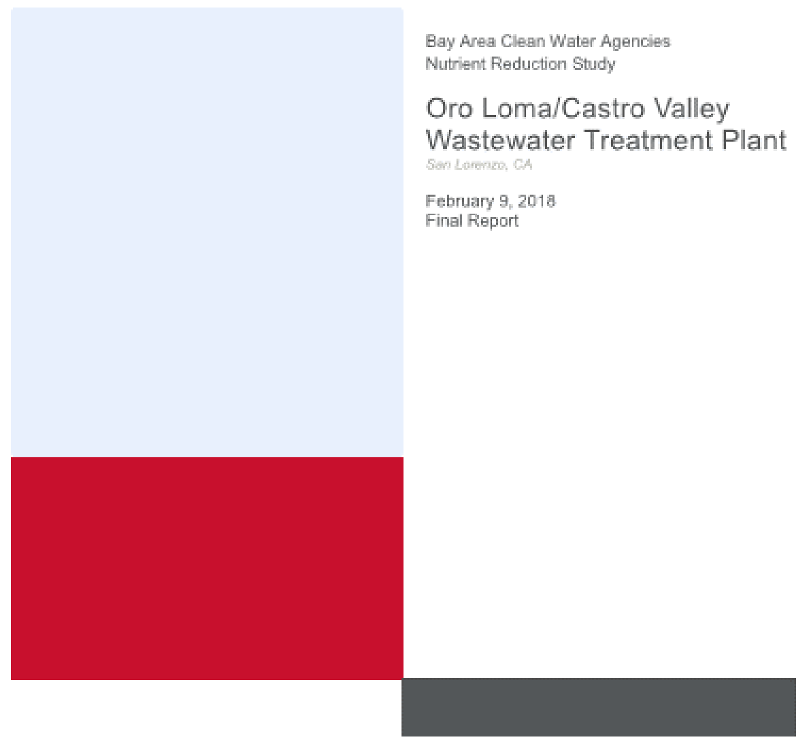
Jason Warner
General Manager

2655 Grant Avenue, San Lorenzo, California 94580-1838 ▪ info@oroloma.org ▪ P: (510) 276-4700 ▪ F: (510) 276-1528 ▪ www.oroloma.org

Individual Plant Reports
(Appendix in the Main Report for each of the 37 Plants)

Each Report is 25-35 pages, which includes:

- Executive Summary
- Introduction
- Current Conditions
- Basis of Analysis
- Nutrient Load Reduction by Optimization
- Nutrient Load Reduction by Sidestream Treatment
- Nutrient Load Reduction by Upgrades (Levels 2 and 3)
- Nutrient Load Reduction By Other Means
- Greenhouse Gas Emissions
- Emerging Technologies


Bay Area Clean Water Agencies
Nutrient Reduction Study

Oro Loma/Castro Valley
Wastewater Treatment Plant
San Lorenzo, CA

February 9, 2018
Final Report

Optimization Results

Optimization Approach

- Basis of Analysis
  - Identify no / low cost strategies to reduce effluent nutrients
  - Planning Period: 2025 Horizon
  - Loading:
    - 0% Increase in Flows
    - 15% Increase in Loads
  - Design Criteria: Aggressive – no permit limits
- Potential Optimization Concepts
  - Use offline tankage
  - Operate in split treatment mode
  - Modify operational mode (e.g., raise SRT)
  - Add chemicals
  - Process control instrumentation
  - Add internal recycle for denitrification

Optimization Findings

Which nutrients are easiest to remove?

- Ammonia load reduction is most difficult
  - Increasing SRT for plants with act sludge
  - Operating Trickling Filter as a Nitrifying Trickling filter
- TN load reduction is possible if ammonia removal implemented
- TP load is easier to remove
  - Most plants already have metal salt chemical feed facilities
  - Some have anaerobic zones
  - Lose TP removal capability by forfeiting anaerobic zone

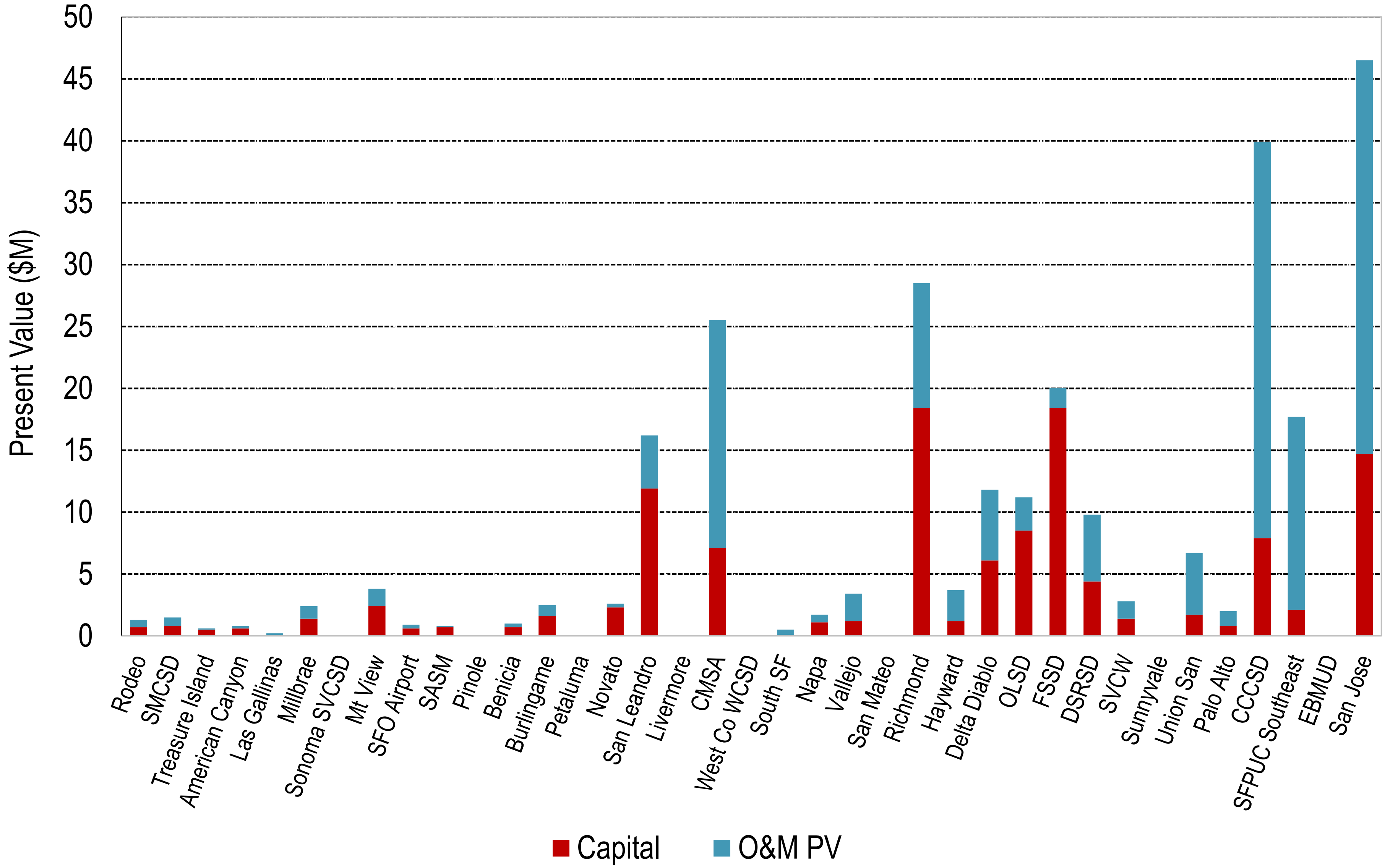
Costs

- Total PV
  - $241M Dry Permit and $266M Year-Round Permit
  - Ranged from $0.2M to $45M per plant
- Unit Costs
  - Flow-weighted Total PV unit cost = ~$0.5/gpd
  - Total PV/lb N rem = ~$6/lb N
  - Total PV/lb P rem = ~$8/lb P
- Plants identified for Ammonia/TN load reduction: 15 of 37 plants for dry or year round reductions

Load Reduction w/Respect to Current Discharge:

- Ammonia load reduction is 14%
- TN load reduction is 7%
- Overall TP load reduction is 34%

Total PV Costs for Optimization



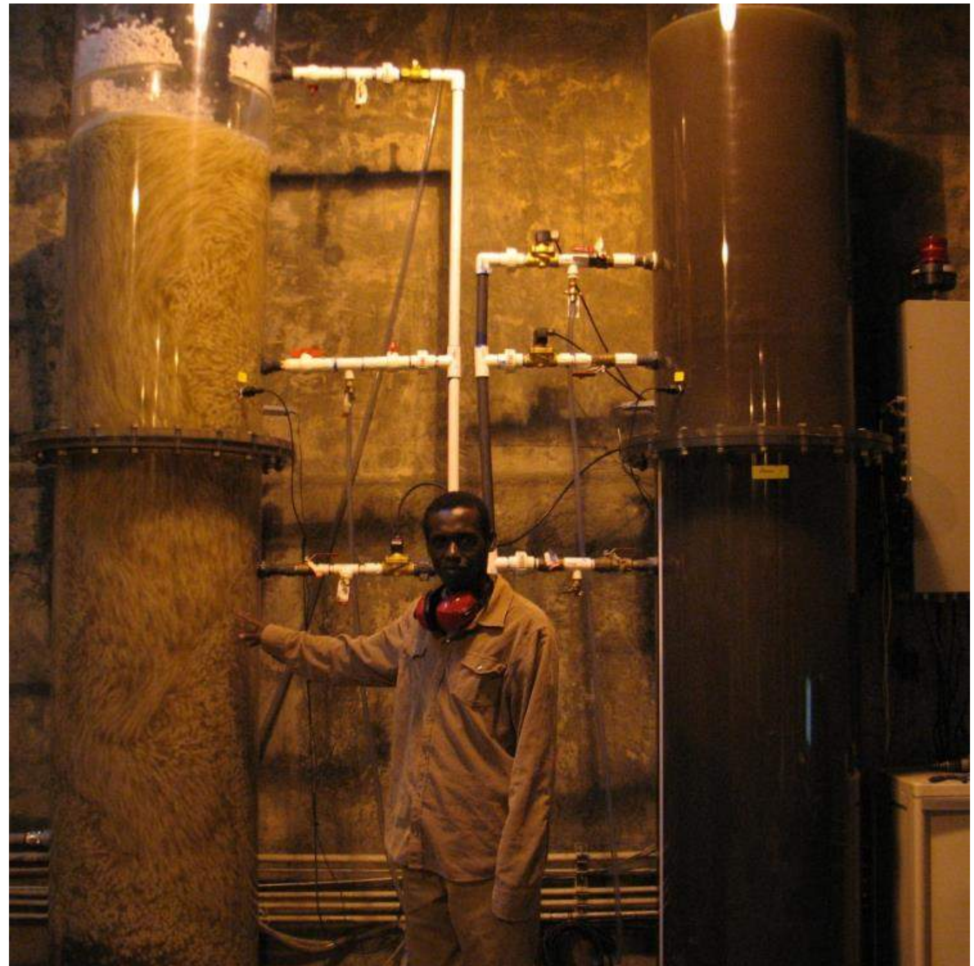
* Results are Sorted by Permitted Capacity

Sidestream Treatment Results

Sidestream Approach

- Basis of Analysis
  - Identify upgrade strategies to reduce nutrients
  - Planning Period: 30 Years
  - Loading: Plant Permitted Capacity
  - Requirements for Sidestream:
    - Anaerobic digestion
    - Year-round sidestream
    - Sufficient Dewatering Frequency ($\geq$4 days/week)
    - Water temperature governs technology selection
- Concepts
  - Ammonia/TN Removal:
    - Conventional nitrification technology
    - Deammonification technology
  - TP Removal: metal salt precipitation
- Acknowledgements

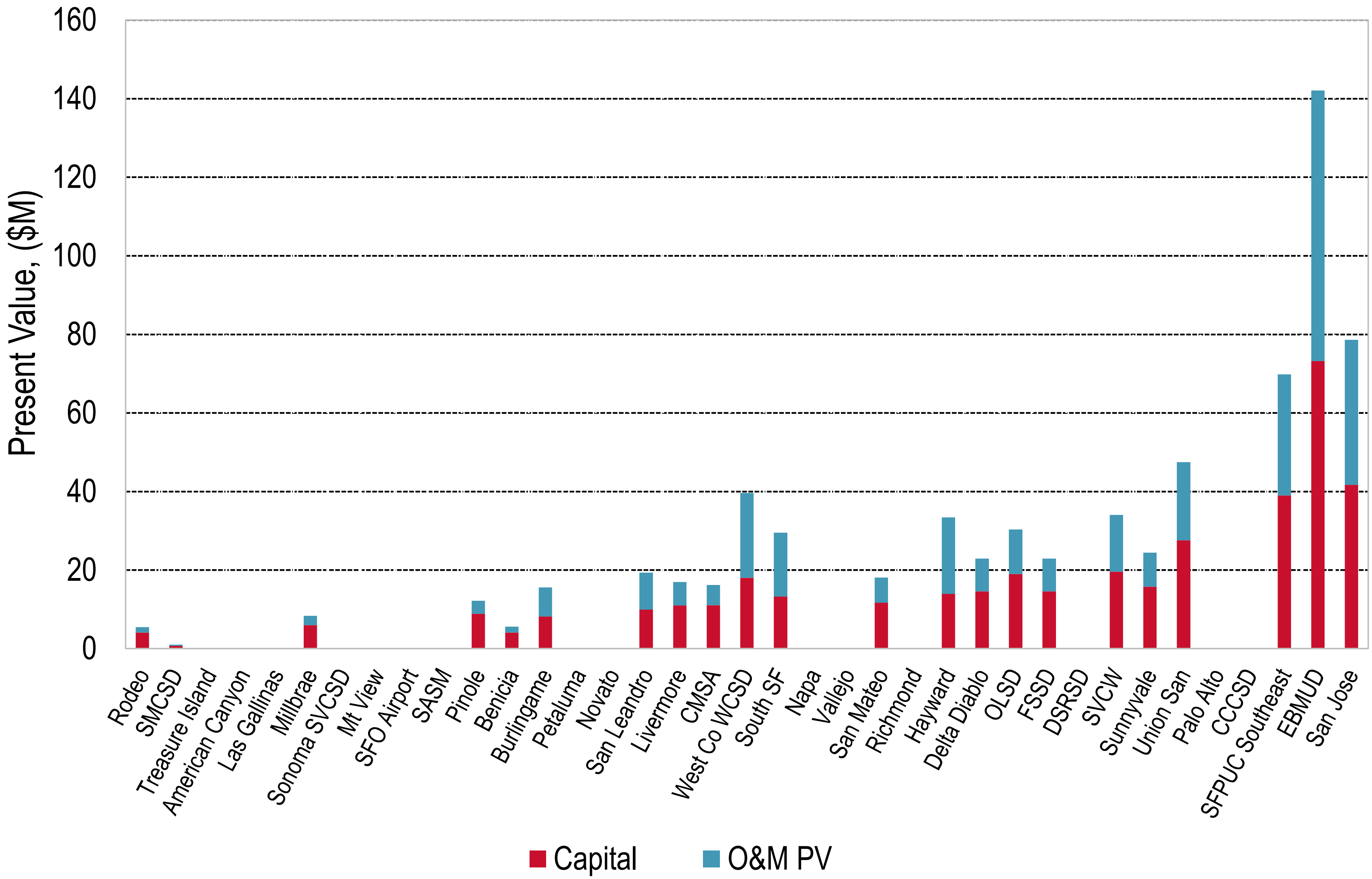
  - EPA Regional Grant led by EBMUD
  - Agencies that hosted pilots: EBMUD, SPFUC SEP, DD, OLSD, USD, CCCSD



Sidestream Findings

- Criteria for feasible sidestream implementation:
  - Anaerobic digestion
  - Year-round sidestream
  - Year-round discharge
  - Sufficient dewatering frequency ($\geq$4 days/week)
- Number of candidate plants
  - 15 out of 37 plants if ammonia reduction is the discharge objective
  - 23 out of 37 plants if TN reduction is the discharge objective
  - 15 out of 37 plants if TP reduction is the discharge objective
- Costs
  - The Total PV cost is $736 Mil for all the nutrients ($690 Mil for TN Load Reduction)
  - Removal Metric = $2.0/lb N removed; $2.8/lb P removed
- The overall Ammonia/TN/TP load reduction from Current Discharge is up to 24, 19, and 12 percent, respectively

Total PV Costs for Sidestream



* Results are Sorted by Permitted Capacity

Upgrades Results

Upgrades Approach

- Basis of Analysis
  - Identify upgrade strategies to meet effluent levels
  - Planning Period: 30 Years
  - Loading: Permitted Capacity
  - Design Criteria: Reliability – meet permit limits
- Concepts
  - Design Facilities for Level 2 that could be further upgraded to meet Level 3 – no stranded assets

Treatment Levels

Level	Ammonia	TN	TP
Level 1	--	Optimization	--
Level 2	2 mg N/L	15 mg N/L	1.0 mg P/L
Level 3	2 mg N/L	6 mg N/L	0.3 mg P/L

Upgrade Findings

Which nutrients are easiest to remove?

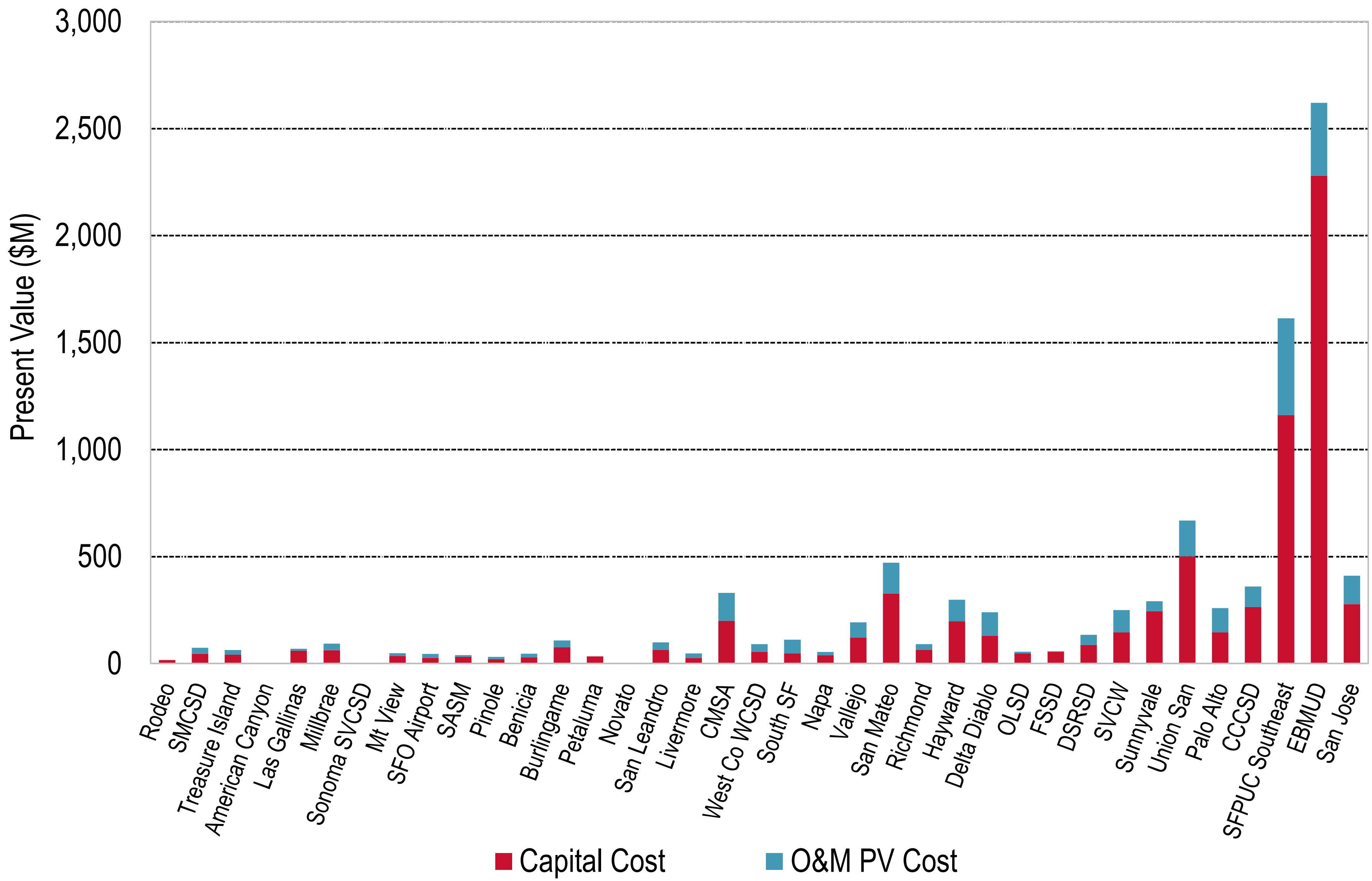
- Ammonia is the most difficult and expensive
  - Bigger basins due to increasing SRT for act sludge plants
  - Expanded aeration system
  - Additional pumping
- TN load reduction requires ammonia removal
  - Level 3 typically require an external carbon source
- TP load reduction is the simplest/most straight forward
  - Level 3 requires tertiary filtration
  - Upgrades use MBR (includes filtration in Level 2)
- Number of Plants Already/Planning to Meet Levels:
  - Level 2: 6
  - Level 3: 1

Costs

- Total PV Costs
  - Level 2 = $8.8B Dry & $9.4B Year Round
  - Level 3 = $10.8B Dry & $12.4B Year Round
- Total PV Cost Range per Plant
  - Level 2 = $1.4M to $2,620M per plant
  - Level 3 = $9M to $2,870M per plant
- Unit Costs
  - Level 2: $8.5/lb N Dry & $8.7/lb N Year Round
    $44/lb P Dry & $44/lb P Year Round
  - Level 3: $8.4/lb N Dry & $7.7/lb N Year Round
    $66/lb P Dry & $59/lb P Year Round

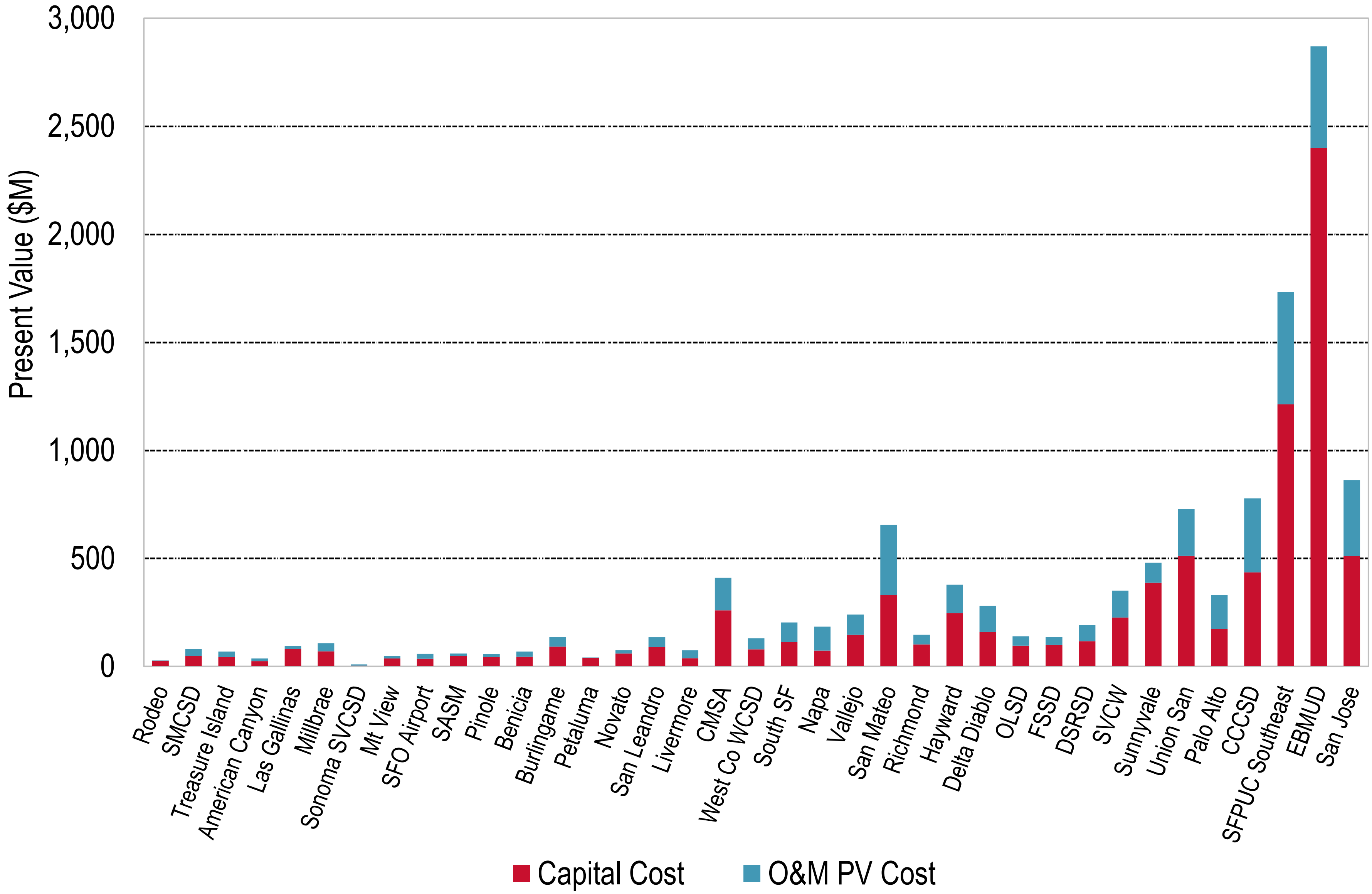
Parameter	Level 2 Load Reduction	Level 3 Load Reduction
Ammonia	>93%	>93%
Total N	>57%	>82%
Total P	>59%	>88%

Total PV Costs for Level 2 Upgrades



* Results are Sorted by Permitted Capacity

Total PV Costs for Level 3 Upgrades

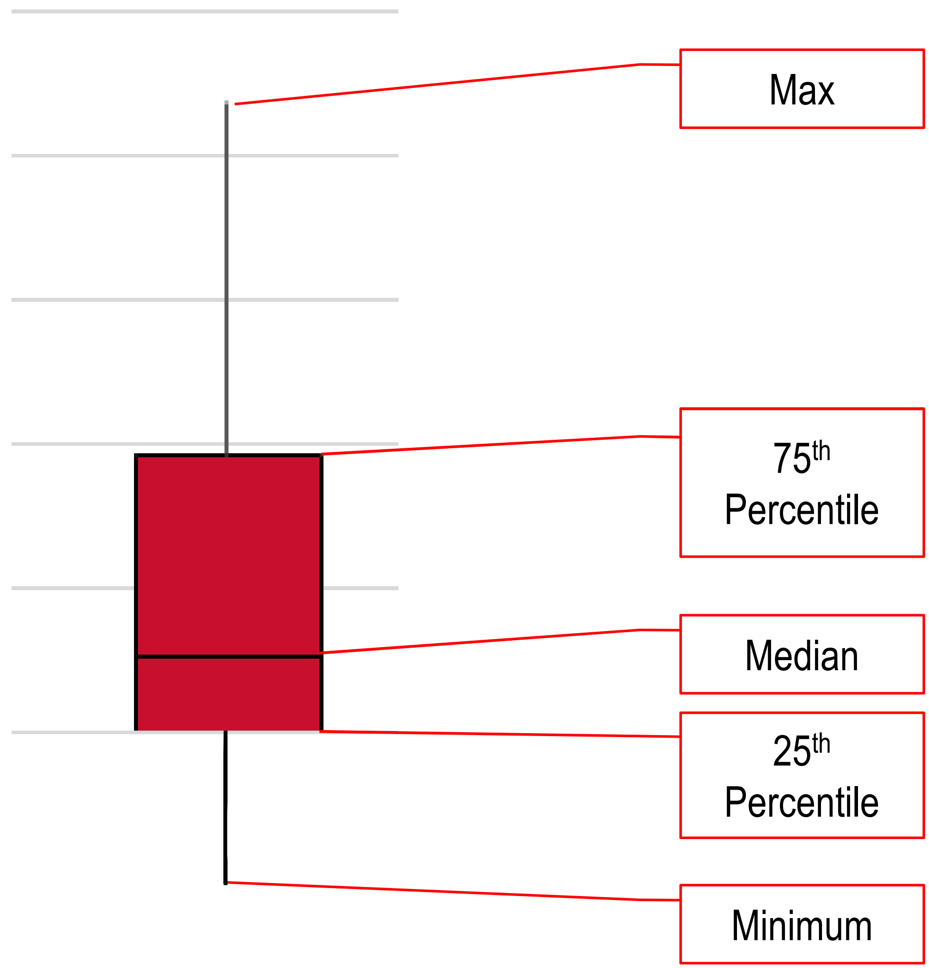


* Results are Sorted by Permitted Capacity

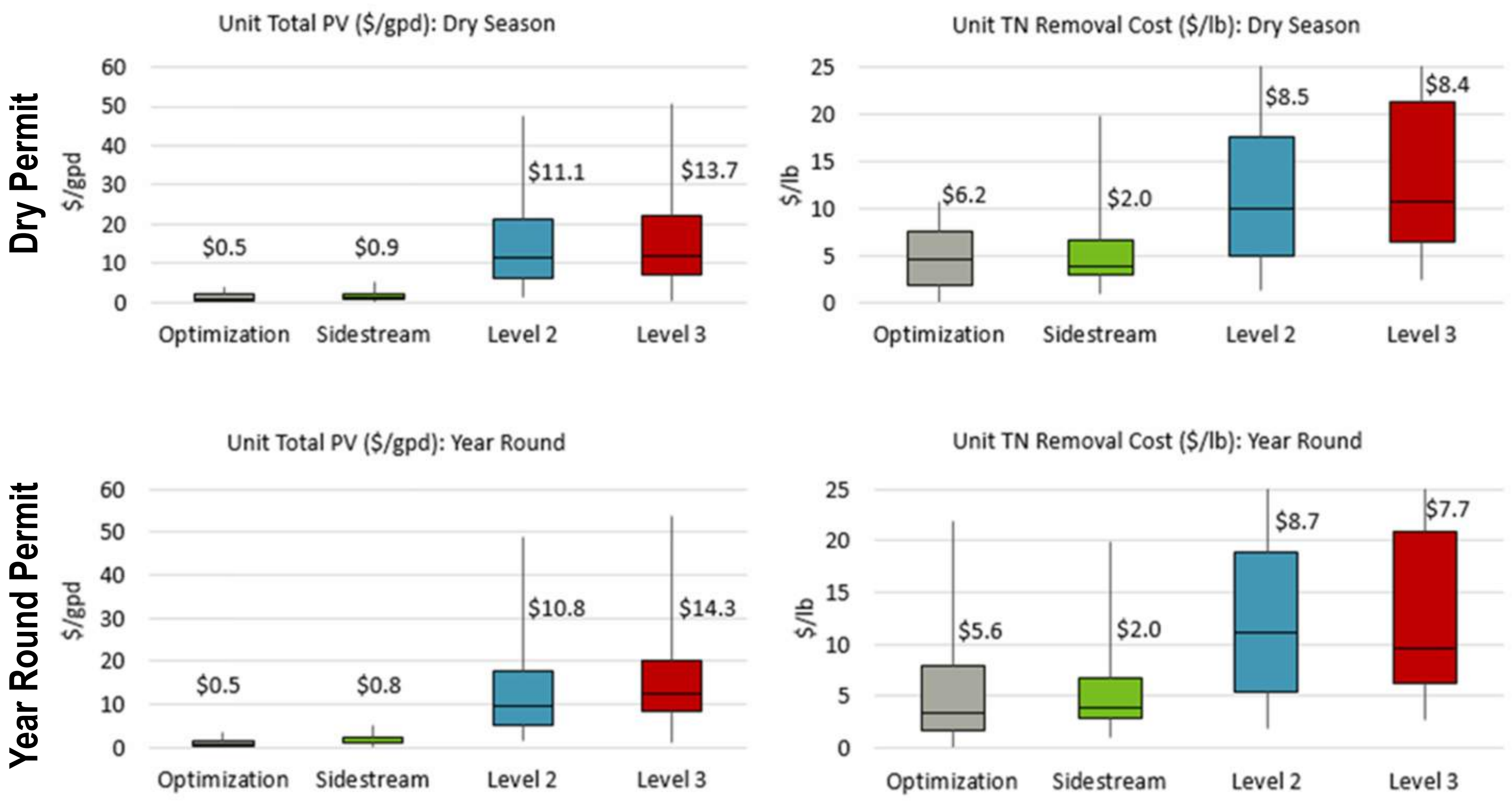
Summary of Results

Box and Whisker Plots

- Used to Illustrate Data Distribution, Central Value, and Variability
- Box:
  - Median is horizontal line inside box
  - Box ends represent upper and lower quartiles (25th and 75th percentiles)
- Lines represent max and min values

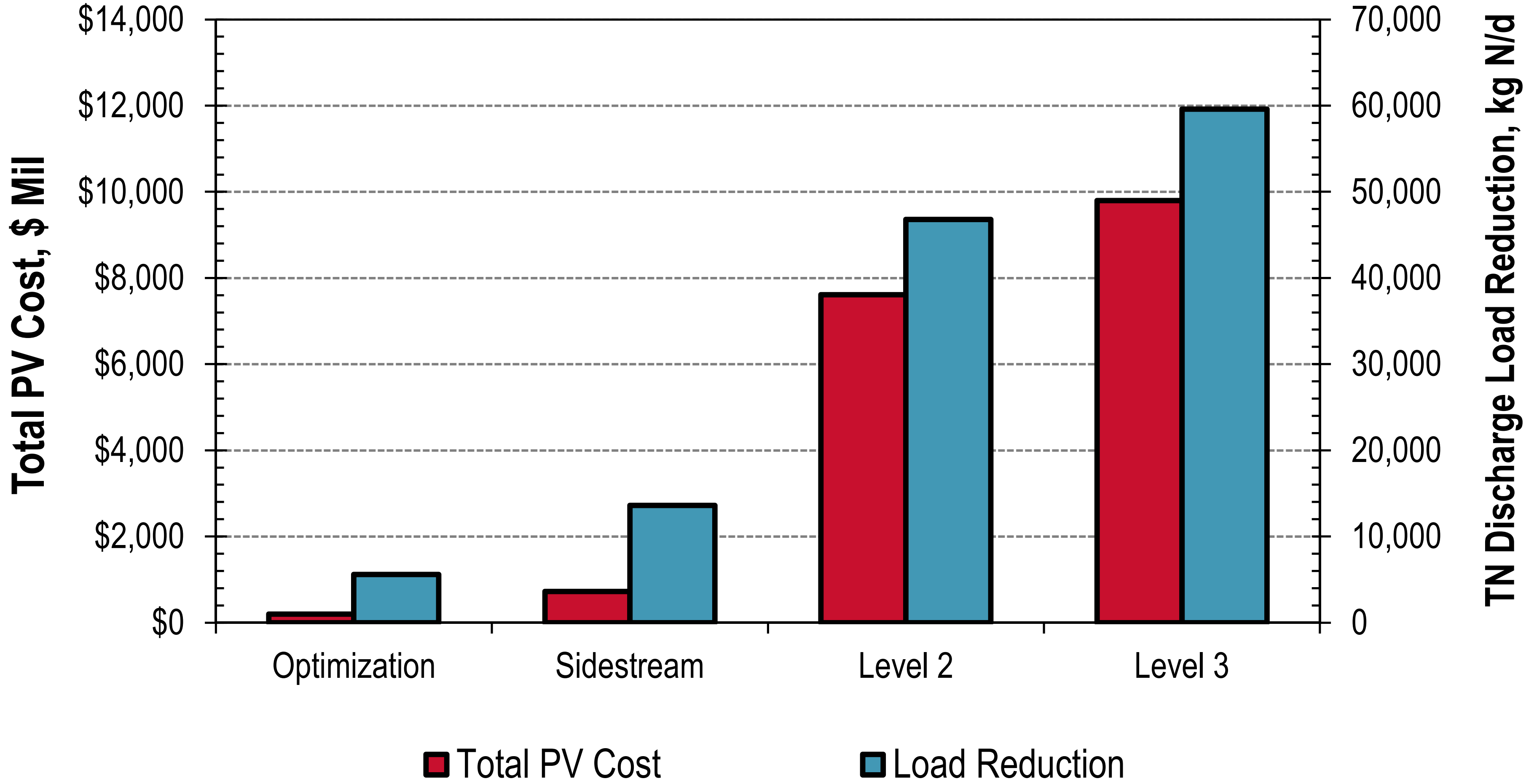


Box and Whisker Plots for TN Load Reduction Metrics:
Unit Total PV, $/gpd (Left) and Removal Efficiency, $/lb (Right)



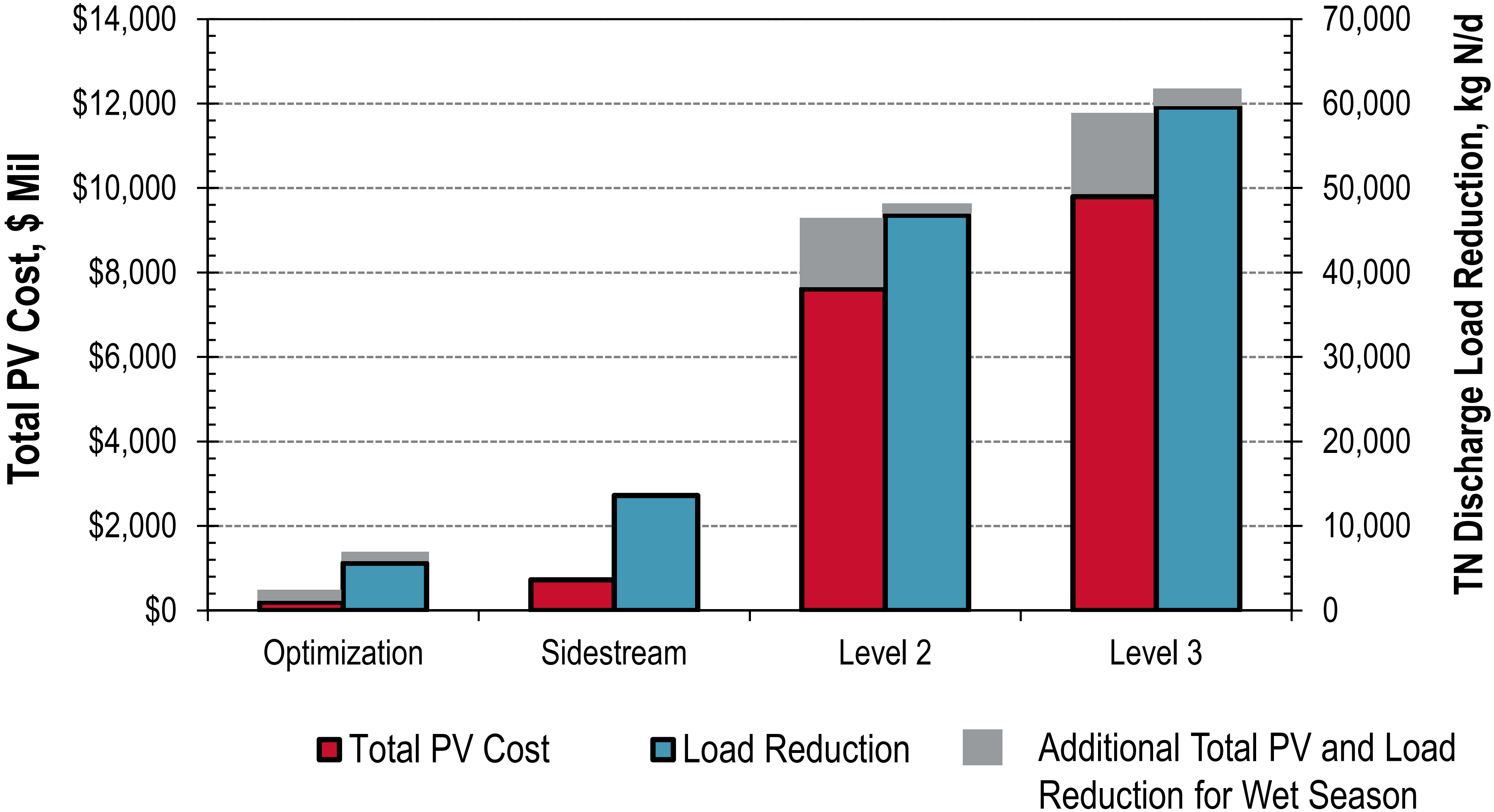
Notes:
1. The unit cost graphs are presented as box and whisker plots, where the boxes represent the range of costs falling within the 25th to 75th percentiles, the horizontal bar within the box represents the median cost, and the ends of the whiskers represent the minimum and maximum unit costs, respectively.

Total N Discharge Load Reduction and Costs under Various Scenarios (Dry Season Permit)



- Optimization = 10-yr planning horizon
- Sidestream and Upgrades (Level 2 and 3) = 30-yr planning horizon using Permitted Capacity

Total N Discharge Load Reduction and Costs under Various Scenarios (Year Round Permit)



- Optimization = 10-yr planning horizon
- Sidestream and Upgrades (Level 2 and 3) = 30-yr planning horizon using Permitted Capacity

Greenhouse Gas Emissions

Greenhouse Gas (GHG) Emissions

- Captures the impacts from additional energy and chemicals associated with nutrient load reduction
- Not intended to satisfy GHG emissions reporting requirements
- Nitrous oxide emissions not included but will likely increase with biological nitrogen removal processes

Annual GHG Emissions (mt CO2 eq/yr) from Additional Energy/Chemicals for Nutrient Load Reduction

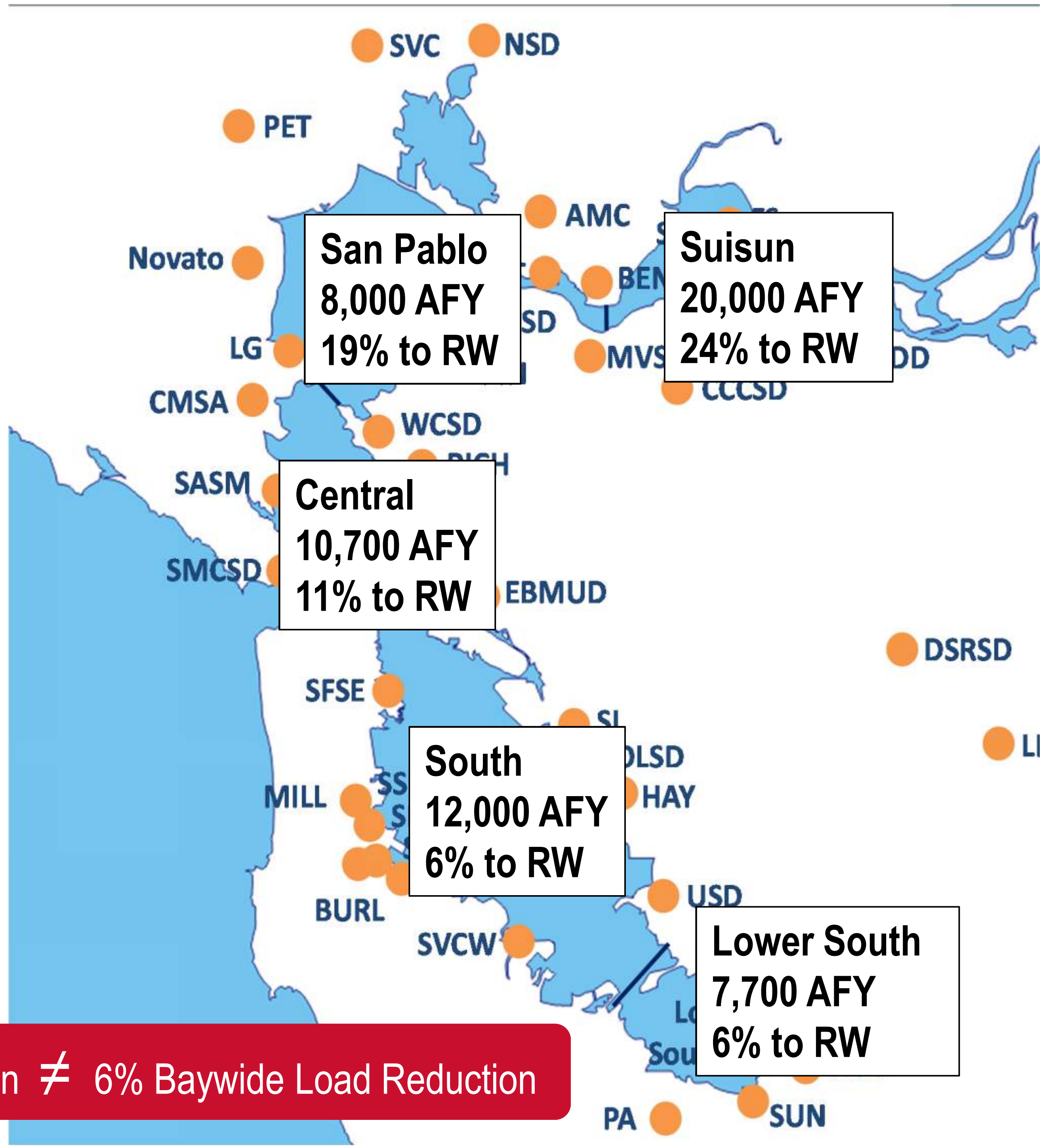
Parameter	Unit	Optimization	Sidestream	Level 2 Upgrades	Level 3 Upgrades
Energy	mt CO2 eq/yr	14,400	4,500	119,000	138,500
Chemicals	mt CO2 eq/yr	48,700	600	138,400	168,400
Total	mt CO2 eq/yr	**63,100**	**5,100**	**257,400**	**306,900**
Increase in Bay Area GHG Emissions*	**%**	**0.09%**	**0.007%**	**0.4%**	**0.5%**

*** WWTPs contribute ~3% to global GHG Emissions (IPCC, 2007)**

Nutrient Reduction By Other Means

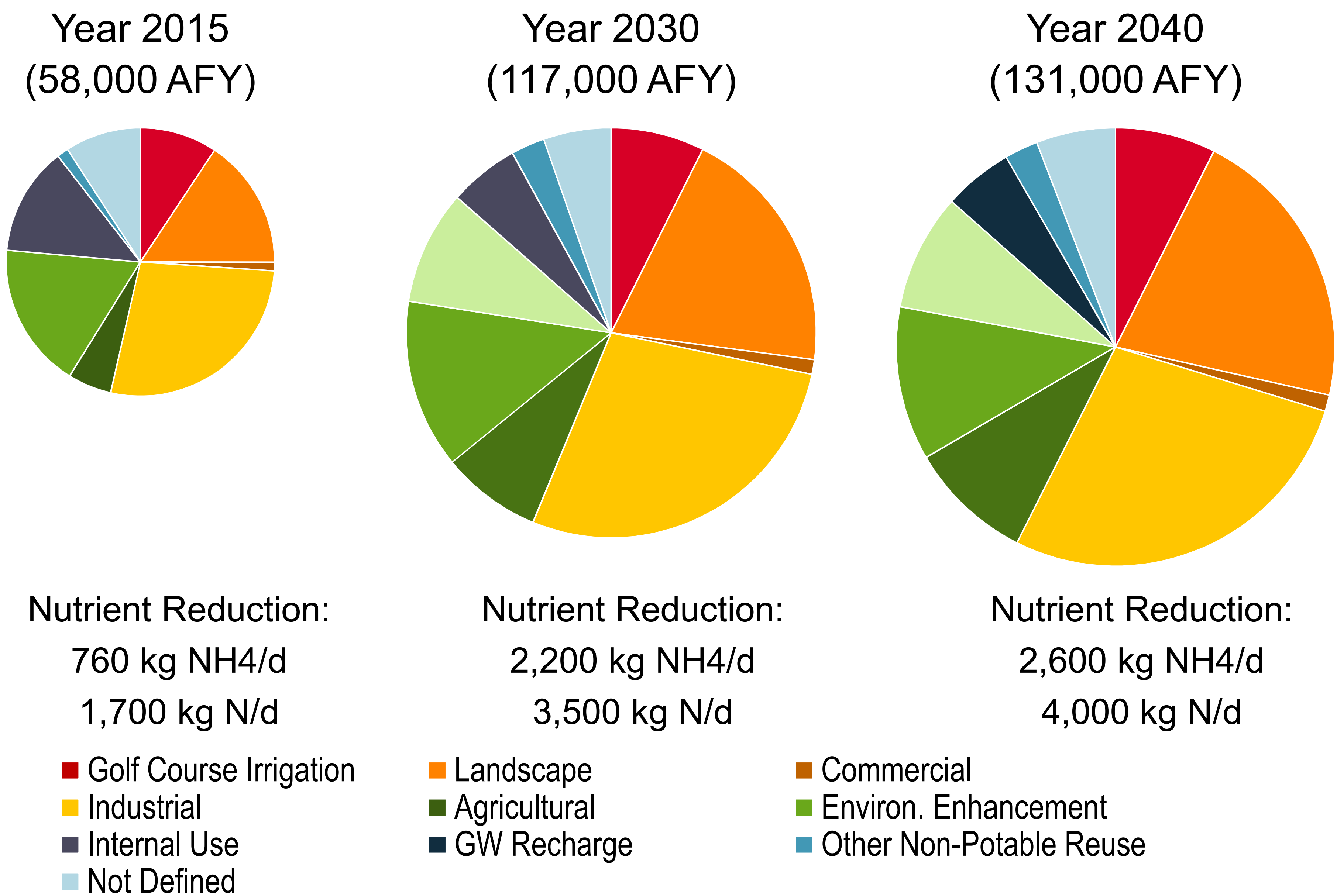
Current Recycled Water Quantities

- ~6% of Baywide plant effluent goes to recycled water
- Recycled water is expected to double by 2035
- The primary application is industrial (~40%)



6% Baywide Flow Reduction ≠ 6% Baywide Load Reduction

Recycled Water Distribution and Future Projection

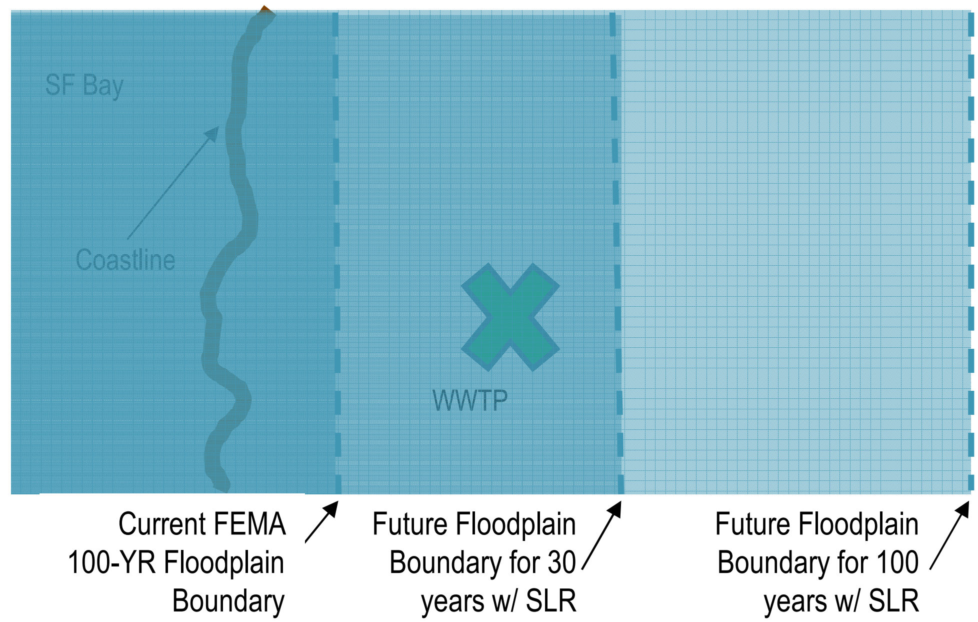


Sea Level Rise

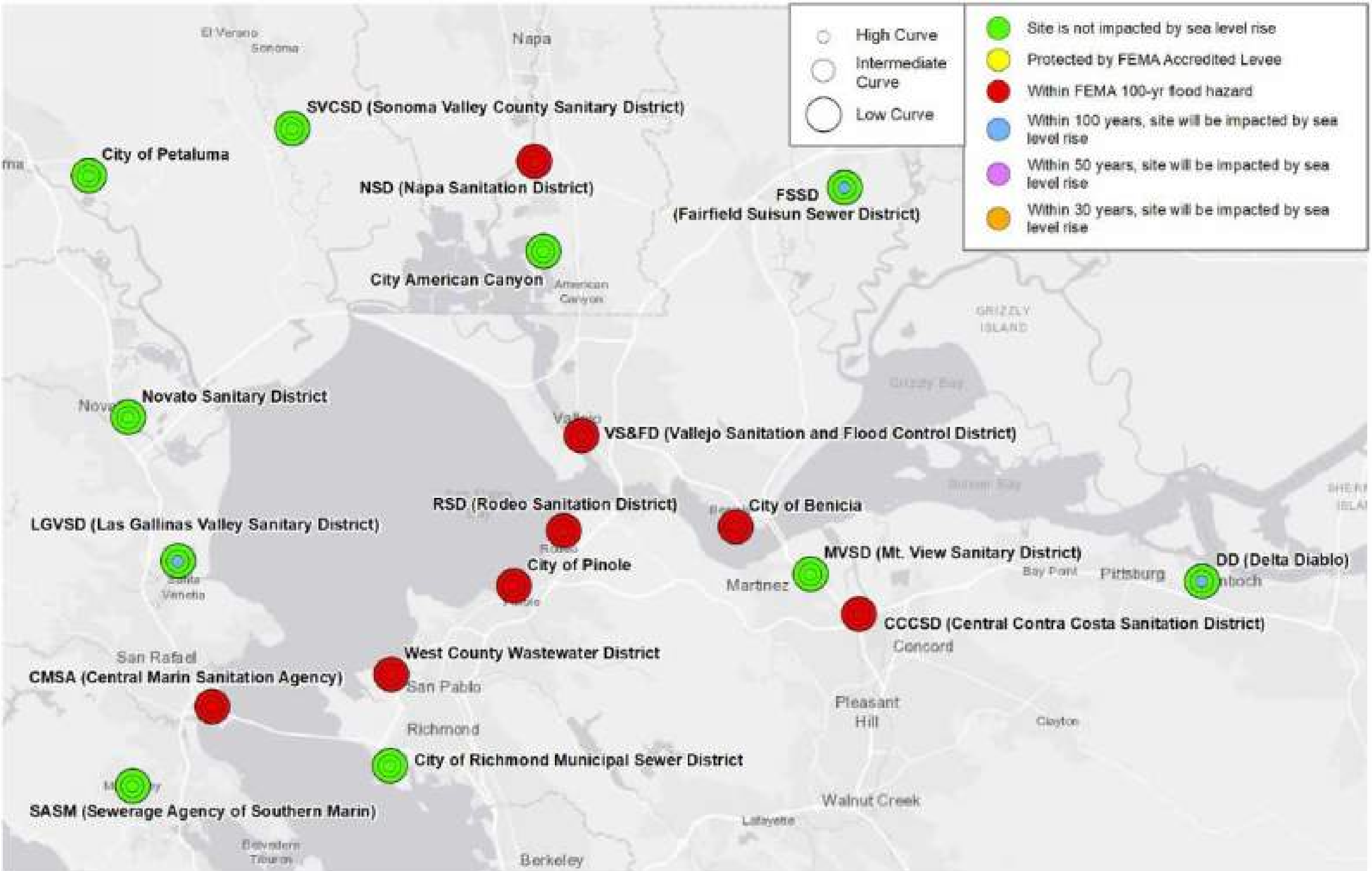
Sea Level Rise Approach

Purpose: Identify plants vulnerable to impacts of future sea level rise (SLR)

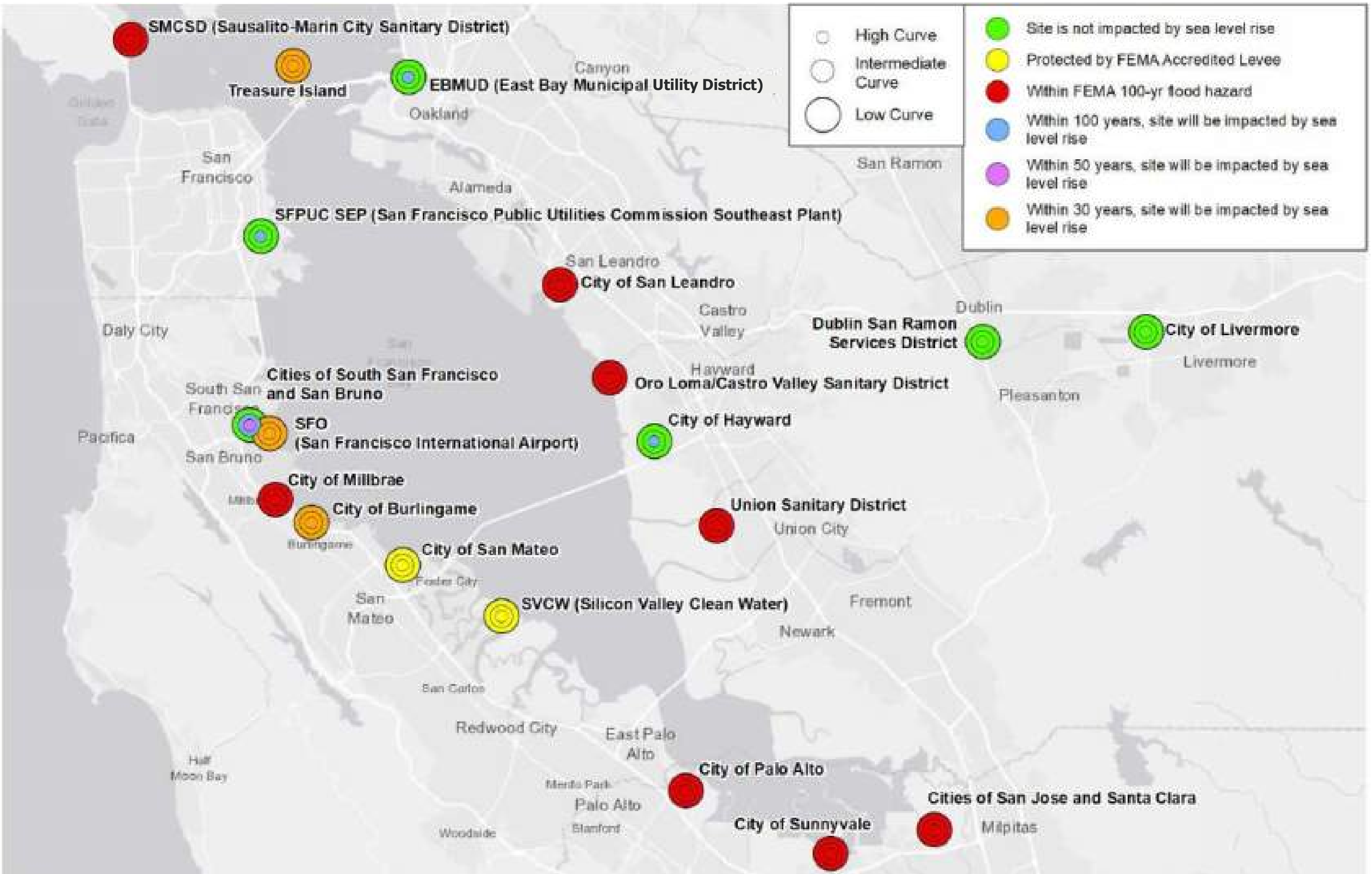
- Information Sources: USACE and FEMA
- Considered high, intermediate, low rise rates
  - Low curve is based on historical rate of change
  - Intermediate – NRCS Curve 1
  - High – NRCS Curve 3
- Results
  - 16 plants are within 100-yr flood hazard
  - 2 plants are protected by FEMA accredited levees
  - 9 plants are not vulnerable to sea level rise under low, intermediate, or high projections
  - 10 plants are vulnerable under low, intermediate, or high rate of rise projections



Sea Level Rise Assessment, North Bay



Sea Level Rise Assessment, South Bay



Key Observations

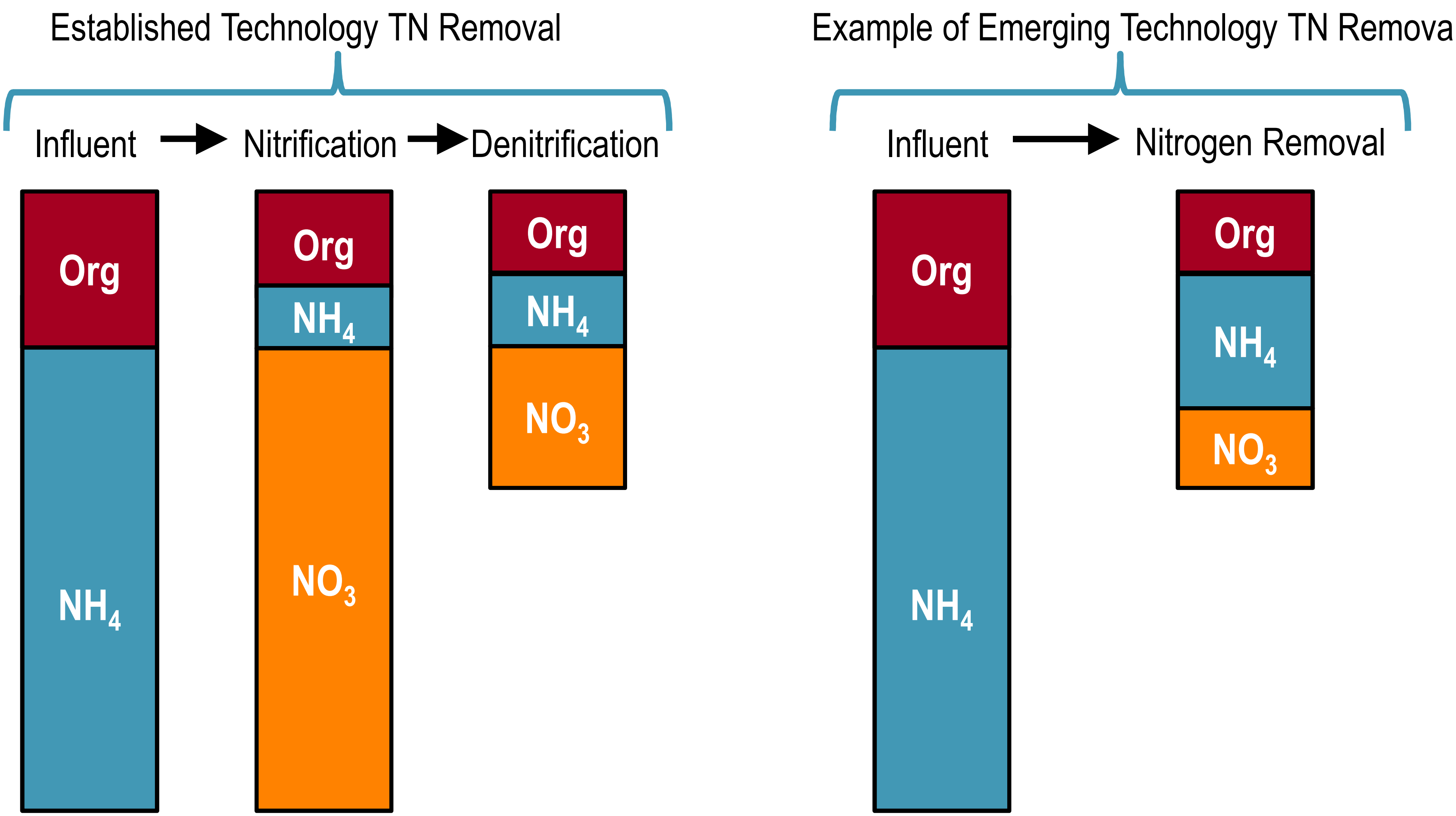
Key Observations

1. Capital Costs are Substantial
2. There are Competing Needs for Resources:
   - Aging infrastructure, collection system upgrades, storm water, recycled water, etc.
   - SF Bay Area is resource limited; planning and prioritization would be key for implementation
   - SRF funding is limited. Plants using bond funding would have higher costs
3. Water Quality Objectives Influence Technology Selection
4. Averaging Periods Influence Footprint and Cost
5. Flexible Permit Structures Facilitate Innovation
6. Constrained Sites Influence Technology Selection
7. Technology Selection Influences Effluent Quality, Footprint, GHGs, and Costs
8. GHG Emissions Impacted By Water Quality Objectives

3. Water Quality Objectives Influence Technology Selection

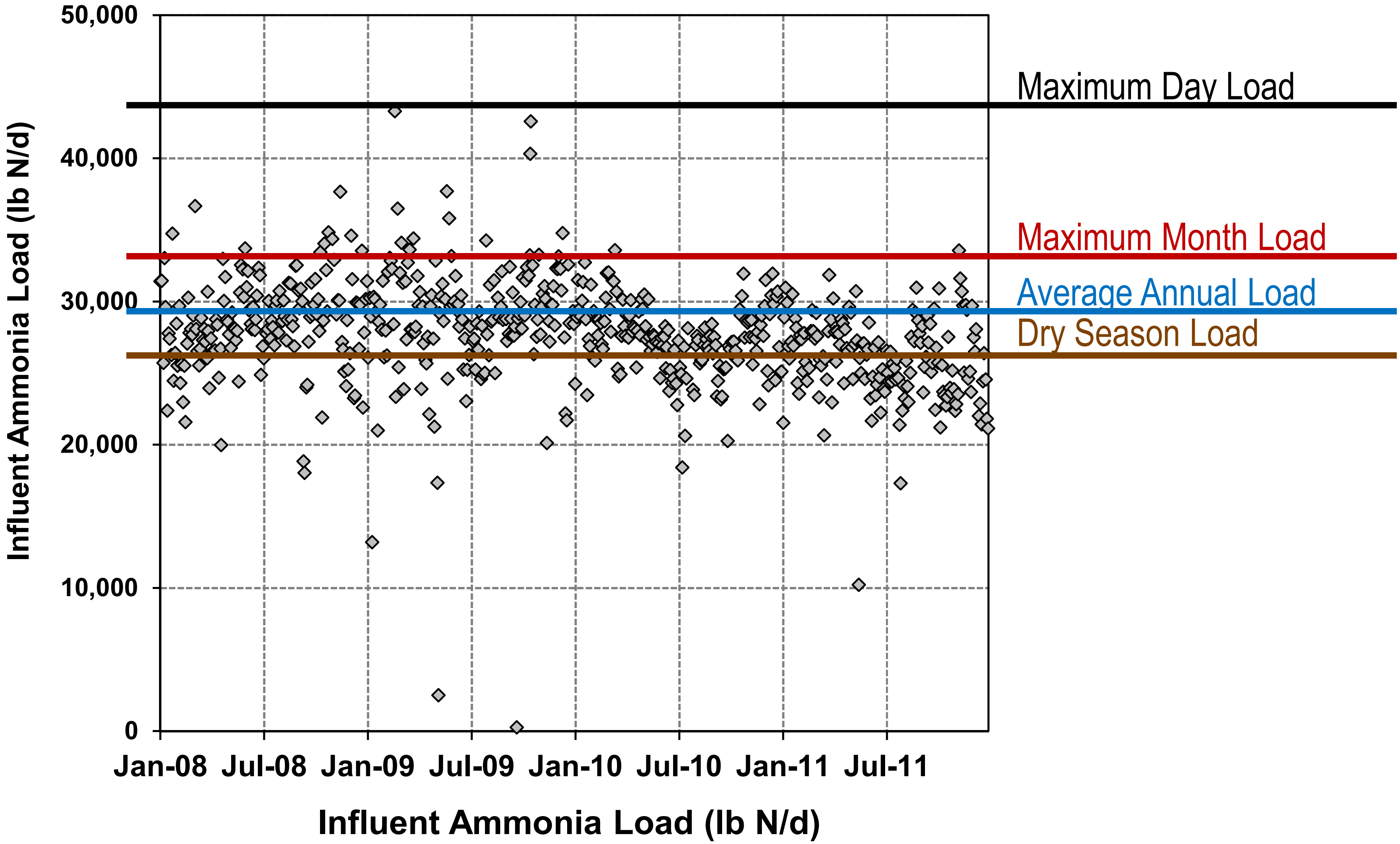
Water Quality Objectives Influence Facility Needs

- Lower limits dictate additional treatment
- Ammonia limits may preclude emerging technologies (See example below)
- Permitting uncertainty increases capital costs

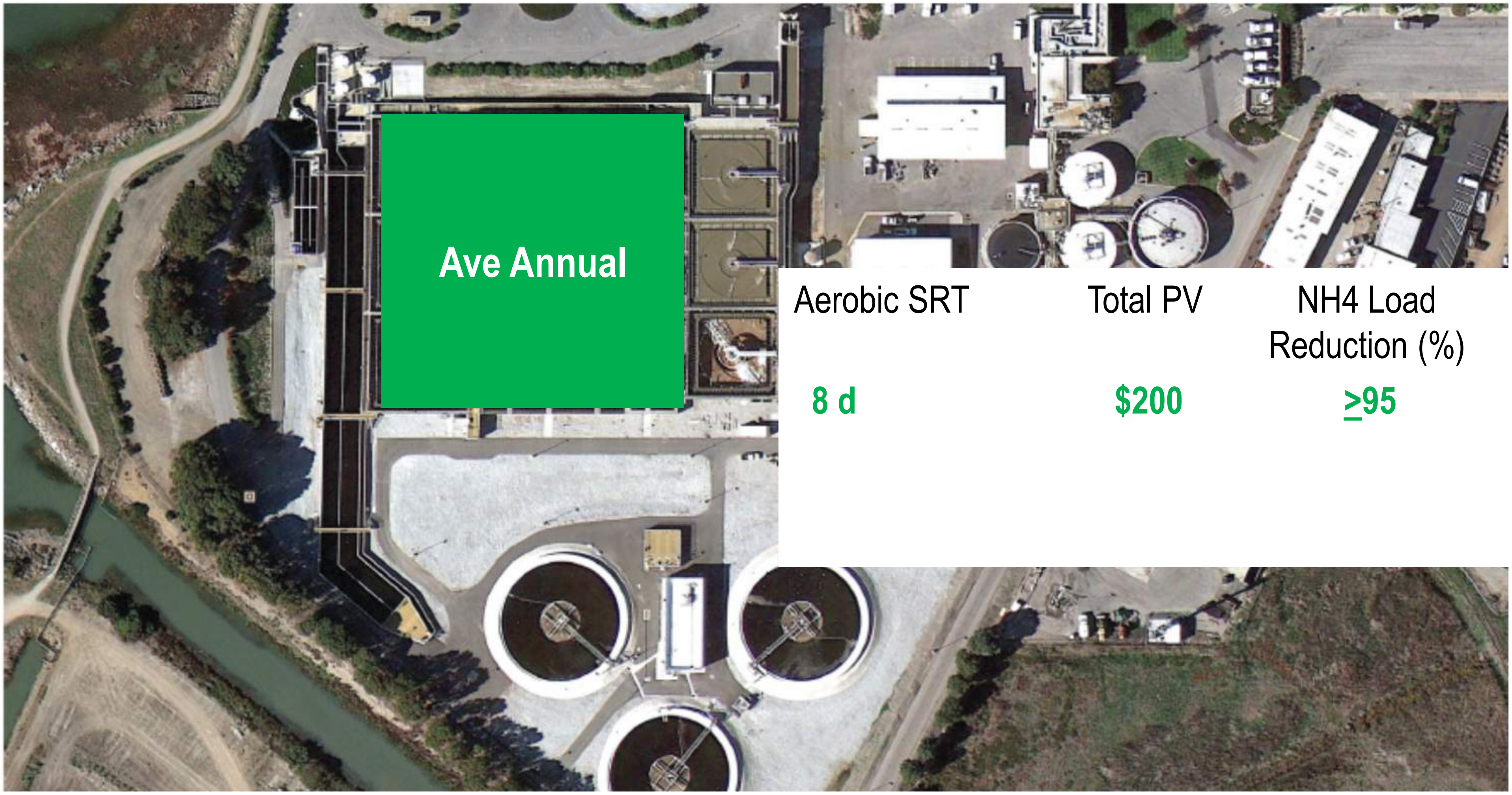


4. Averaging Periods Influence Footprint and Cost

Importance of Averaging Periods on Sizing Facilities



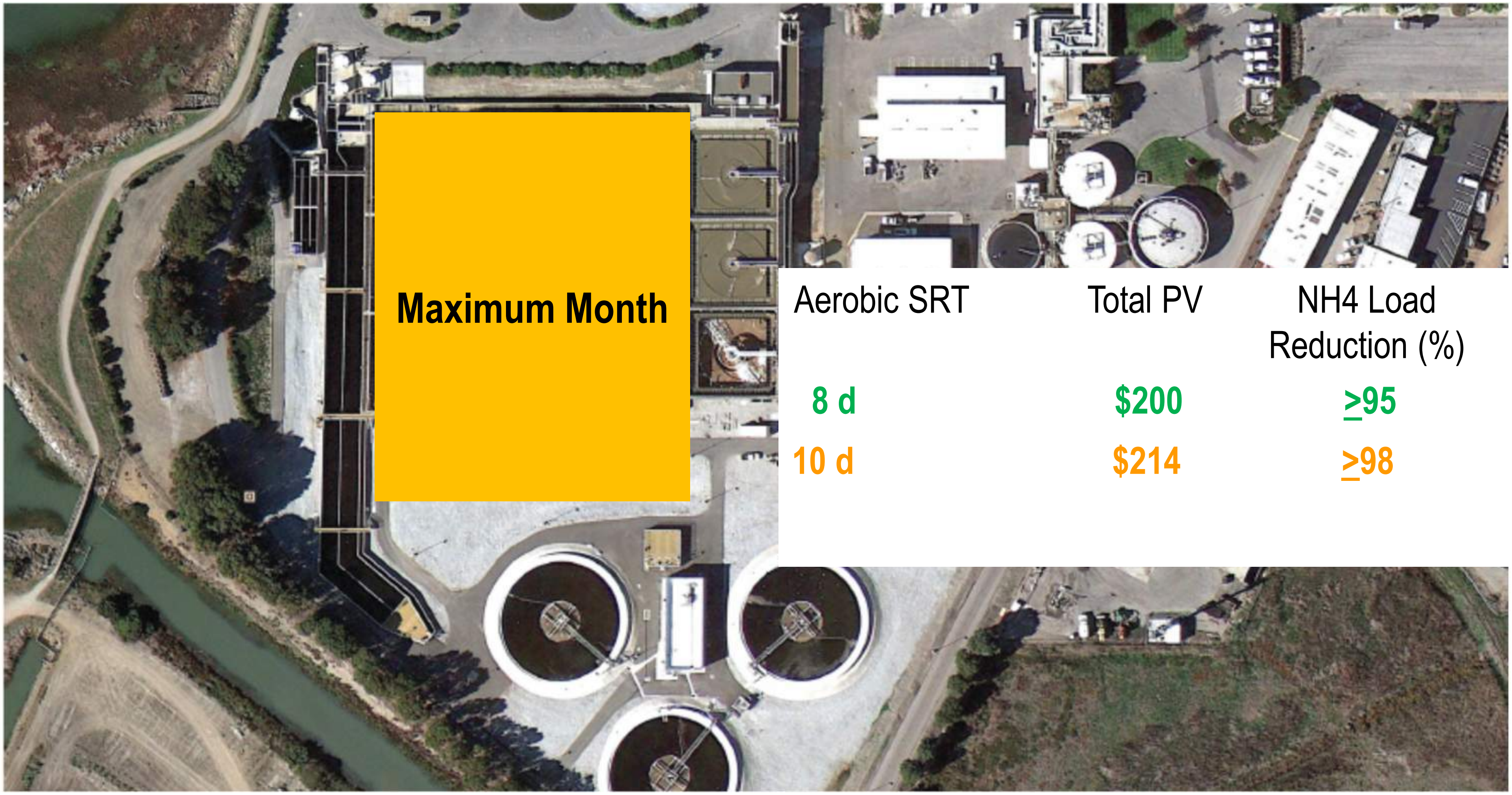
Role of Averaging Periods on SRT and Basin Volume



Aerobic SRT	Total PV	NH4 Load Reduction (%)
8 d	$200	$\geq$95

Averaging Periods Govern the SRT and Overall Basin Volume

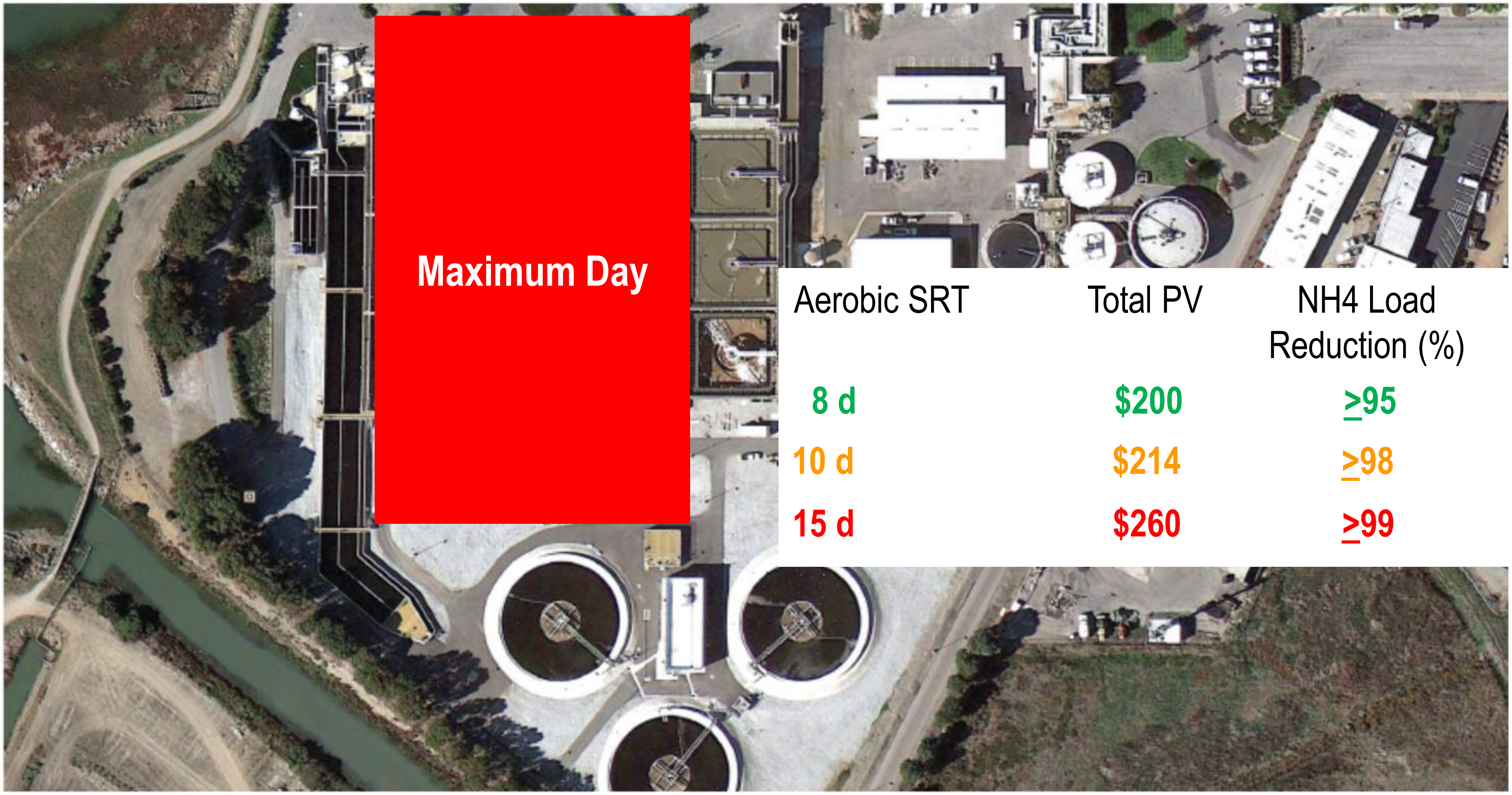
Role of Averaging Periods on SRT and Basin Volume



Aerobic SRT	Total PV	NH4 Load Reduction (%)
8 d	$200	≥95
10 d	$214	≥98

Averaging Periods Govern the SRT and Overall Basin Volume

Role of Averaging Periods on SRT and Basin Volume



Aerobic SRT	Total PV	NH4 Load Reduction (%)
8 d	$200	$\geq$95
10 d	$214	$\geq$98
15 d	$260	$\geq$99

Averaging Periods Govern the SRT and Overall Basin Volume

5. Flexible Permit Structures Facilitate Innovation

Flexible Permit Structure for Nutrients

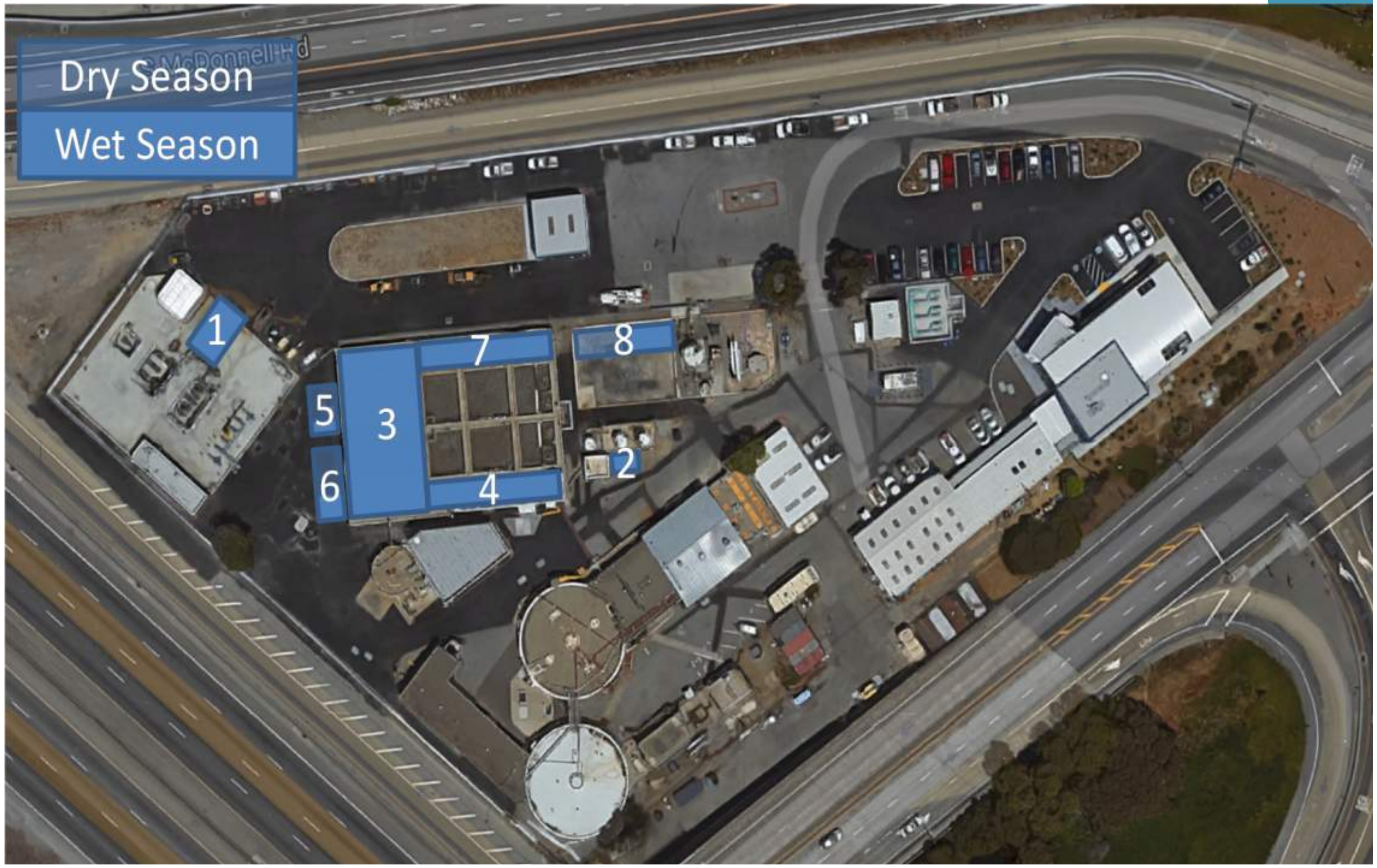
- Provides opportunities for creative and economical approaches.
- Traditional approaches (e.g., monthly and weekly limits on both a concentration and mass basis) may eliminate the most effective watershed solutions.
- Avoid disincentives to watershed management, nutrient trading and offsets, and other approaches to optimization.
- Adaptive Management is Recommended: when the relationship between nutrient loadings and water quality responses is not well defined, it is advisable to avoid overly restrictive effluent limits at the outset, which may result in over investment in advanced treatment.

6. Constrained Sites Influence Technology Selection

Complexity of Upgrades in a Tight Space

Millbrae Case Study

- Permitted Capacity = 3.0 mgd ADWF
- Peak = 9.0 mgd
- Key process:
  - Must be MBR
  - Must move blower building for a train
  - Must move disinfection for a train
  - Add new disinfection
- 8 Plants were pushed to MBR due to space constraints

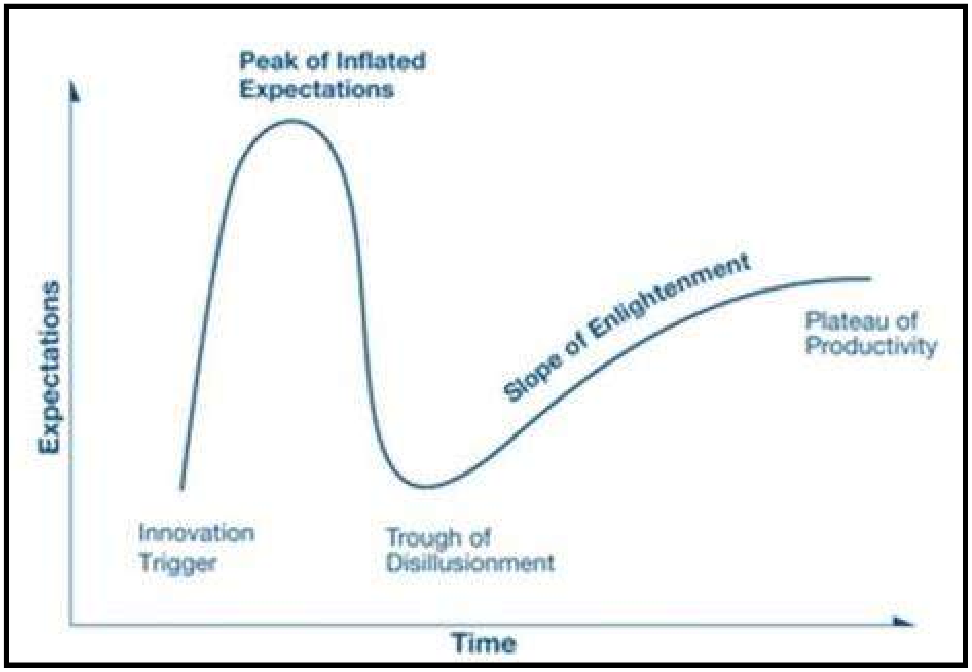


7. Technology Selection Influences Effluent Quality, Footprint, GHGs, and Costs

Findings are based on Established Technologies; Emerging Technologies Should be Considered if Implementation Required

Emerging technologies

- Aerobic Granular Sludge
- FibrePlate Hybrid-membrane
- Membrane Aerated Biofilm Reactors (MABR)
- Dual Processes – Wet Weather/Dry Weather
  - CEPT, Micro-screens
- Cloth Media Filtration Primary Treatment
- Mainstream Deammonification
- Shortcut nitrogen removal
- HydroGrav
- Sidestream Deammonification
- AirPrex (Struvite)
- CalPrex (Brushite)
- Ammonia Recovery Processes
- Advanced Super Critical Water Technology
- Clean B Chlorine Dioxide Solids Stabilization

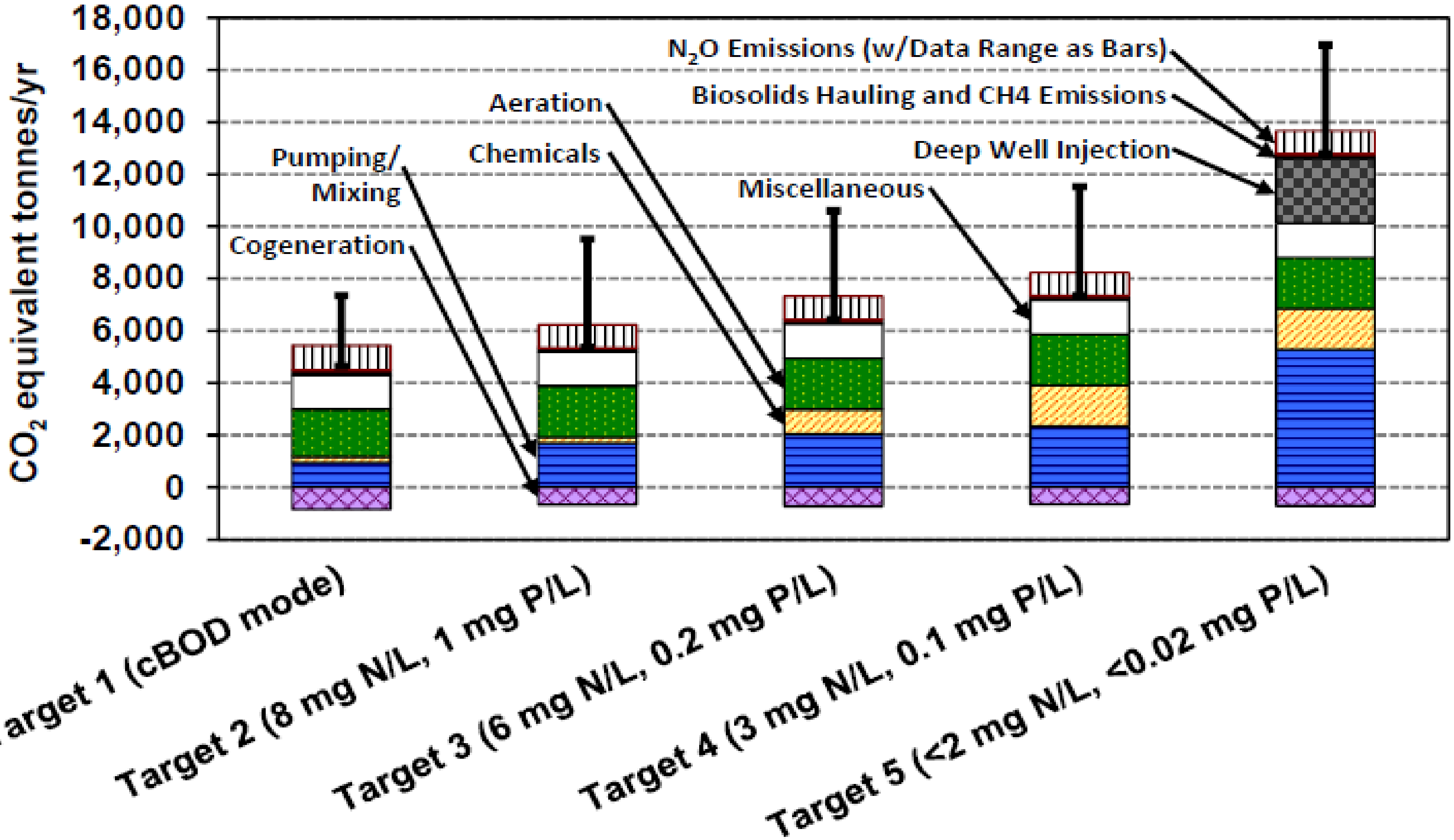


Gartner Hype Cycle

Source for Gartner Hype Curve:
http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp

8. GHG Emissions Impacted By Water Quality Objectives

Increase in GHG Emissions for Various Nutrient Targets based on a Nominal 10 mgd Plant



- Captures the impacts from additional energy and chemicals associated with nutrient load reduction
- Not intended to satisfy GHG emissions reporting requirements
- Nitrous oxide emissions not included but will likely increase with biological nitrogen removal processes

Source: Falk, M.W.; Neethling, J.B.; Reardon, D.J. (2011) Striking the Balance between Nutrient Removal in Wastewater Treatment and Sustainability. Water Environment Research Foundation, NUTR106n.

Summary

Summary

1) Load reductions increase with more treatment
2) Sidestream is cost-effective for both TN and TP ($/lb) but not feasible at all plants
3) Upgrade costs are substantial
4) Future limits would impact technology selection
5) A basis of design report is recommended for any nutrient removal projects

Parameter	Unit	Treatment Strategy			
		Opt.	Sidestream	Level 2	Level 3
Load Reduction					
Ammonia	%	14%	24%	93%	93%
TN	%	7%	19%	57%	82%
TP	%	34%	12%	59%	88%
Costs					
Capital	$M	119	391	6,976	8,517
O&M PV	$M	147	345	2,443	3,888
Total PV	$M	266	736	9,420	12,405
Average Unit Costs					
Per gpd	$/gpd	0.5	0.8	10.8	14.3
Per lb N	$/lb N	5.6	2.0	8.7	7.7
Per lb P	$/lb P	8.6	2.8	44	59

BACWA Meeting with Regional Board: Review of the Nutrient Reduction Study

17 September 2018

HDR

Brown AND Caldwell

BACWA BAY AREA CLEAN WATER AGENCIES