



BACWA Pre-Pardee Workshop: Nutrient Reduction by Treatment Optimization and Upgrades Update

15 September 2017



Brown AND Caldwell



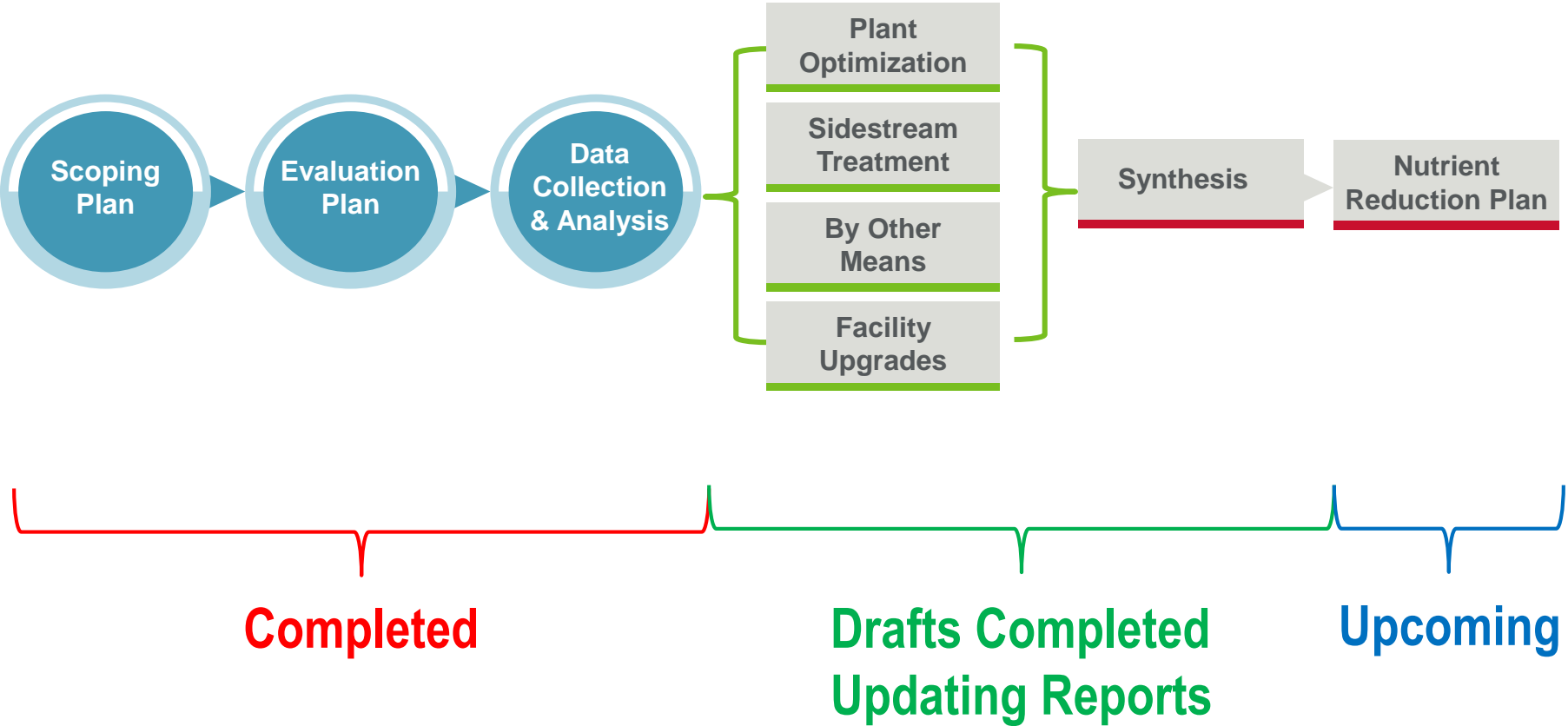
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A G E N C I E S

Agenda

1. Project Status
2. Draft Group Annual Report Findings
3. Summary of Key Draft Report Comments
4. Draft Findings of Nutrient Removal Reports
 - a) Progression of Technologies
 - b) Updated Costs for each Task
5. Key Variables that Impact Results
6. Role of Phosphorus
7. Results of Recycled Water/CIP Surveys
8. Next Steps



Overview / Status of Study





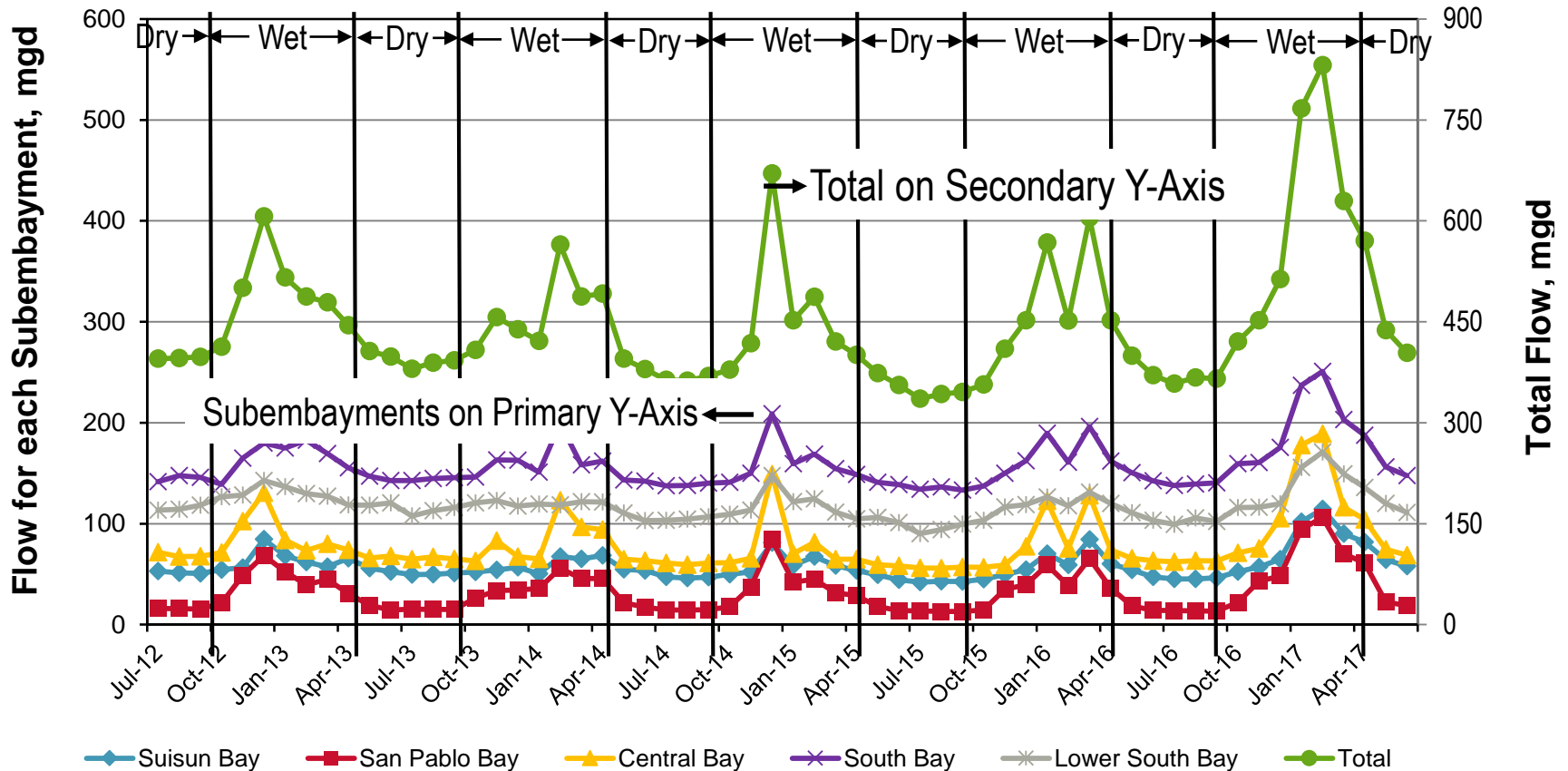
DRAFT 2017 Group Annual Report Findings

Preliminary 2017 Group Annual Report Summary

- Dry weather flows increased in 2016/2017 to pre-drought levels
- Annual average flows were the highest since sampling began in July 2012
- Ammonia and TN loads were the highest since sampling began in July 2012
(for both dry and average annual)
- TP loads were the highest since sampling began in July 2012
(for both dry and average annual)

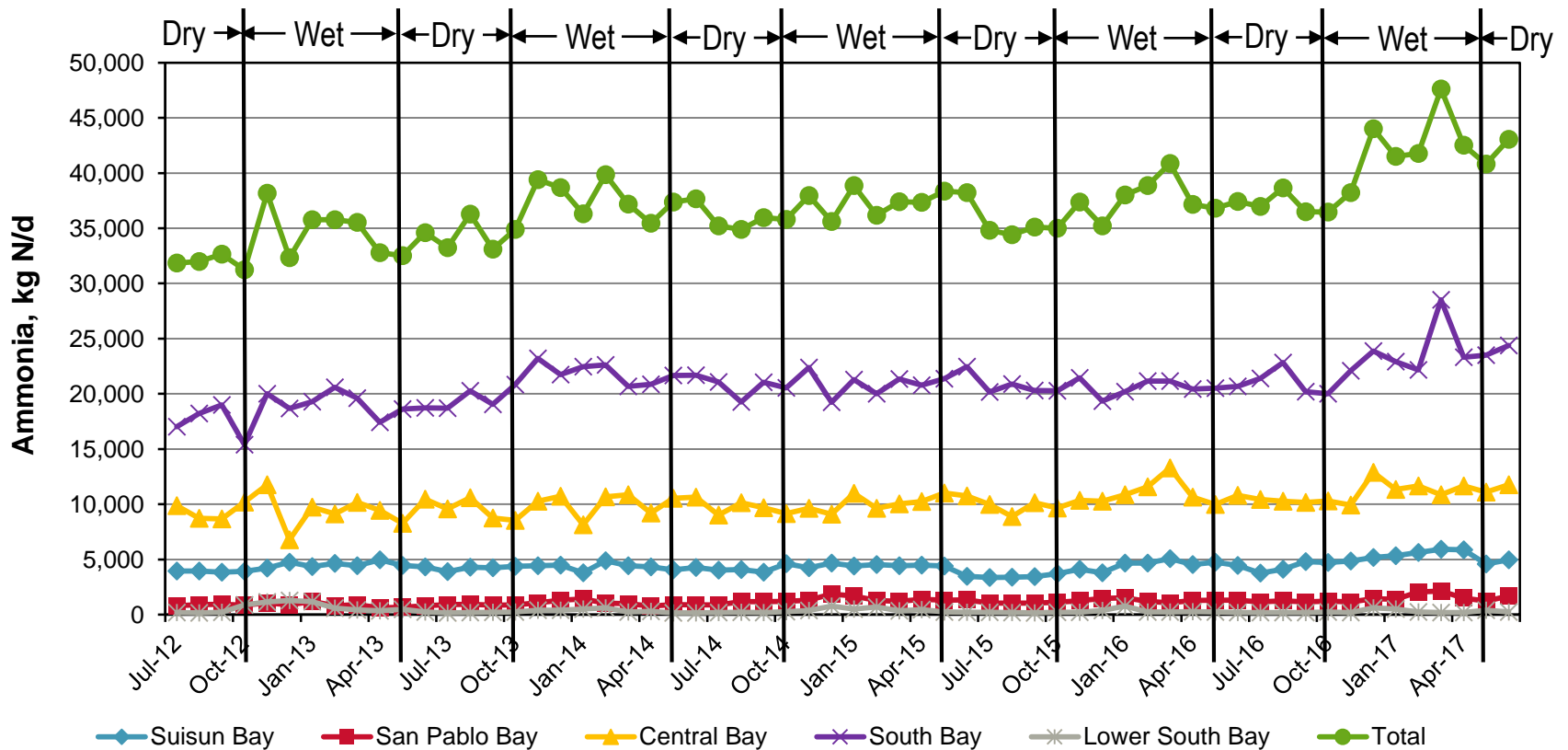
Preliminary 2017 Group Annual Report: Flow

- Total average annual flow for 2016-17 was the highest since 2012 at 510 mgd
- Increase in average annual flows is primarily due to wet season influence, though dry season flows also increased to 2013-14 levels



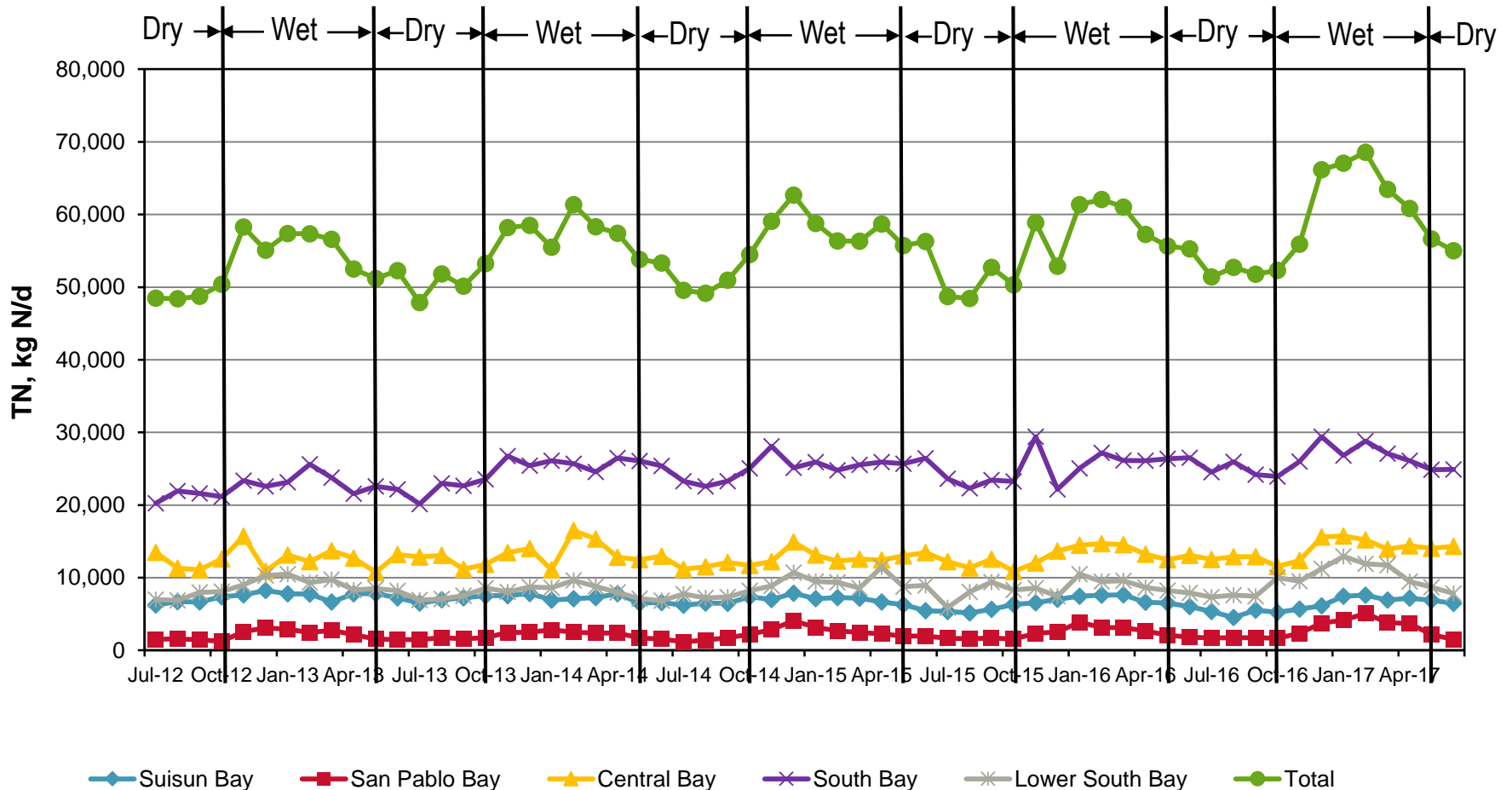
Preliminary 2017 Group Annual Report: Ammonia

- Dry season ammonia load is increasing in all Subembayments except Lower South Bay and Suisun Bay
- Total average annual ammonia load for 2016-17 was the highest since 2012 at 40,700 kg N/d



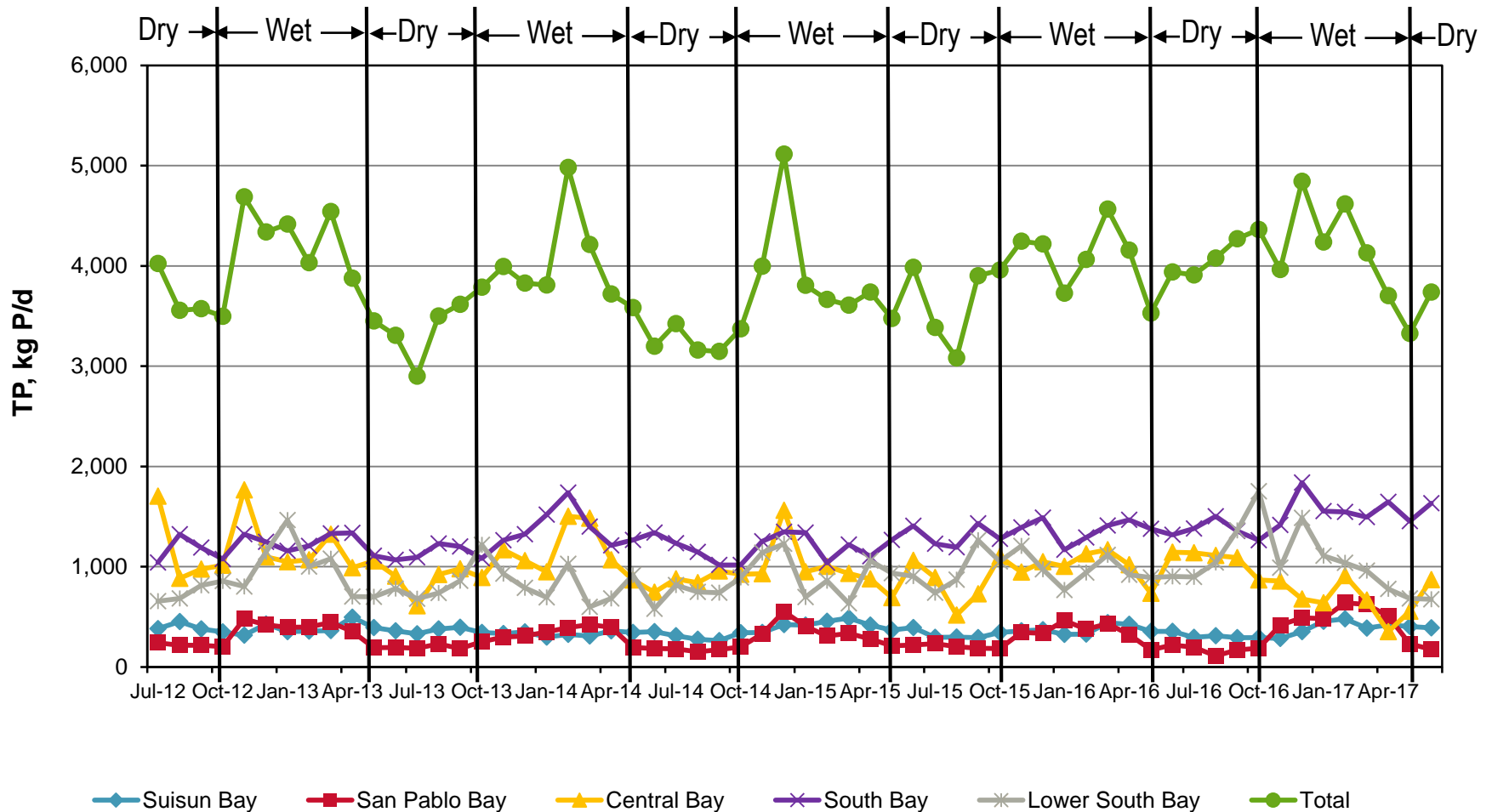
Preliminary 2017 Group Annual Report: Total Nitrogen

- Both dry and annual average TN loads are increasing
- Dry season TN load is increasing in all Subembayments except Suisun Bay (decreasing) and Lower South Bay (no trend)



Preliminary 2017 Group Annual Report : Total Phosphorus

- Both dry and annual average TP loads are increasing
- Dry season TP load is increasing in all Subembayments except Central Bay



Preliminary 2017 Group Annual Report Summary

Dry Season Average

Parameter	Units	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017
Total Flow	mgd	399	387	365	359	387
Total Ammonia	kg N/d	32,719	35,540	36,560	35,747	39,225
Total TN	kg N/d	49,857	51,484	52,501	52,208	53,258
Total TP	kg P/d	3,603	3,398	3,450	3,651	3,872

Annual Average

Parameter	Units	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017
Total Flow	mgd	453	434	421	425	510
Total Ammonia	kg N/d	33,769	36,624	36,861	36,801	40,711
Total TN	kg N/d	53,095	54,997	55,779	55,449	58,416
Total TP	kg P/d	3,954	3,772	3,717	3,939	4,107

The increase in 2016/2017 flows and loads is likely due to a combination of i) population increase, ii) a wetter than average year, iii) suppressed drought concerns, iv) industrial impacts (resource recovery with organics and FOG receiving), v) sampling frequency, vi) sampling requirements between Section 13267 Letter data and Watershed Permit, and vii) others



Draft Report Comments

Draft Report: Comments Applicable to all Reports

Comment	Response
How do you calc \$/lb?	Added language to the report AND considering updating to consider seasonality
GHG emissions section needs more clarity. What is the intent and how does this apply to AB 32 and reporting	Additional clarifying language added that addresses the intent, permit requirements, and nitrous oxide emissions
Is Level 2 to 3 additive for capital or stand-alone?	Stand-alone; clarifying language added

Draft Report: \$/lb Metric

Parameter	Units	Dry Season	Wet Season	Comment
Costs				
Capital	\$ Mil	10.0	11.7	
O&M PV	\$ Mil	3.6	3.8	Assumes year-round operation
Total PV	\$ Mil	13.6	15.5	Sum of Capital and O&M PV
Load				
TN Removed from Bay (Ave.)	lb N/yr	42,000	44,500	Assumes year-round removal
Unit Cost Metric				
TN Cost	\$/lb N Removed	11	12	Total PV divided by load reduction over 30 years

The draft report assumes the seasonal operation is year-round. This has implications for seasonal dischargers.

Updated Concept: \$/lb Metric

Parameter	Units	Dry Season	Wet Season	Comment
Costs				
Capital	\$ Mil	10.0	11.7	Year-Round equals Wet Season
O&M PV	\$ Mil	1.5	2.2	Seasonal values pro-rated
Total PV	\$ Mil	11.5	13.9	Sum of Capital and O&M PV
Load				
TN Removed from Bay (Ave.)	lb N/yr	17,600	25,900	Seasonal values pro-rated
Unit Cost Metric				
TN Cost	\$/lb N Removed	22	18	Total PV divided by load reduction over 30 years

Consider pro-rating the O&M and load reduction

Updated: \$/lb Metric

Parameter	Units	Dry Season	Wet Season	Year-Round	Comment
Costs					
Capital	\$ Mil	10.0	11.7	11.7	Year-Round equals Wet Season
O&M PV	\$ Mil	1.5	2.2	3.7	Seasonal values pro-rated
Total PV	\$ Mil	11.5	13.9	15.4	Sum of Capital and O&M PV
Load					
TN Removed from Bay (Ave.)	lb N/yr	17,600	25,900	43,500	Seasonal values pro-rated
Unit Cost Metric					
TN Cost	\$/lb N Removed	22	18	12	Total PV divided by load reduction over 30 years

Consider pro-rating the O&M and load reduction



Draft Findings of Nutrient Removal Reports



Updated Costs

DRAFT 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

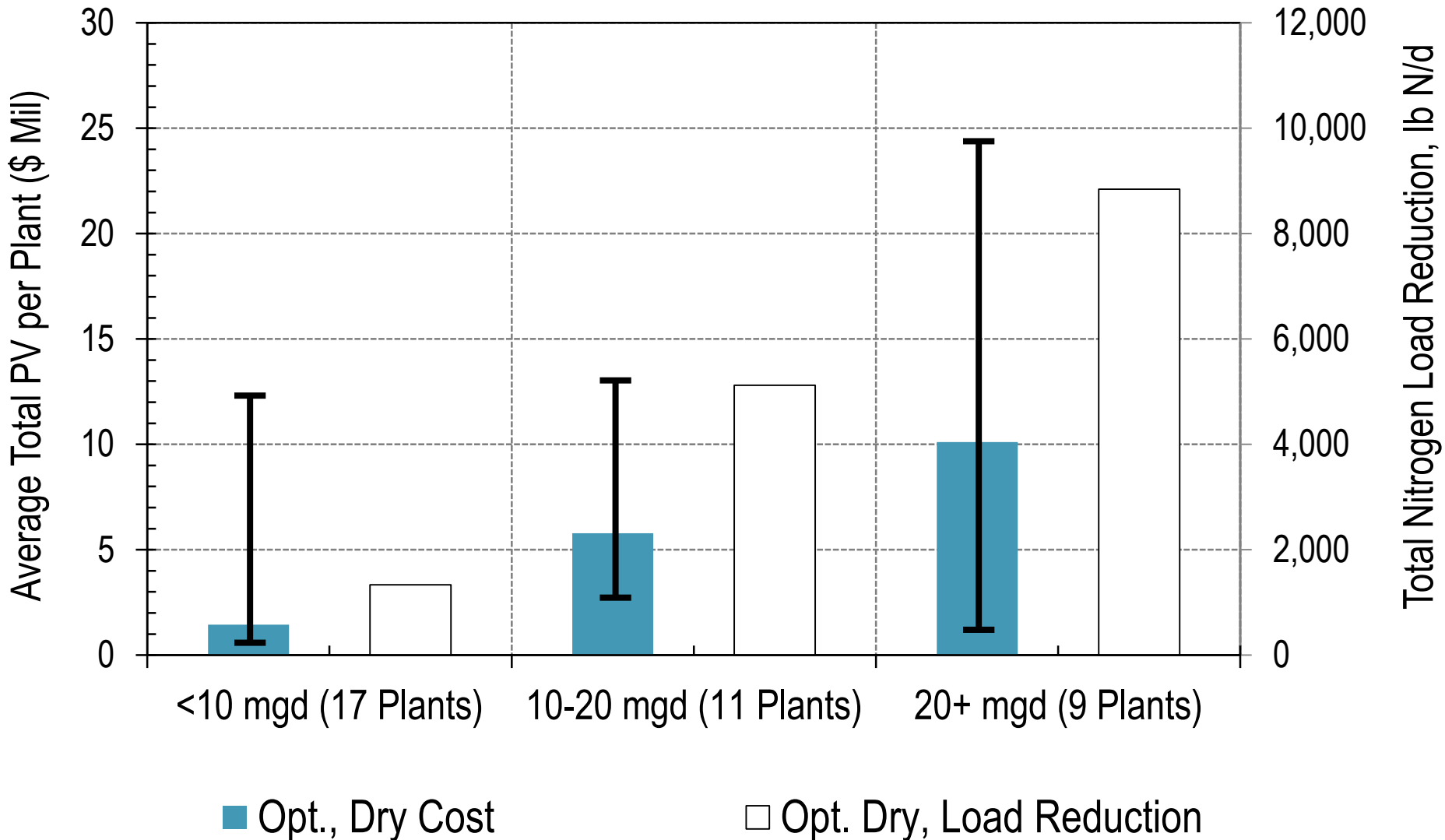
Costs

- Total PV
 - \$180M Dry and \$223M Wet
 - Ranged from \$0.4M to \$28M per plant
- Unit Costs
 - Flow-weighted Total PV unit cost = ~\$0.4/gpd
 - Flow-weighted Total PV/lb N rem = ~\$1.4/lb N
 - Flow-weighted Total PV/lb P rem = ~\$12/lb P
- Not all plants can reduce ammonia/TN loads for both dry and wet seasons:
 - 21 of 37 plants for dry season reduction
 - 19 of 37 plants for wet season reduction

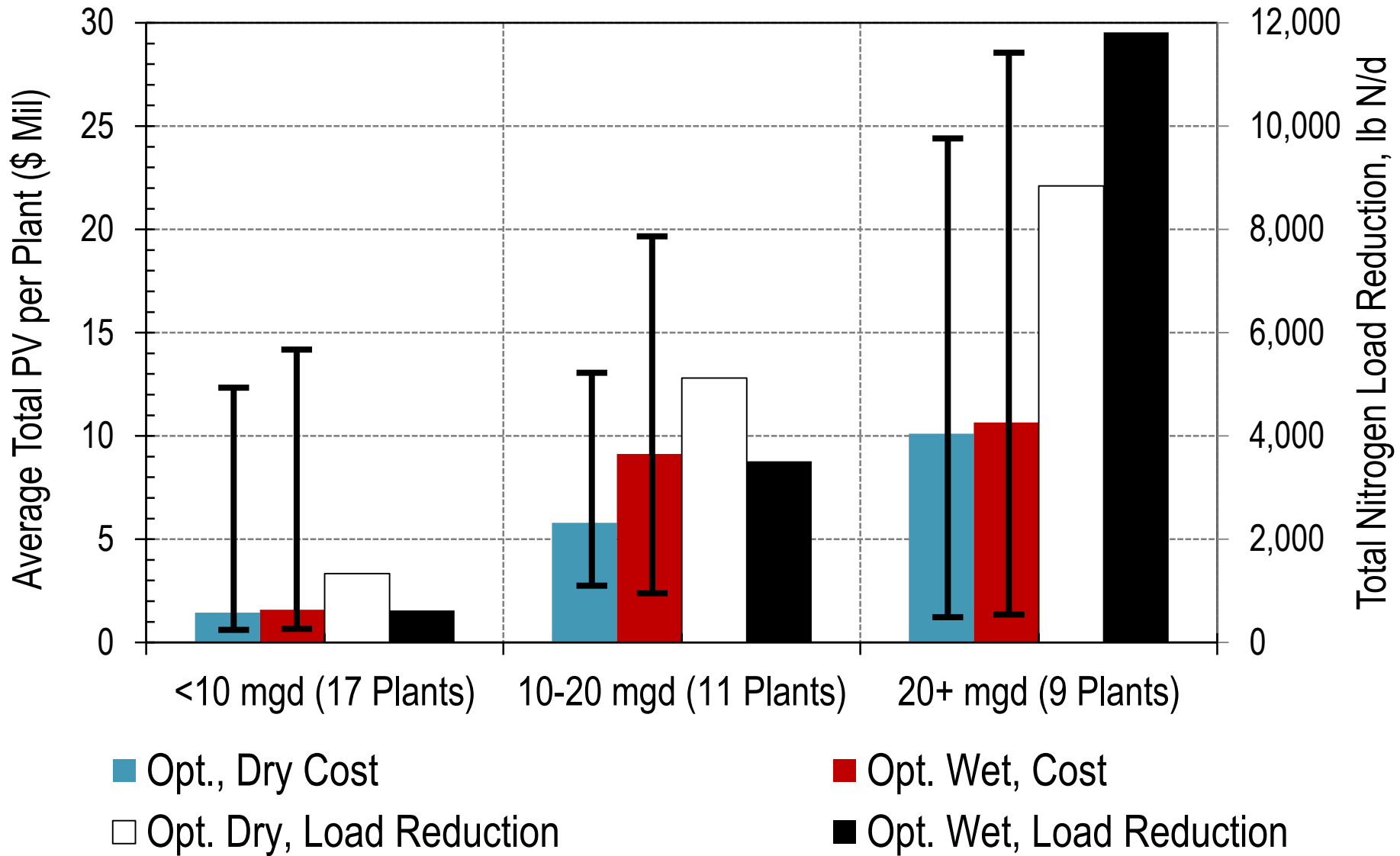
Load Reduction w/Respect to Current Discharge:

- Ammonia load reduction is 18%
- TN load reduction is 10%
- Overall TP load reduction is 44%

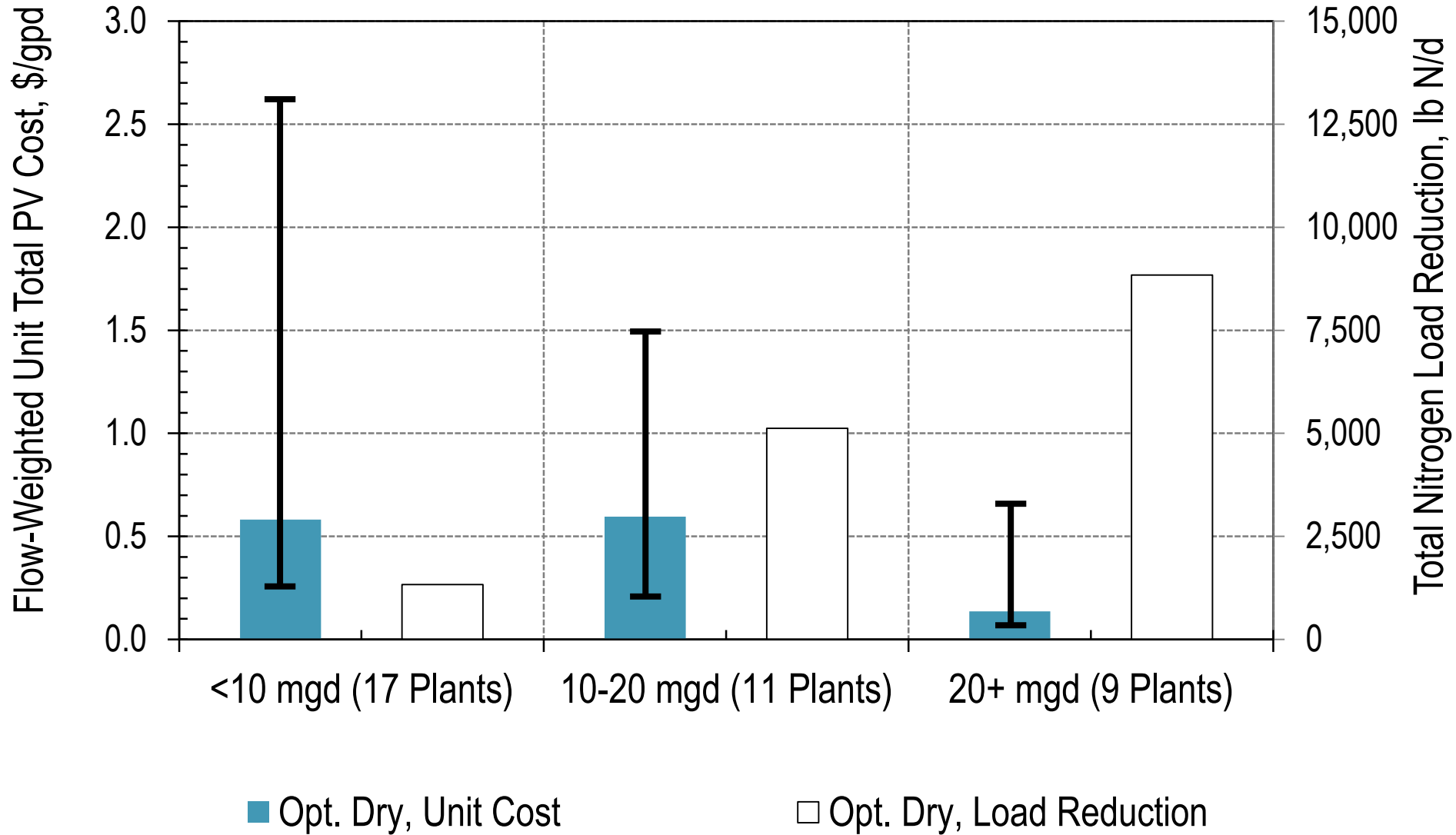
DRAFT Optimization Average Total PV Costs per Plant



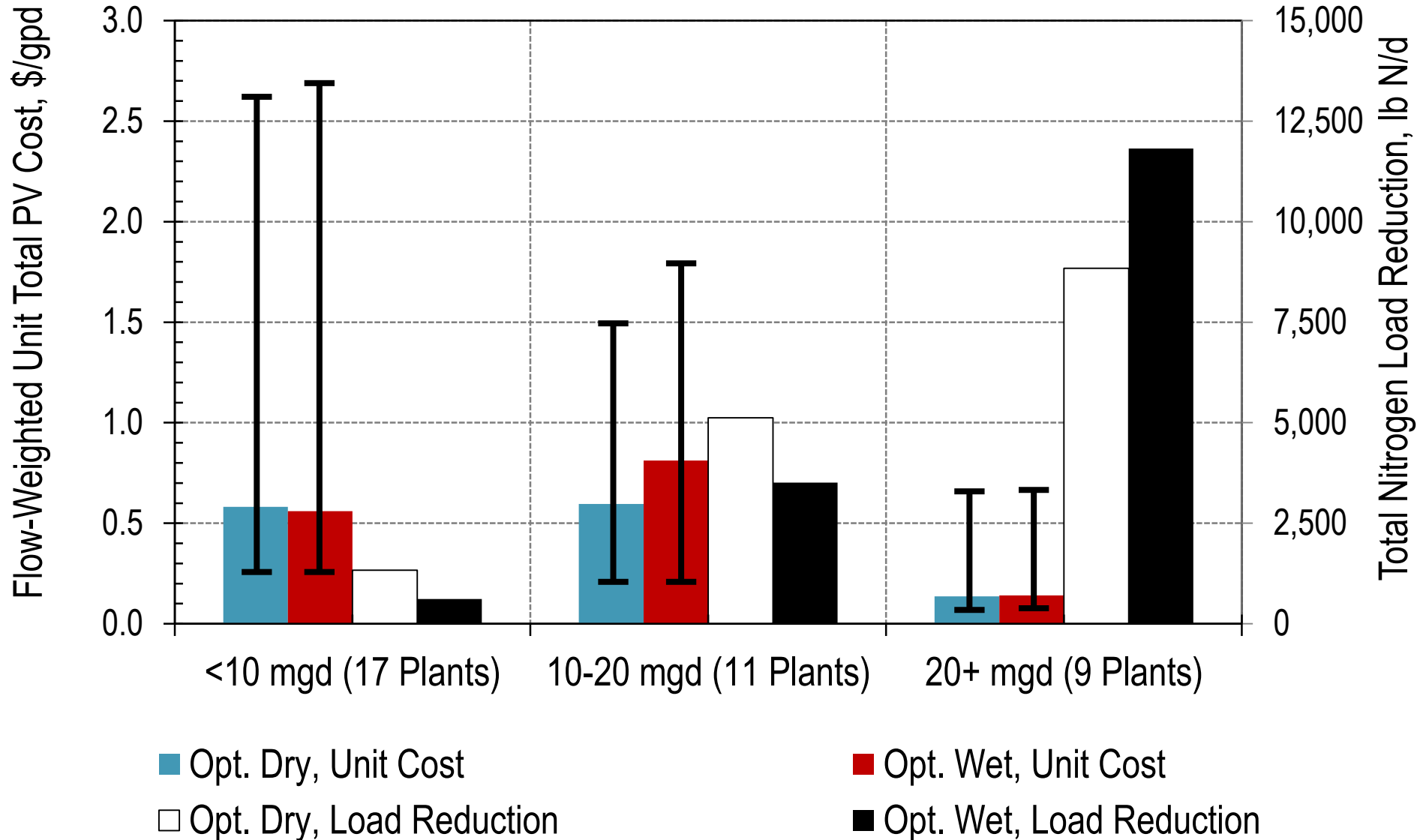
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DRAFT Optimization Total PV Unit Costs



DRAFT Optimization Total PV Unit Costs



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Preliminary Sidestream Results

Sidestream Approach

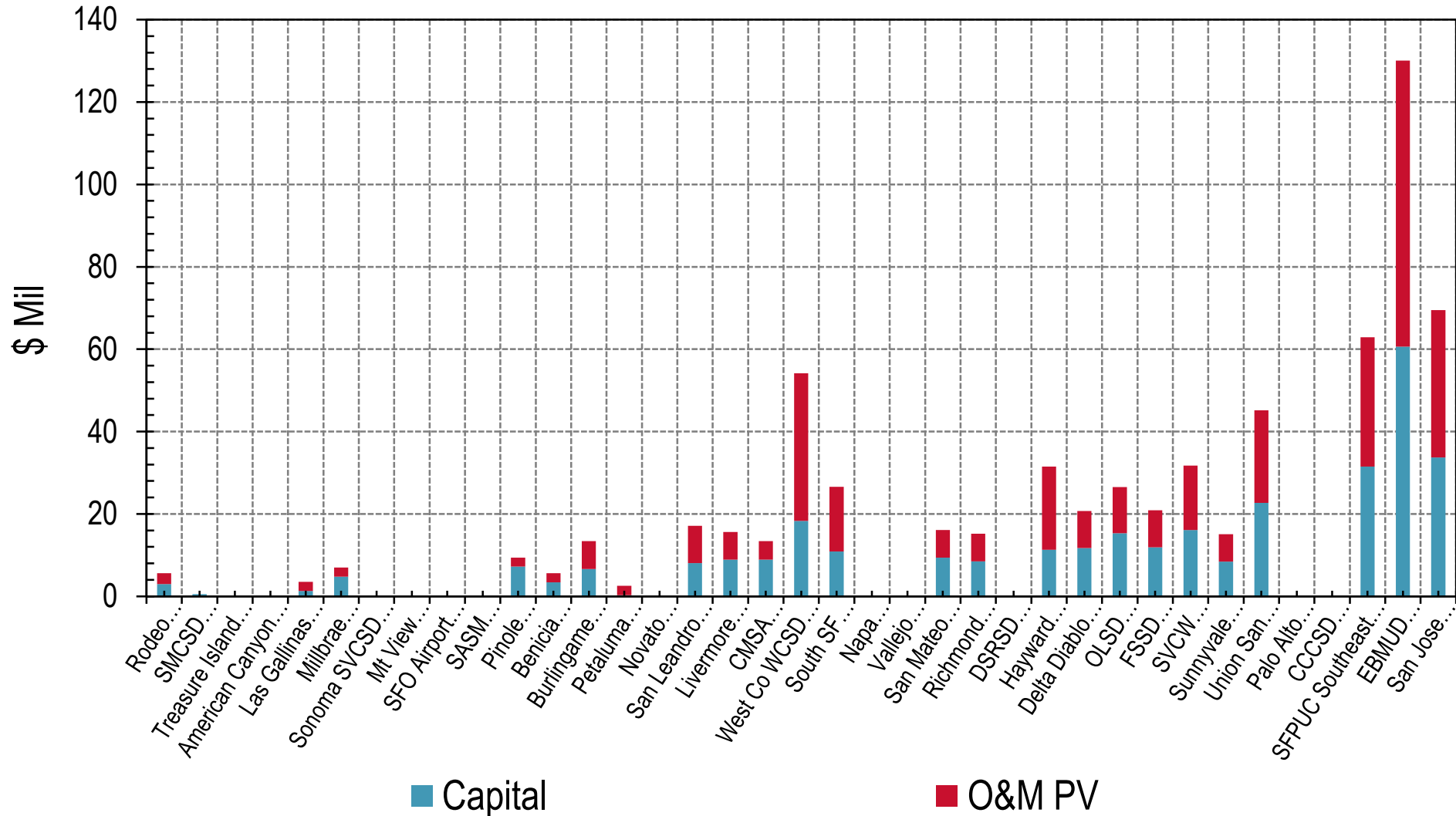
- Basis of Evaluation
 - Identify upgrade strategies to reduce nutrients
 - Planning Period: 30 Years
 - Loading: Design Capacity
 - Design Criteria:
 - Year-round sidestream
 - Sufficient Dewatering Frequency (≥ 4 days/week)
 - Water temperature governs technology selection
- Concepts
 - Ammonia/TN Removal:
 - Conventional nitrification technology
 - Deammonification technology
 - TP Removal: metal salt precipitation
- Acknowledgements
 - EPA Regional Grant led by EBMUD
 - Agencies that hosted pilots



DRAFT Plants Eligible for Sidestream Treatment by Subembayment

Subembayment	No. Plants Eligible for Ammonia Discharge Reduction to the Bay	No. Plants Eligible for Total Nitrogen Discharge Reduction to the Bay
Suisun Bay	1	3
San Pablo Bay	1	4
Central Bay	4	5
South Bay	10	11
Lower South Bay	0	2
Total	16	25

DRAFT Total PV Costs for Sidestream



Plants are Reviewing their Candidacy for Sidestream Treatment

*Draft Results are Sorted by Permitted Capacity

DRAFT Sidestream Findings

- Criteria used for screening:
 - Year-round sidestream
 - Year-round discharge
 - Sufficient dewatering frequency (≥ 4 days/week)
- Number of candidate plants
 - 16 out of 37 plants if ammonia reduction is the discharge objective
 - 25 out of 37 plants if TN reduction is the discharge objective
- Costs
 - The Total PV costs is \$660 Mil
 - Flow-weighted average = \$1.7/lb N removed
- The overall Ammonia/TN load reduction from Current Discharge is 21 and 17 percent, respectively





Preliminary Upgrades Results

DRAFT 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 which includes filtration in Level 2
- Number of Plants Already/Planning to Meet Targets:
 - Level 2: 6
 - Level 3: 1

* Excludes San Jose

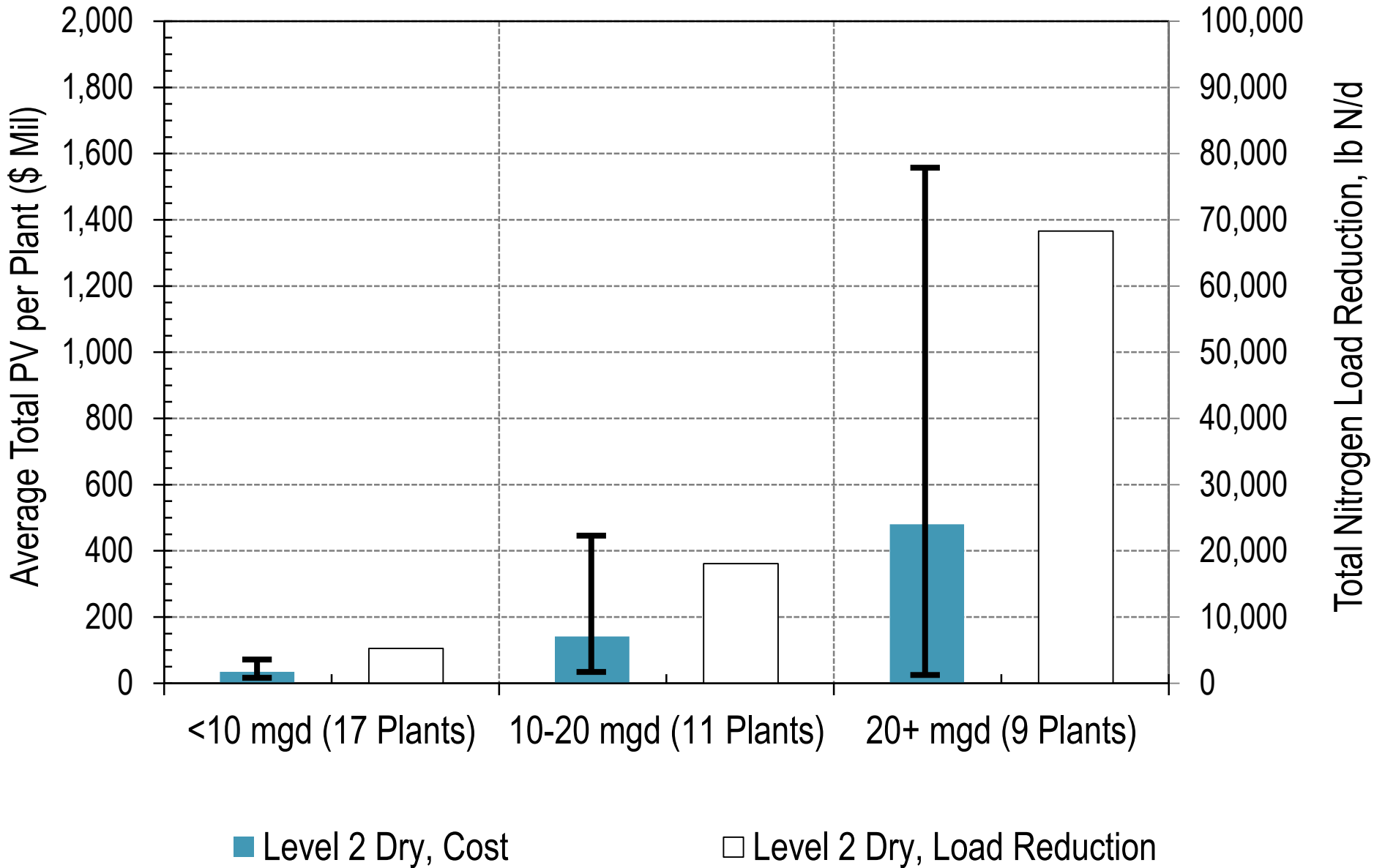
** Excludes Sunnyvale

Costs

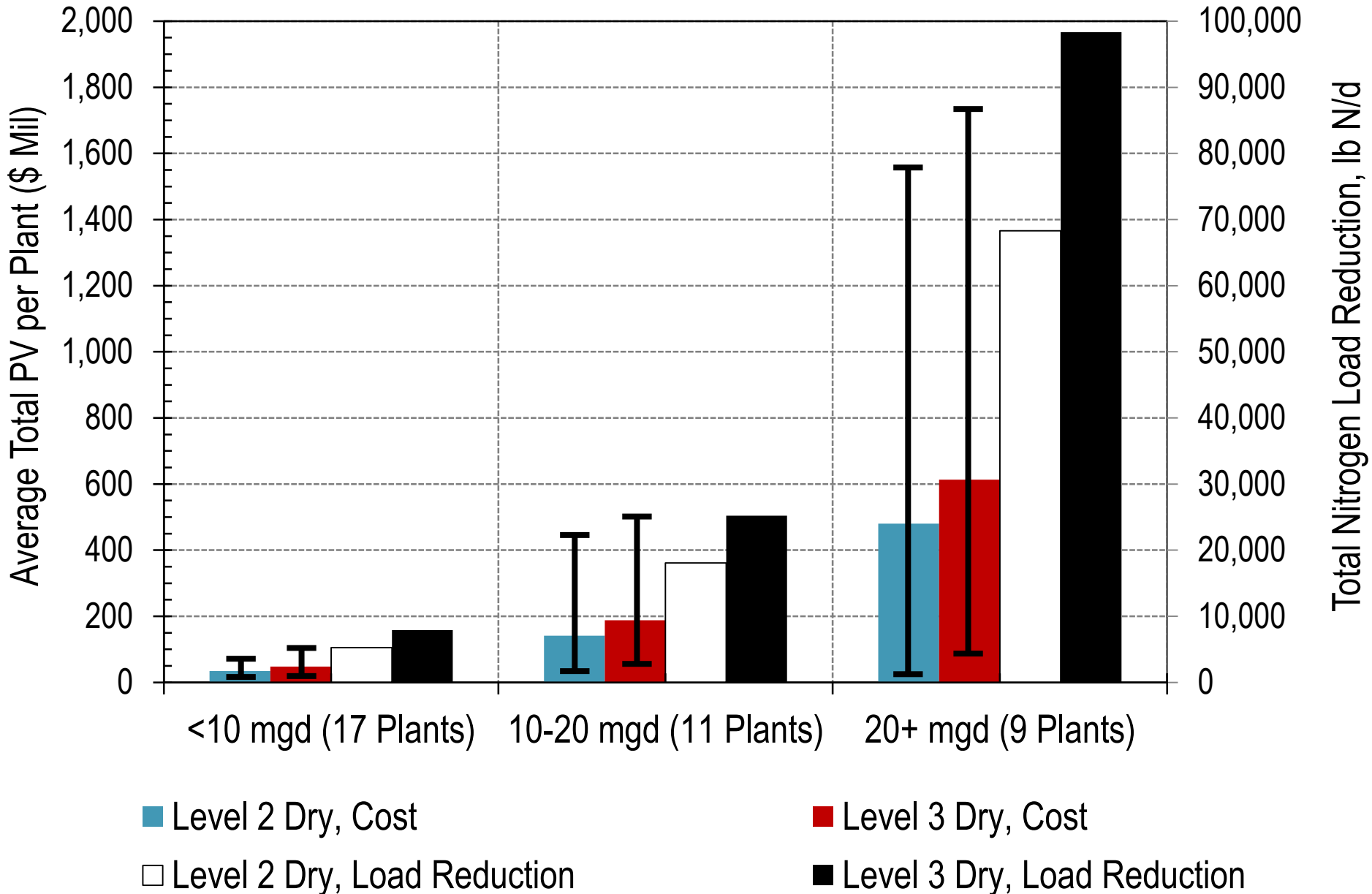
- Total PV Costs
 - Level 2 = \$6,430M Dry and \$8,050M Wet
 - Level 3 = \$8,350M Dry and \$10,370M Wet
- Total PV Cost Range per Plant
 - Level 2 = \$3.8M to \$2,240M per plant
 - Level 3 = \$21M to \$2,470M per plant
- Unit Costs
 - Level 2: \$6/lb N Dry* and \$8/lb N Wet
\$34/lb P Dry and \$29/lb P Wet
 - Level 3: \$12/lb N Dry** and \$6/lb N Wet**
>\$60/lb P for Dry or Wet

Parameter	Level 2 Load Reduction	Level 3 Load Reduction
Ammonia	>88%	>88%
Total N	>61%	>84%
Total P	>63%	>89%

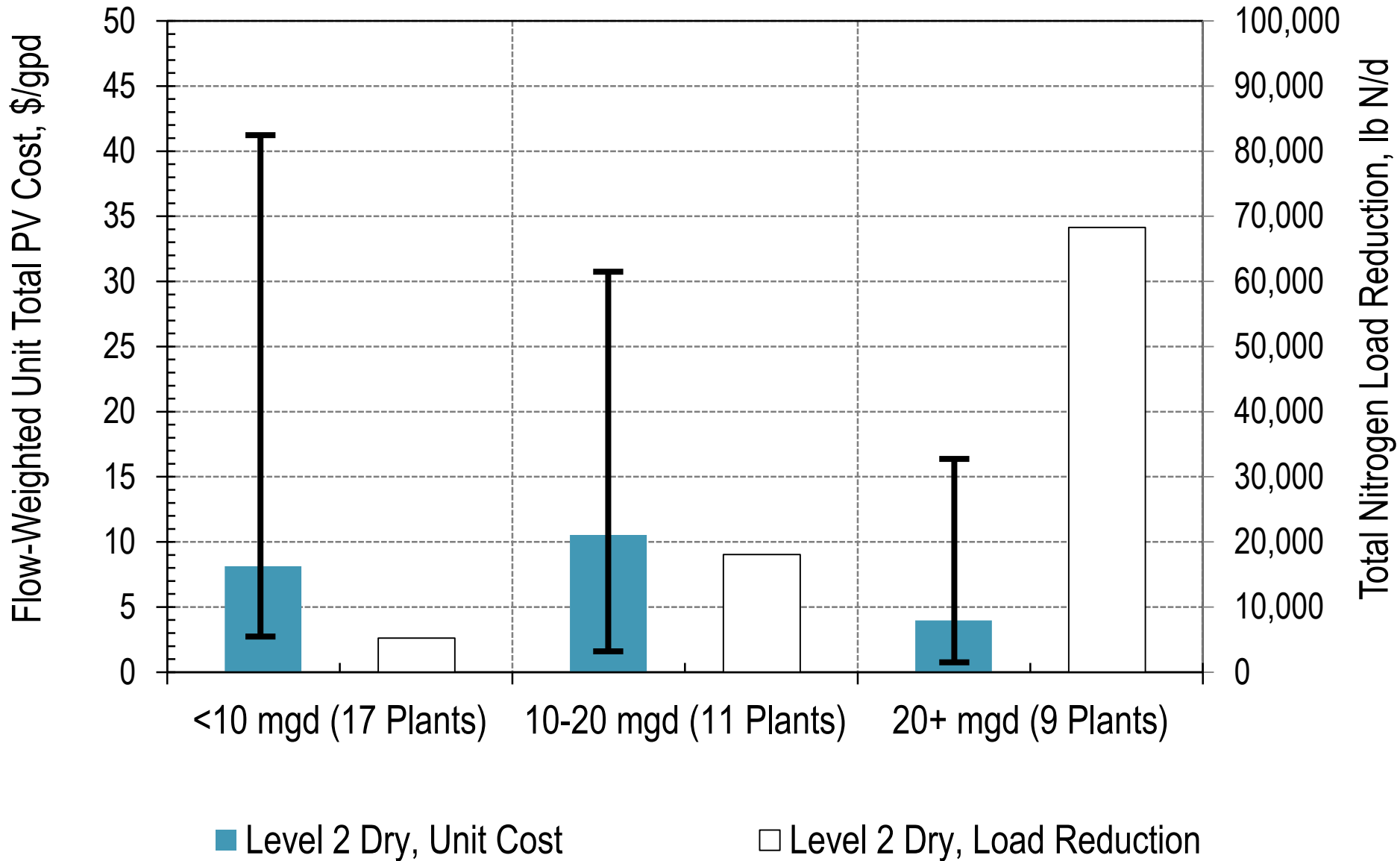
DRAFT Total PV Costs for Upgrades



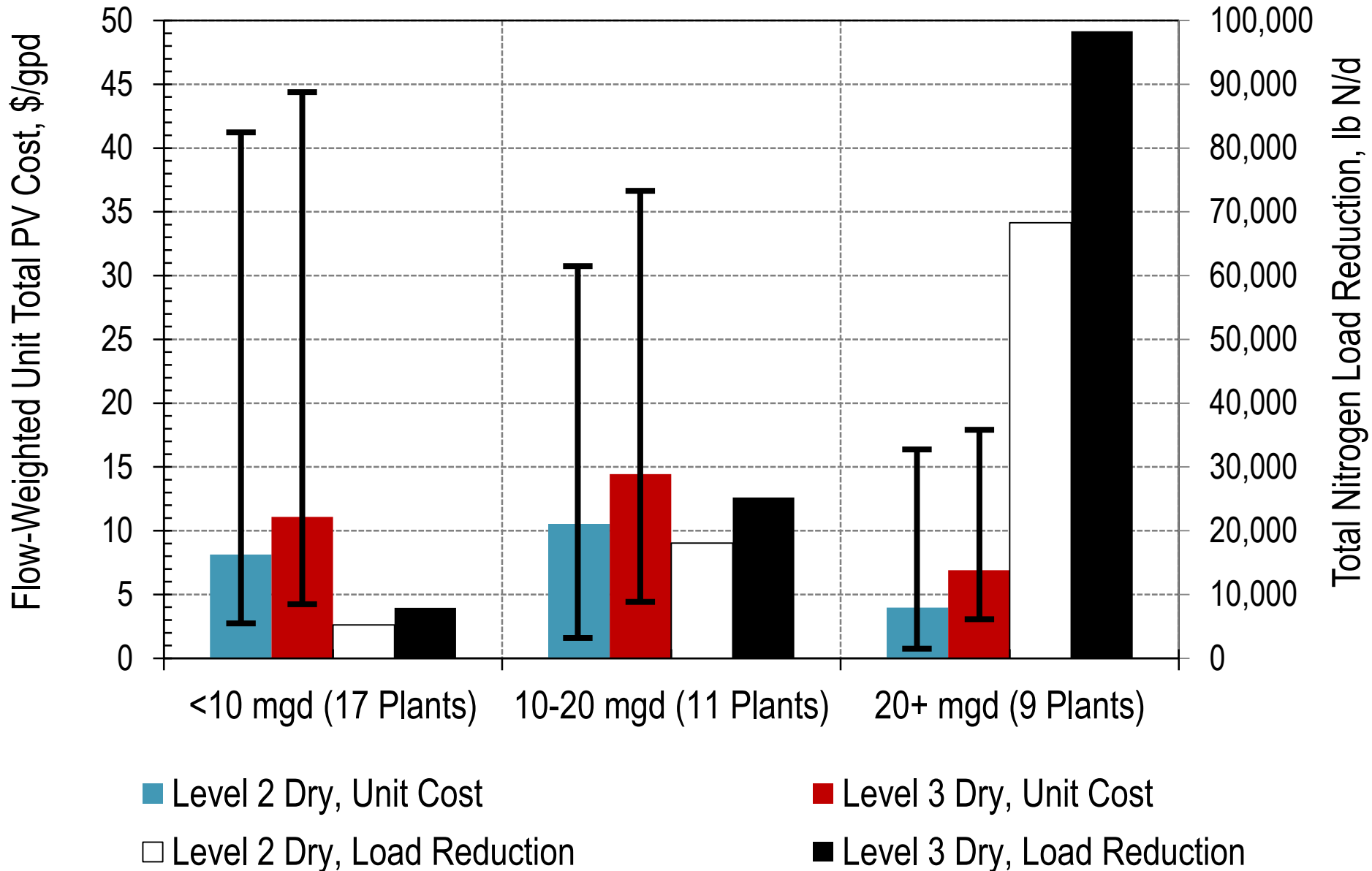
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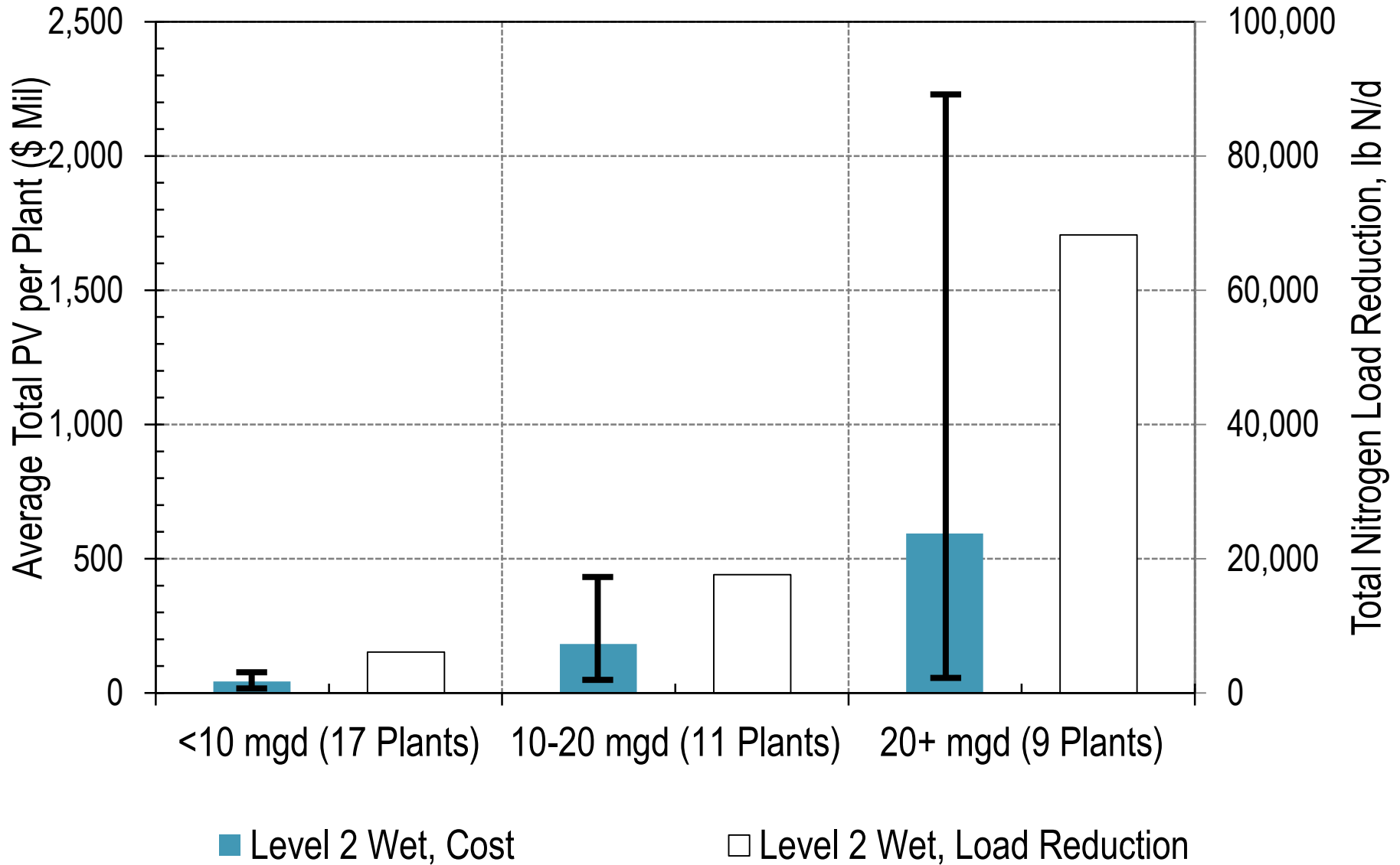
DRAFT Total PV Unit Costs for Upgrades



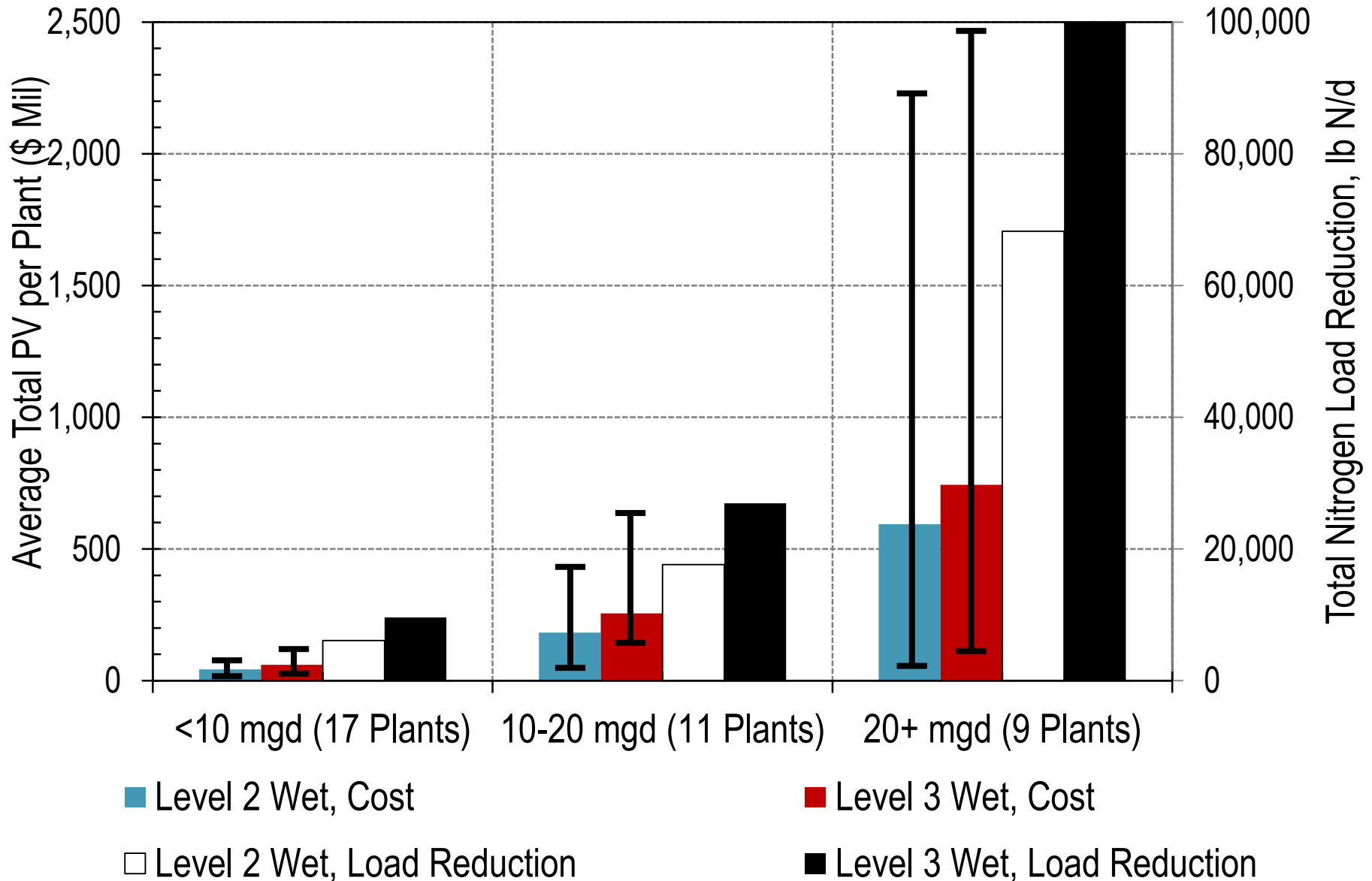
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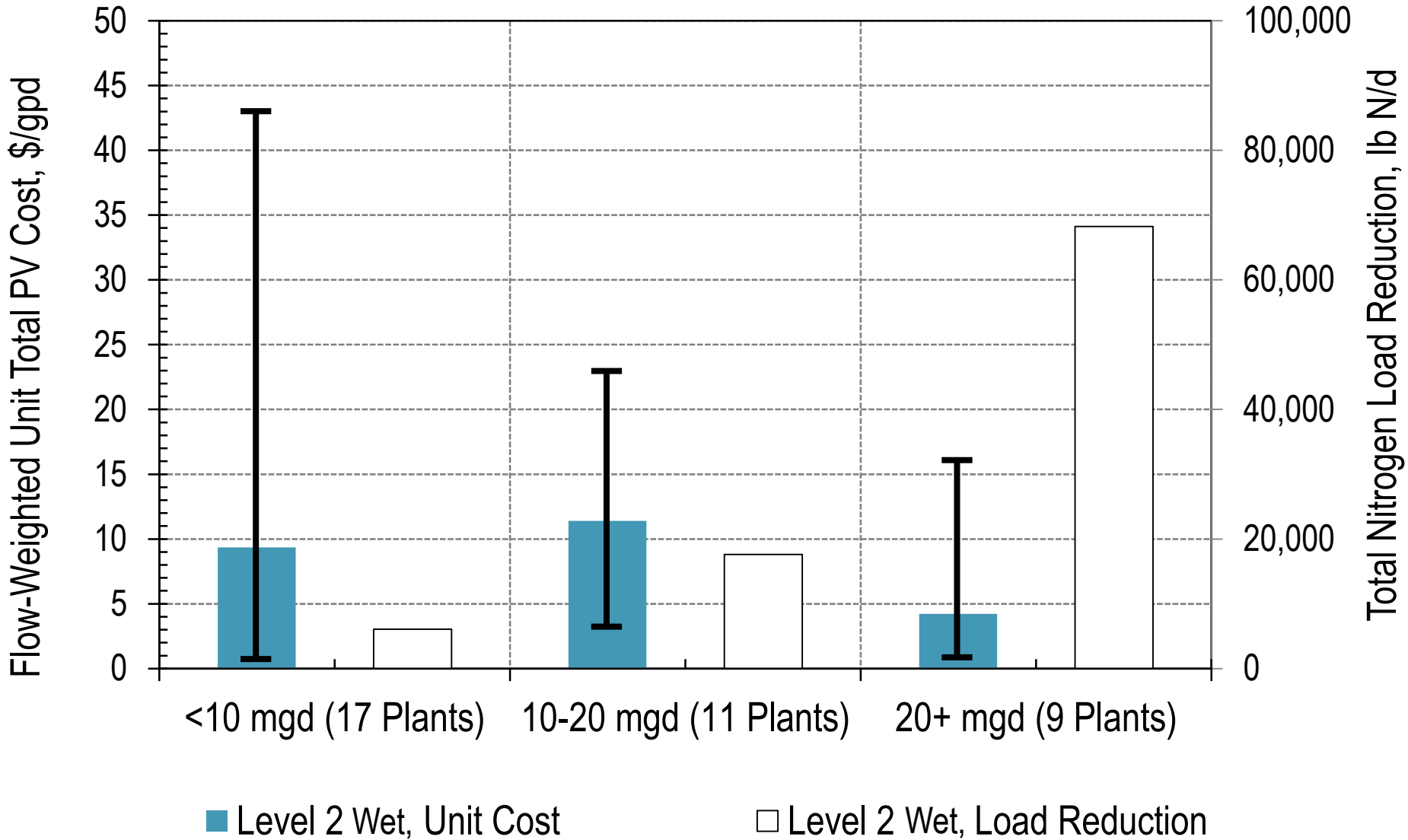
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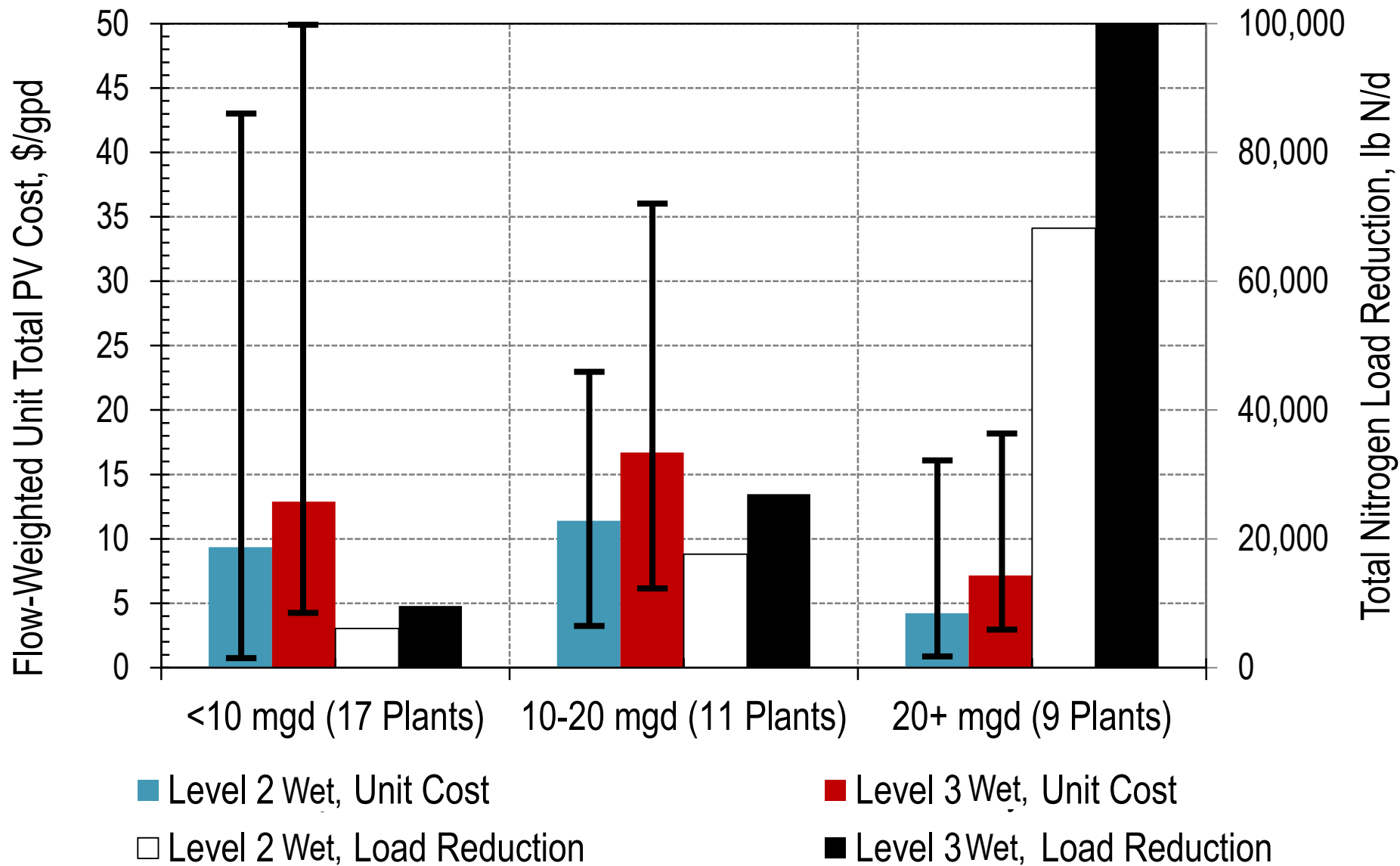
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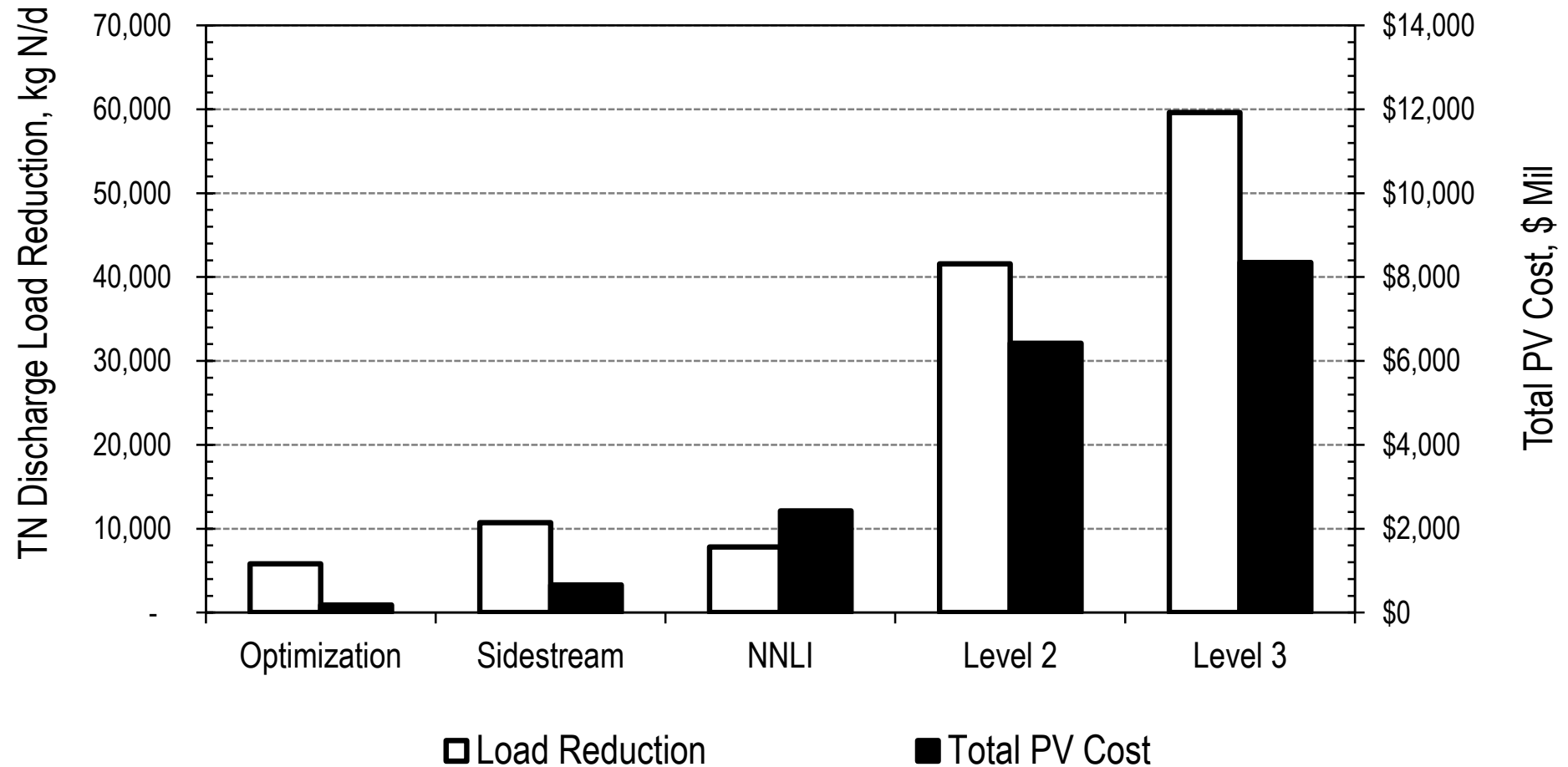
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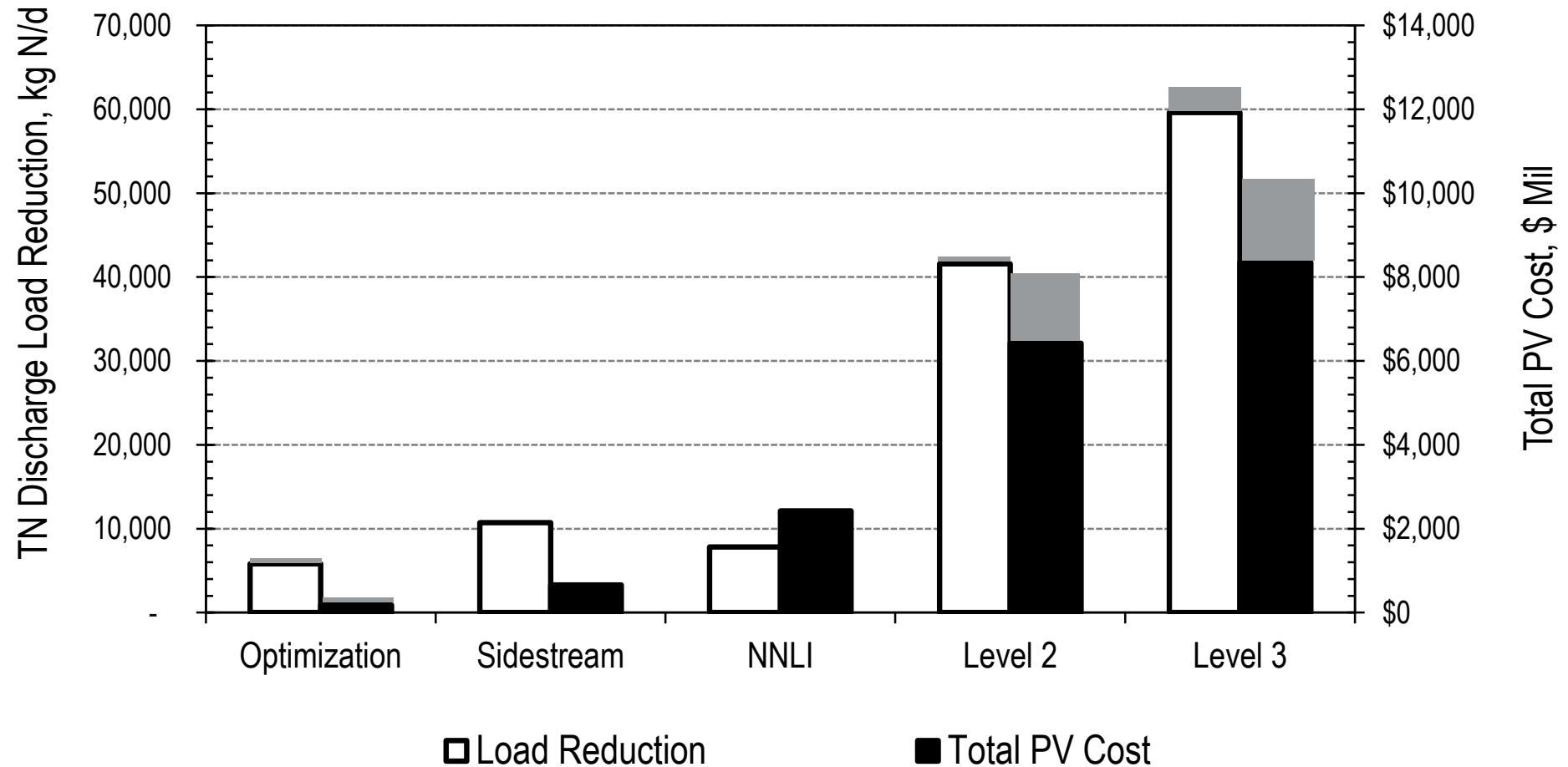
Summary of Results

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



- Optimization = 10-yr planning horizon
- NNLI = 25-yr planning horizon (Projected to all 37 Plants)
- Sidestream and Upgrades (Level 2 and 3) = 30-yr planning horizon using Permitted Capacity

DRAFT: Total N Discharge Load Reduction and Costs under Various Scenarios (Wet Season)



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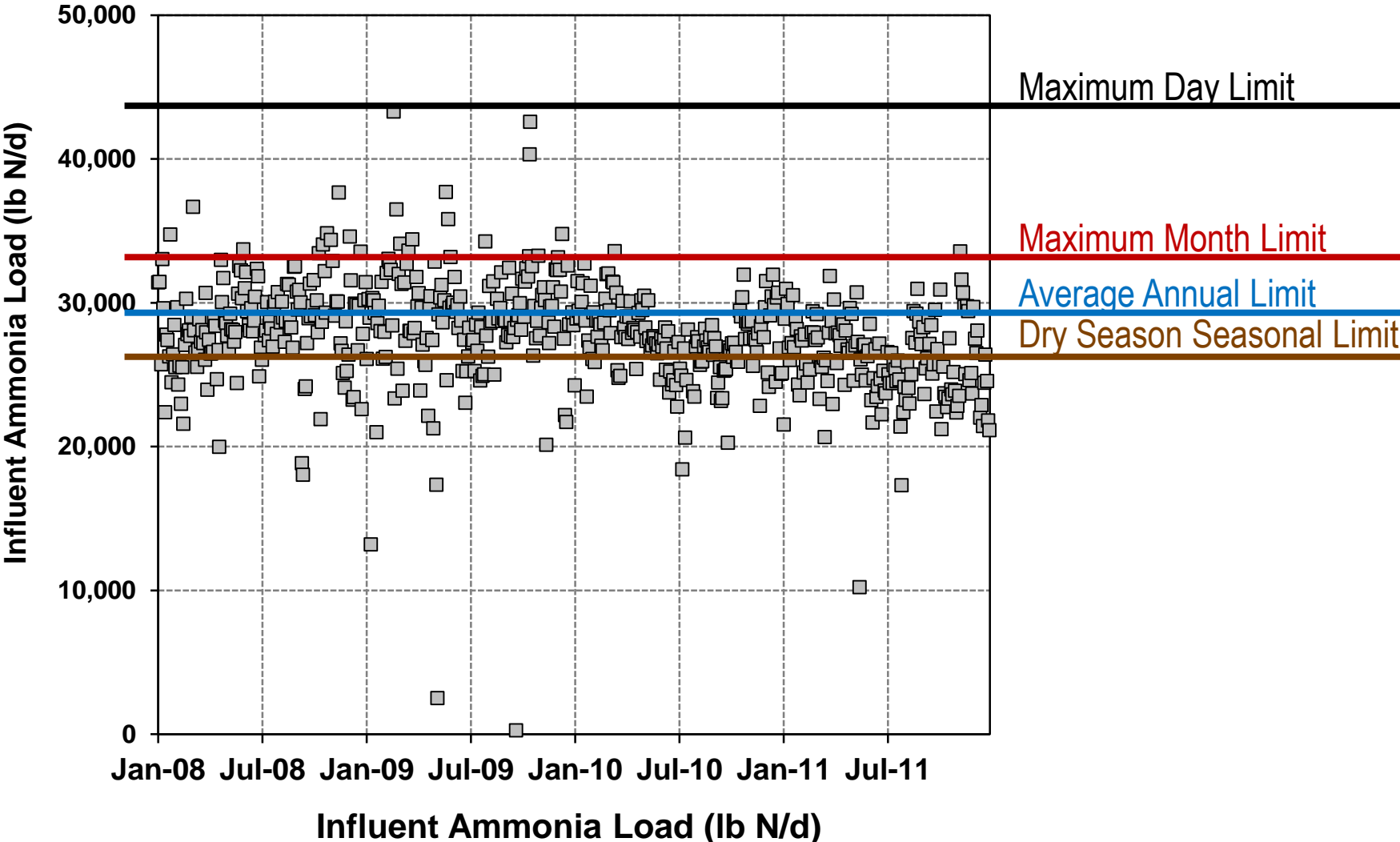
Insights

Key Cost Drivers

1. Role of Capital in Total PV (60 – 70% for upgrades)
2. Averaging periods are key to reducing capital costs
 - Dry is 75-80% of the capital for wet (for Level 2 or 3 upgrades)
 - Design criteria for meeting average annual load limits would be considerably more aggressive than for meeting a max month or max day load limit (governed by SRT)
3. Wet weather flow capacity for nutrient load reduction is problematic for several of the plants
4. Site constraints will push several of the plants towards compact technologies, such as MBR (8 plants in the Draft Reports)
5. Construction estimates have changed since the effort began

Role of Averaging Periods

Importance of Averaging Periods



Role of Averaging Periods on SRT and Basin Volume



Averaging Periods Govern the SRT and Overall Basin Volume

Role of Averaging Periods on Cost: Oro Loma for Level 3

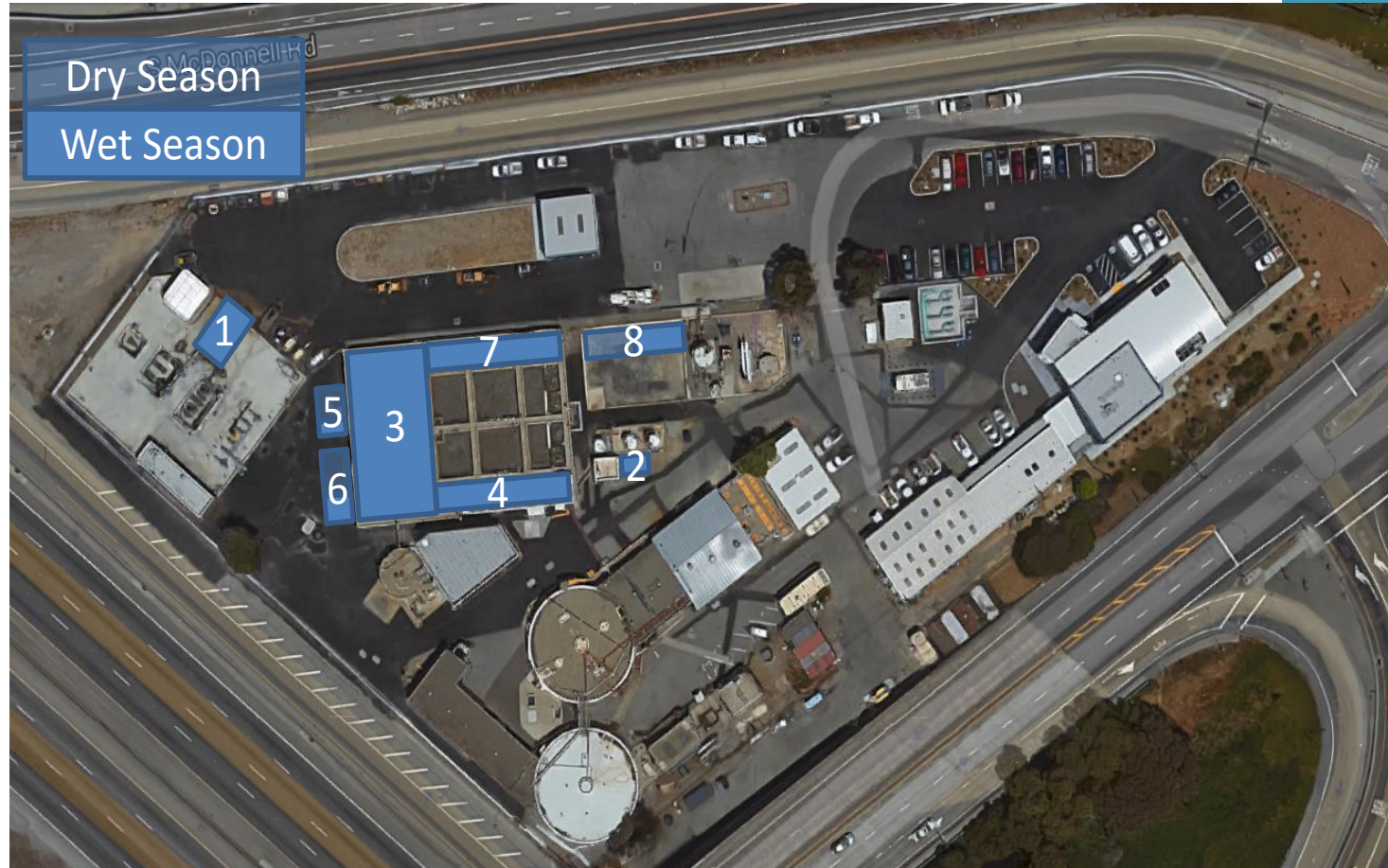
Parameter	Units	Dry Season			Wet Season		
		Ave Annual	Max Month	Max Day	Ave Annual	Max Month	Max Day
Capital PV	\$ Mil	60	68	84	66	73	110
O&M	\$ Mil /yr	5.7	6.0	6.3	6.1	6.6	7.1
O&M PV	\$ Mil	130	134	140	137	147	159
Total PV	\$ Mil	190	202	224	203	221	267
NH4 Load Reduction *	%	97	99	>99	92	99	>99

* Based on 6-years historical data from Hampton Roads Sanitation District VIP Plant

Wet Weather Flow Capacity

Case Study: City of Millbrae

- 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 compact footprint technology due to peaks

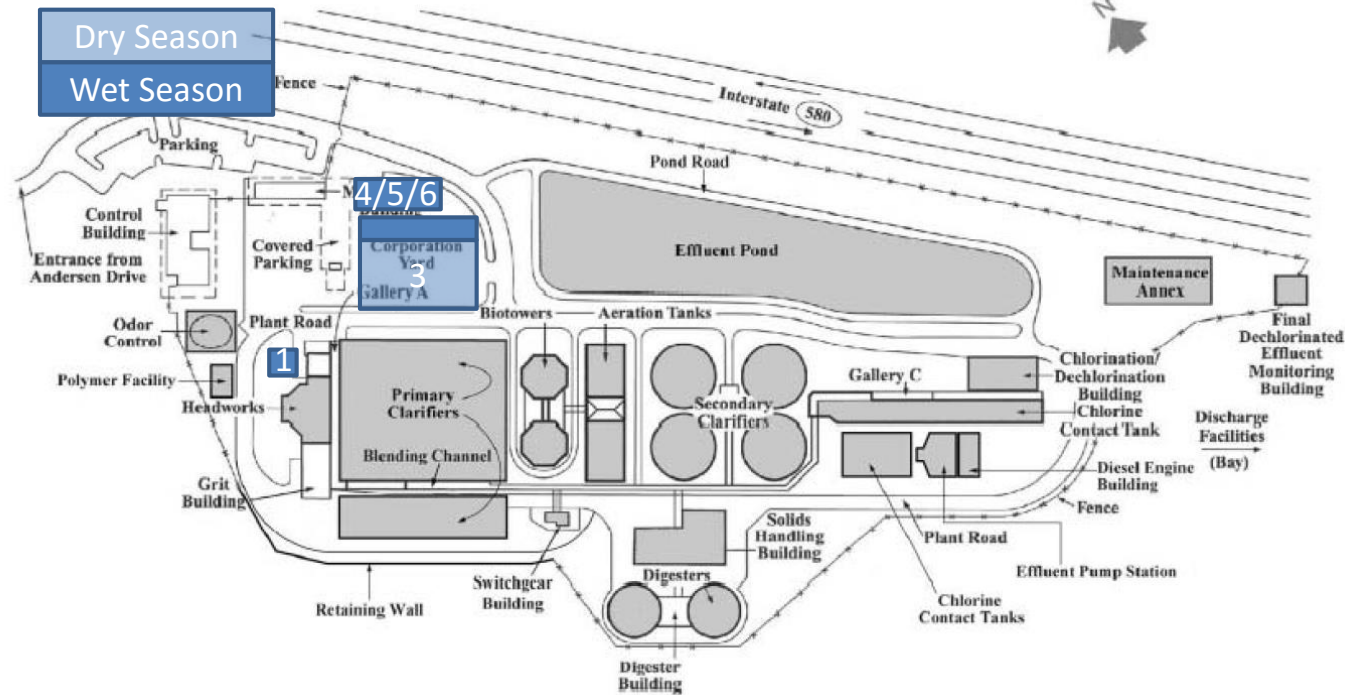


(1) Optimize ferric addition, (2) add polymer, (3) convert act sludge to MBR, (4) expand the aeration basins to create a third train, (5) add alkalinity, (6) add external carbon, (7) decommission the chlorination disinfection system (use for additional aeration basin volume), and (8) add an ultraviolet disinfection system.

Space Constraints

Case Study: CMSA

- MBR selected since it's the only option that could meet Level 3 (split treatment with existing facilities would work for Level 2)
- Plant surrounded by highway or steep hills
- 8 Plants were pushed to compact footprint technology due to space constraints



- (1) Use existing ferric chloride for CEPT, (3) Add MBR facilities, (4) add an external carbon source, (5) add alkalinity, and (6) add ferric chloride

Construction Cost Estimates

Construction Cost Estimates used in Draft Reports

Planning to update to reflect current pricing environment

Undefined Items	Values
Undefined Unit Processes	20%
Miscellaneous Site Structures	15%
Site Conditions	
Sitework	10%
Yard Piping	5%
Soil Conditions	7%
Site Electrical Power Distribution	1%
Contractor's Costs	
Field General Conditions, Mobilization, Demobilization	12%
Sales Tax (Allowance)	8%
General Contractor Overhead and Profit	10%
Bonds and Insurance	1.5%
Construction Contingency - Change Orders	4%
Soft Costs	
Engineering	10%
Construction Management	10%
Legal, Fiscal, Administration, Environmental	5%

Assumed ENR SF Bay Index of 11,155 (January, 2015)

Unit	Unit Cost
Power	\$0.17 per kWh
Labor	\$150 per hour
50% Sodium Hydroxide	\$350 per ton
Sodium Hypochlorite	\$0.43/gal for 12.5%
Ferric Chloride	\$619/dry ton
Hydrated Lime	\$396/wet ton (45% alkali lime)
Liquid Alum	\$0.80/gal
Methanol	\$1.25/gal
Citric Acid	\$6.38/gal or \$1.15/lb
Polymer (Emulsion)	\$9.10/gal which is \$1.07/lb

Technology Selection

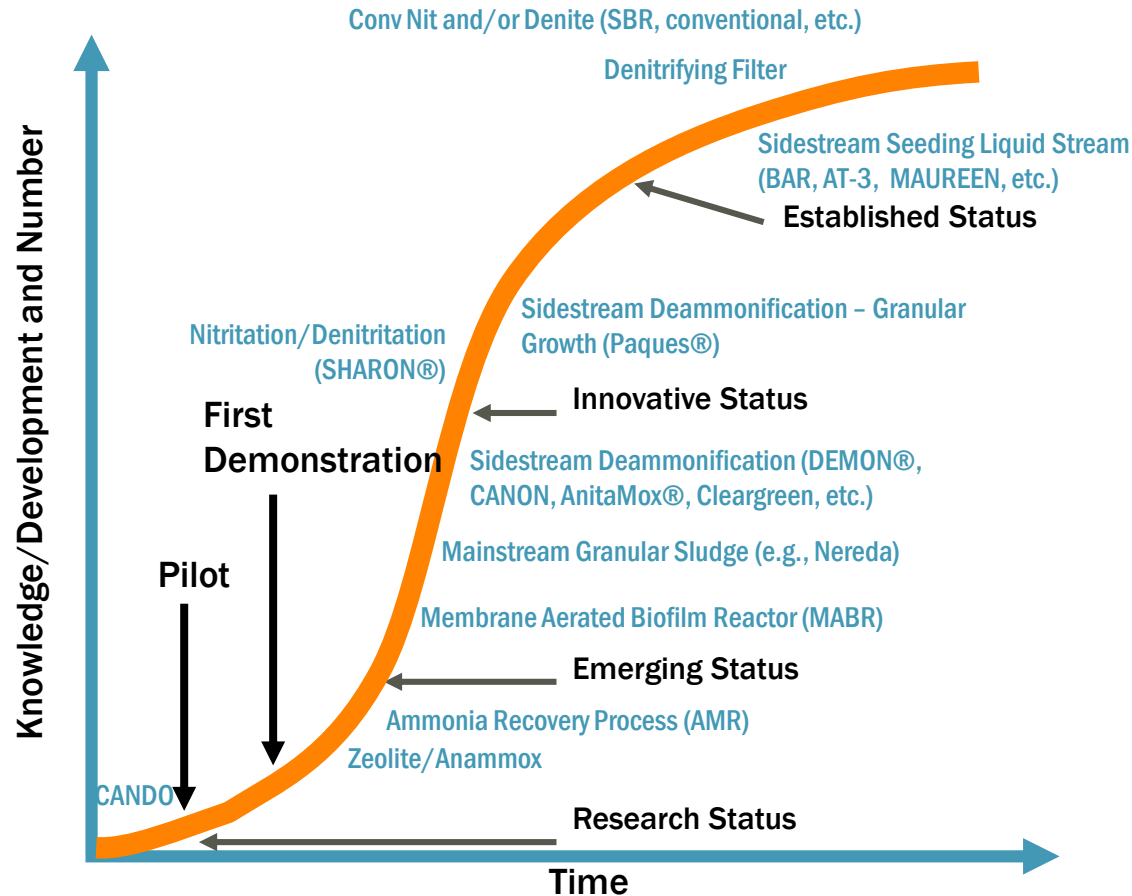
Technology Selection

Assumed established technologies for Draft Reports:

- Confidence in cost estimates
- Footprints are well understood
- Energy and chemicals demands are well understood

Emerging Technologies

- Listed up to 2 technologies per plant to monitor
- They are typically more compact and require less energy/chemicals than established technologies
- The preferred emerging technologies will become established technologies in the future



Adapted from Tetra Tech (2013) and Parker et al. (2011)



Role of Phosphorus

Differences in N and P Removal

Nitrogen Removal

- Challenging to remove with major operational changes
 - Activated Sludge (typical): with longer SRT and intensive mixed liquor returns
 - Biological Filters (to trim): requires large filter footprint plus an external carbon source
- More expensive to remove
- Requires a large footprint
- Energy and chemical intensive (at low targets)
- Can be recovered in the sidestream

Phosphorus Removal

- Straightforward removal
 - Biological P (Act Sludge)
 - Chemical Precipitation: Primaries, Filters, or Sidestream
- Less expensive to remove
- Less additional footprint (extra zone or filters)
- Chemical intensive
- Can be recovered in the sidestream

Role of TP Removal in Cost

Dry Season

Parameter	Level 2		Level 3	
	Total N	Both N and P	Total N	Both N and P
Capital, \$ Bil	3.9	4.0	4.6	4.9
O&M PV, \$ Bil	1.9	2.0	2.7	3.1
Total PV, \$ Bil	5.8	6.1	7.3	8.0

Wet Season

Parameter	Level 2		Level 3	
	Total N	Both N and P	Total N	Both N and P
Capital, \$ Bil	5.1	5.2	5.9	6.2
O&M PV, \$ Bil	2.2	2.4	3.2	3.8
Total PV, \$ Bil	7.3	7.6	9.1	10.0

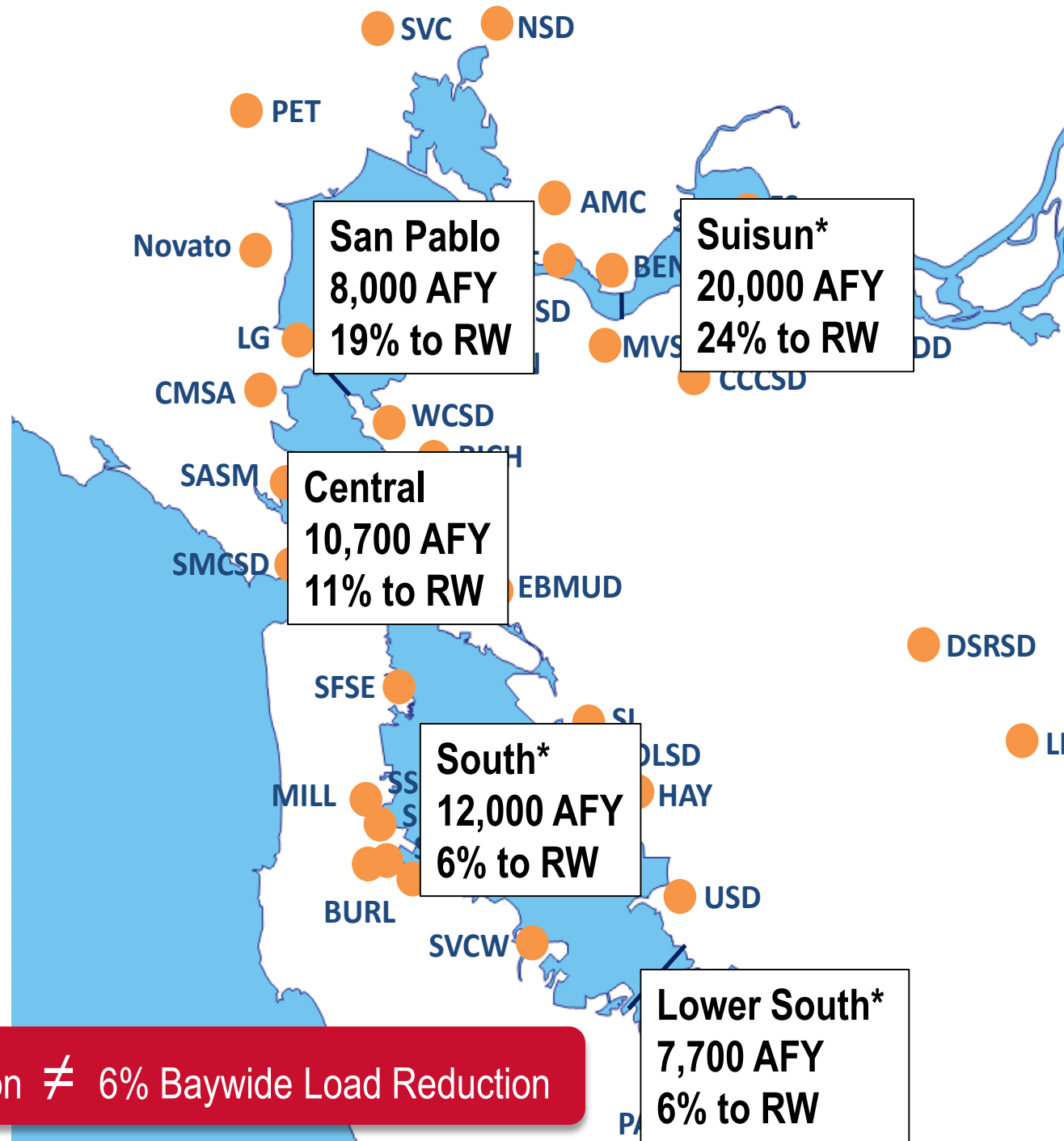
The cost impact for TP removal is more pronounced for Level 3 as it requires filtration and chemicals



Recycled Water

Current Recycled Water Findings

- ~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 \neq 6% Baywide Load Reduction

Recycled Water Distribution over Time

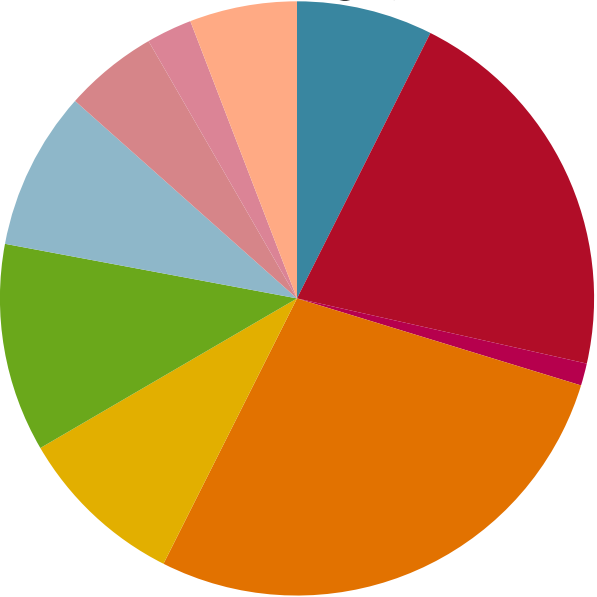
Year 2015
(58,000 AFY;
52 mgd)



Year 2030
(117,000 AFY;
104 mgd)



Year 2040
(131,000 AFY;
117 mgd)



- Golf Course Irrigation
- Landscape
- Commercial
- Industrial
- Agricultural
- Environ. Enhancement
- Internal Use
- GW Recharge
- Other Non-Potable Reuse
- Not Defined



Projects in CIPs

Nutrient Related Projects in CIPs

- 22 out of 37 plants have either on-going or planned CIP projects for nutrient load reduction
- Total Capital Cost of CIPs = \$1.5 Bil
- Example: San Mateo
 - Nutrient Removal and Wet Weather Flow Management Update and Expansion Project
 - New headworks, primary clarifiers, membrane bioreactor with nutrient removal, and disinfection
 - Estimated capital cost = \$349-369 Mil

Next Steps

- Group Annual Report (10/1/17 Submittal Date)
- Updated Reports by Thanksgiving
- Draft Main Body Report by Thanksgiving
- Others

