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

15 September 2017
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

- Scoping Plan
- Evaluation Plan
- Data Collection & Analysis
- Plant Optimization
- Sidestream Treatment
- By Other Means
- Facility Upgrades

Summary:

- Completed
- Drafts Completed
- Updating Reports
- Upcoming
DRAFT 2017 Group Annual Report
Findings
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
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).
Both dry and annual average TP loads are increasing.
Dry season TP load is increasing in all Subembayments except Central Bay.
### Dry Season Average

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Flow</td>
<td>mgd</td>
<td>399</td>
<td>387</td>
<td>365</td>
<td>359</td>
<td>387</td>
</tr>
<tr>
<td>Total Ammonia</td>
<td>kg N/d</td>
<td>32,719</td>
<td>35,540</td>
<td>36,560</td>
<td>35,747</td>
<td>39,225</td>
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<tr>
<td>Total TN</td>
<td>kg N/d</td>
<td>49,857</td>
<td>51,484</td>
<td>52,501</td>
<td>52,208</td>
<td>53,258</td>
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<tr>
<td>Total TP</td>
<td>kg P/d</td>
<td>3,603</td>
<td>3,398</td>
<td>3,450</td>
<td>3,651</td>
<td>3,872</td>
</tr>
</tbody>
</table>

### Annual Average

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Flow</td>
<td>mgd</td>
<td>453</td>
<td>434</td>
<td>421</td>
<td>425</td>
<td>510</td>
</tr>
<tr>
<td>Total Ammonia</td>
<td>kg N/d</td>
<td>33,769</td>
<td>36,624</td>
<td>36,861</td>
<td>36,801</td>
<td>40,711</td>
</tr>
<tr>
<td>Total TN</td>
<td>kg N/d</td>
<td>53,095</td>
<td>54,997</td>
<td>55,779</td>
<td>55,449</td>
<td>58,416</td>
</tr>
<tr>
<td>Total TP</td>
<td>kg P/d</td>
<td>3,954</td>
<td>3,772</td>
<td>3,717</td>
<td>3,939</td>
<td>4,107</td>
</tr>
</tbody>
</table>

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

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

The draft report assumes the seasonal operation is year-round. This has implications for seasonal dischargers.
### Updated Concept: $/lb Metric

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Dry Season</th>
<th>Wet Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td>$ Mil</td>
<td>10.0</td>
<td>11.7</td>
</tr>
<tr>
<td>O&amp;M PV</td>
<td>$ Mil</td>
<td>1.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Total PV</td>
<td>$ Mil</td>
<td>11.5</td>
<td>13.9</td>
</tr>
<tr>
<td>Load</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN Removed from Bay (Ave.)</td>
<td>lb N/yr</td>
<td>17,600</td>
<td>25,900</td>
</tr>
<tr>
<td>Unit Cost Metric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN Cost</td>
<td>$/lb N Removed</td>
<td>22</td>
<td>18</td>
</tr>
</tbody>
</table>

**Comment**
- Year-Round equals Wet Season
- Seasonal values pro-rated
- Sum of Capital and O&M PV
- Seasonal values pro-rated
- Total PV divided by load reduction over 30 years

**Consider pro-rating the O&M and load reduction**
### Updated: $/lb Metric

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Dry Season</th>
<th>Wet Season</th>
<th>Year-Round</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Way-Round equals Wet Season</td>
</tr>
<tr>
<td>Capital</td>
<td>$ Mil</td>
<td>10.0</td>
<td>11.7</td>
<td>11.7</td>
<td></td>
</tr>
<tr>
<td>O&amp;M PV</td>
<td>$ Mil</td>
<td>1.5</td>
<td>2.2</td>
<td>3.7</td>
<td>Seasonal values pro-rated</td>
</tr>
<tr>
<td>Total PV</td>
<td>$ Mil</td>
<td>11.5</td>
<td>13.9</td>
<td>15.4</td>
<td>Sum of Capital and O&amp;M PV</td>
</tr>
<tr>
<td><strong>Load</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>lb N/yr</td>
<td>17,600</td>
<td>25,900</td>
<td>43,500</td>
<td>Seasonal values pro-rated</td>
</tr>
<tr>
<td><strong>Unit Cost Metric</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN Cost</td>
<td>$/lb N Removed</td>
<td>22</td>
<td>18</td>
<td>12</td>
<td>Total PV divided by load reduction over 30 years</td>
</tr>
</tbody>
</table>

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

Average Total PV per Plant ($ Mil)

Total Nitrogen Load Reduction, lb N/d

<10 mgd (17 Plants)  10-20 mgd (11 Plants)  20+ mgd (9 Plants)

Opt., Dry Cost
Opt. Wet, Cost
Opt. Dry, Load Reduction
Opt. Wet, Load Reduction

Dry Flow - Weighted Ave = $12 Mil per Plant
Which nutrients are easiest to remove?

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  - Increasing SRT for plants with act sludge
  - Operating Trickling Filter as a Nitrifying Trickling filter
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Load Reduction w/Respect to Current Discharge:

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- Overall TP load reduction is 44%
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 ($\geq$ 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
## DRAFT Plants Eligible for Sidestream Treatment by Subembayment

<table>
<thead>
<tr>
<th>Subembayment</th>
<th>No. Plants Eligible for Ammonia Discharge Reduction to the Bay</th>
<th>No. Plants Eligible for Total Nitrogen Discharge Reduction to the Bay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suisun Bay</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>San Pablo Bay</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Central Bay</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>South Bay</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Lower South Bay</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>
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
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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level 2 Load Reduction</th>
<th>Level 3 Load Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>&gt;88%</td>
<td>&gt;88%</td>
</tr>
<tr>
<td>Total N</td>
<td>&gt;61%</td>
<td>&gt;84%</td>
</tr>
<tr>
<td>Total P</td>
<td>&gt;63%</td>
<td>&gt;89%</td>
</tr>
</tbody>
</table>
DRAFT Total PV Costs for Upgrades

Average Total PV per Plant ($ Mil)

Level 2 Dry, Cost

<10 mgd (17 Plants) 10-20 mgd (11 Plants) 20+ mgd (9 Plants)

Total Nitrogen Load Reduction, lb N/d
DRAFT Total PV Unit Costs for Upgrades

Flow-Weighted Unit Total PV Cost, $/gpd

- <10 mgd (17 Plants)
- 10-20 mgd (11 Plants)
- 20+ mgd (9 Plants)

Level 2 Dry, Unit Cost

Level 2 Dry, Load Reduction

Total Nitrogen Load Reduction, lb N/d
First I present L2 and 3 Dry for Total PV and Unit Total PV, followed by the same sequence w/Wet. The intent is to bring it all home for comparing dry vs wet in the summary slides.
First I present L2 and 3 Dry for Total PV and Unit Total PV, followed by the same sequence w/Wet. The intent is to bring it all home for comparing dry vs wet in the summary slides.

DRAFT Total PV Unit Costs for Upgrades

Average Total PV per Plant ($ Mil)

Level 2 Wet, Cost
Level 3 Wet, Cost
Level 2 Wet, Load Reduction
Level 3 Wet, Load Reduction

Total Nitrogen Load Reduction, lb N/d

<10 mgd (17 Plants) 10-20 mgd (11 Plants) 20+ mgd (9 Plants)
DRAFT Total PV Unit Costs for Upgrades

Flow-Weighted Unit Total PV Cost, $/gpd

Level 2 Dry, Unit Cost

Level 2 Wet, Unit Cost

Level 2 Wet, Load Reduction

Total Nitrogen Load Reduction, lb N/d
DRAFT Total PV Unit Costs for Upgrades

Flow-Weighted Unit Total PV Cost, $/gpd

Level 2 Dry, Unit Cost
Level 3 Dry, Unit Cost
Level 2 Wet, Load Reduction
Level 3 Wet, Load Reduction

Total Nitrogen Load Reduction, lb N/d

<10 mgd (17 Plants) 10-20 mgd (11 Plants) 20+ mgd (9 Plants)
DRAFT Upgrade Findings

Which nutrients are easiest to remove?

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  - 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

<table>
<thead>
<tr>
<th>Parameter</th>
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<tr>
<td>Total P</td>
<td>&gt;63%</td>
<td>&gt;89%</td>
</tr>
</tbody>
</table>
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)

- 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
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

- Maximum Day Limit
- Maximum Month Limit
- Average Annual Limit
- Dry Season Seasonal Limit

Influent Ammonia Load (lb N/d)

Jan-08 Jul-08 Jan-09 Jul-09 Jan-10 Jul-10 Jan-11 Jul-11

Influent Ammonia Load (lb N/d)
Role of Averaging Periods on SRT and Basin Volume

Ave Annual SRT = 8.0 d
Max Month SRT = 10 d
Max Day SRT = 15 d

Averaging Periods Govern the SRT and Overall Basin Volume
## Role of Averaging Periods on Cost: Oro Loma for Level 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Dry Season</th>
<th></th>
<th>Wet Season</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ave Annual</td>
<td>Max Month</td>
<td>Max Day</td>
<td>Ave Annual</td>
</tr>
<tr>
<td>Capital PV</td>
<td>$ Mil</td>
<td>60</td>
<td>68</td>
<td>84</td>
<td>66</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>$ Mil /yr</td>
<td>5.7</td>
<td>6.0</td>
<td>6.3</td>
<td>6.1</td>
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<td>O&amp;M PV</td>
<td>$ Mil</td>
<td>130</td>
<td>134</td>
<td>140</td>
<td>137</td>
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<tr>
<td>Total PV</td>
<td>$ Mil</td>
<td>190</td>
<td>202</td>
<td>224</td>
<td>203</td>
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<tr>
<td>NH4 Load Reduction *</td>
<td>%</td>
<td>97</td>
<td>99</td>
<td>&gt;99</td>
<td>92</td>
</tr>
</tbody>
</table>

* 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

<table>
<thead>
<tr>
<th>Undefined Items</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined Unit Processes</td>
<td>20%</td>
</tr>
<tr>
<td>Miscellaneous Site Structures</td>
<td>15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site Conditions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitework</td>
<td>10%</td>
</tr>
<tr>
<td>Yard Piping</td>
<td>5%</td>
</tr>
<tr>
<td>Soil Conditions</td>
<td>7%</td>
</tr>
<tr>
<td>Site Electrical Power Distribution</td>
<td>1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contractor’s Costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Field General Conditions, Mobilization, Demobilization</td>
<td>12%</td>
</tr>
<tr>
<td>Sales Tax (Allowance)</td>
<td>8%</td>
</tr>
<tr>
<td>General Contractor Overhead and Profit</td>
<td>10%</td>
</tr>
<tr>
<td>Bonds and Insurance</td>
<td>1.5%</td>
</tr>
<tr>
<td>Construction Contingency - Change Orders</td>
<td>4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soft Costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>10%</td>
</tr>
<tr>
<td>Construction Management</td>
<td>10%</td>
</tr>
<tr>
<td>Legal, Fiscal, Administration, Environmental</td>
<td>5%</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level 2</th>
<th></th>
<th>Level 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total N</td>
<td>Both N and P</td>
<td>Total N</td>
<td>Both N and P</td>
</tr>
<tr>
<td>Capital, $ Bil</td>
<td>3.9</td>
<td>4.0</td>
<td>4.6</td>
<td>4.9</td>
</tr>
<tr>
<td>O&amp;M PV, $ Bil</td>
<td>1.9</td>
<td>2.0</td>
<td>2.7</td>
<td>3.1</td>
</tr>
<tr>
<td>Total PV, $ Bil</td>
<td>5.8</td>
<td>6.1</td>
<td>7.3</td>
<td>8.0</td>
</tr>
</tbody>
</table>

### Wet Season

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level 2</th>
<th></th>
<th>Level 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total N</td>
<td>Both N and P</td>
<td>Total N</td>
<td>Both N and P</td>
</tr>
<tr>
<td>Capital, $ Bil</td>
<td>5.1</td>
<td>5.2</td>
<td>5.9</td>
<td>6.2</td>
</tr>
<tr>
<td>O&amp;M PV, $ Bil</td>
<td>2.2</td>
<td>2.4</td>
<td>3.2</td>
<td>3.8</td>
</tr>
<tr>
<td>Total PV, $ Bil</td>
<td>7.3</td>
<td>7.6</td>
<td>9.1</td>
<td>10.0</td>
</tr>
</tbody>
</table>

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

- San Pablo: 8,000 AFY, 19% to RW
- Suisun*: 20,000 AFY, 24% to RW
- Central: 10,700 AFY, 11% to RW
- South*: 12,000 AFY, 6% to RW
- Lower South*: 7,700 AFY, 6% to RW

6% Baywide Flow Reduction ≠ 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)

Legend:
- 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