Nutrient Reduction by Treatment Optimization and Upgrades: Update

BACWA Annual Meeting
15 January 2016
Agenda

- Watershed Permit Requirements
- Update: Optimization and Upgrade Study
  - Optimization Analysis
  - Sidestream Treatment Reduction
  - Case Studies for Optimization and Upgrades
- 2015 Group Annual Report
- Next Steps
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

<table>
<thead>
<tr>
<th>Discharger</th>
<th>Facility Name</th>
<th>Facility Address</th>
<th>Minor/Major</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>151 Maginot Court</td>
<td></td>
</tr>
</tbody>
</table>

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 (Submittal deadline is July 2018)
  - July 2018: Task 2 - Conduct treatment plant upgrades and analysis of removal by other means for nutrient load reductions (Submittal deadline is July 2018)
  - Annual Reporting (Annual submittal in October from 2015 through 2018)
37 Participating Agencies
Update on Optimization and Upgrades Study
Overview / Status of Study

- Scoping Plan
- Evaluation Plan
- Data Collection & Analysis

- Plant Optimization
- Sidestream Treatment
- By Other Means
- Facility Upgrades

Synthesis → Nutrient Reduction Plan

- Completed
- In progress
- Upcoming
## Treatment Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Study</th>
<th>Ammonia</th>
<th>TN</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 *</td>
<td>Optimization</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Level 2 *</td>
<td>Upgrades</td>
<td>2 mg N/L</td>
<td>15 mg N/L</td>
<td>1.0 mg P/L</td>
</tr>
<tr>
<td>Level 3 *</td>
<td>Upgrades</td>
<td>2 mg N/L</td>
<td>6 mg N/L</td>
<td>0.3 mg P/L</td>
</tr>
</tbody>
</table>

* The seasonal impacts will be considered for all three treatment levels:
  - Dry Season = May 1 to September 30
  - Wet Season = October 1 to April 30
Progressive Evaluation

- Identify Options
- Consider Feasibility
- Preferred Option
- Agency Review
- Final Recommendation
Optimization Analysis
Optimization Concepts

- Use offline tankage
- Operate in split treatment mode
- Modify operational mode (e.g., raise SRT)
- Modify blower set points
- Add chemicals
  - P removal
  - To unlock downstream capacity
- Shut down aeration to create anoxic zones
- Process control instrumentation
- Add internal recycle for denitrification
Potential Optimization Strategies Discussed During Site Visits that are Being Further Explored

Based on Master Plan Information or Current Flows and 115% Load

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Number of Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offline tankage</td>
<td>11</td>
</tr>
<tr>
<td>Operate split model</td>
<td>9</td>
</tr>
<tr>
<td>Instrumentation/ABAC</td>
<td>14</td>
</tr>
<tr>
<td>Convert to BNR</td>
<td>14</td>
</tr>
<tr>
<td>Raise SRT</td>
<td>16</td>
</tr>
<tr>
<td>SNDN</td>
<td>4</td>
</tr>
<tr>
<td>Chem P</td>
<td>24</td>
</tr>
<tr>
<td>Convert to MLE</td>
<td>16</td>
</tr>
<tr>
<td>Change DO</td>
<td>8</td>
</tr>
<tr>
<td>Shut air &gt; Denit</td>
<td>10</td>
</tr>
<tr>
<td>CEPT (lower load)</td>
<td>19</td>
</tr>
<tr>
<td>Mixers in zones</td>
<td>9</td>
</tr>
</tbody>
</table>
Sidestream Treatment Reduction

Preliminary Findings
Sidestream Nutrient Load Contributions

Nutrient Discharge Load Distribution

- Nitrogen
- Phosphorus

- Sidestream Contribution
- Main Stream Contribution
Progressive Evaluation

- Identify Candidate Plants
- Characterization/Load Reduction
- Facility Needs/Cost
- Agency Review
- Final Recommendation
Sidestream Treatment Pilot Test Locations, Technologies, and Status

EBMUD:
Anammox
- Suspended-growth
- Attached-growth
Completed

SFPUC:
Anammox
- Suspended-growth
- Attached-growth
- Biozeolite
Ongoing

DD: CANDO
Ongoing

OLSD: Zeolite anammox
Completed

USD: ANITA™ Mox
Completed

CANDO = Coupled Aerobic-anoxic Nitrous Decomposition Operation process, DD = Delta Diablo, EBMUD = East Bay Municipal Utility District, OLSD = Oro Loma Sanitary District, SFPUC = San Francisco Public Utilities Commission, USD = Union Sanitary District
Pictures of Pilot Testing Systems

- CANDO Pilot System at Delta Diablo
- ANITA™ Mox Pilot System at USD
- Zeolite Anammox Pilot System at Oro Loma
- Anammox Pilot System at SFPUC
- Anammox Pilot System at EBMUD
Sidestream Treatment Sampling Results (from Plant X)

- Sampling in July 2015
- Funded by EPA Regional Grant
- Loading is typical of national trends
- Bay wide average NH3 is ~810 mg N/L

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Sample 1 of Plant X</th>
<th>Sample 2 of Plant X</th>
<th>Sample 3 of Plant X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>mg N/L</td>
<td>494</td>
<td>395</td>
<td>412</td>
</tr>
<tr>
<td>Sol COD</td>
<td>mg/L</td>
<td>430</td>
<td>470</td>
<td>1000</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>mg/L</td>
<td>2,700</td>
<td>2,600</td>
<td>2,600</td>
</tr>
<tr>
<td>TKN</td>
<td>mg N/L</td>
<td>950</td>
<td>910</td>
<td>600</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>mg P/L</td>
<td>230</td>
<td>210</td>
<td>190</td>
</tr>
<tr>
<td>Orthophosphate</td>
<td>mg P/L</td>
<td>29</td>
<td>36</td>
<td>31</td>
</tr>
<tr>
<td>Alkalinity:Ammonia</td>
<td></td>
<td>5.5</td>
<td>6.6</td>
<td>6.3</td>
</tr>
</tbody>
</table>
# Preliminary Ammonia Discharge Load Reduction Potential with Sidestream Treatment (based on Current Loading)

<table>
<thead>
<tr>
<th>Subembayment</th>
<th>Annual Average Daily Discharge, lb N/d*</th>
<th>Preliminary Discharge Reduction Potential with Sidestream Treatment, %<strong>;</strong>*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suisun Bay</td>
<td>9,394</td>
<td>5 – 10</td>
</tr>
<tr>
<td>San Pablo Bay</td>
<td>2,906</td>
<td>12 -17</td>
</tr>
<tr>
<td>Central Bay</td>
<td>21,978</td>
<td>25 – 35</td>
</tr>
<tr>
<td>South Bay</td>
<td>46,042</td>
<td>15 - 20</td>
</tr>
<tr>
<td>Lower South Bay</td>
<td>832</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>81,151</td>
<td>15 - 22</td>
</tr>
</tbody>
</table>

* Source: Group Annual Report (November 12, 2016)
** Based on plants identified as candidates for sidestream treatment to further reduce ammonia discharge loads to the Bay
*** Assumes 85% total nitrogen removal in sidestream treatment reactor
Plant Upgrades
Overview of Plant Upgrades

- Evaluate Master Plan and CIP for future upgrades
- Identify strategies to meet Level 2 and Level 3
- Select appropriate technology
- Determine cost, implementation requirements & plant impacts
- Consider innovative technologies/techniques
- Discuss ideas with plant staff and get feedback
Case Studies

- Oro Loma
- Delta Diablo
Influent -> Screen -> Grit Removal -> PCL -> ANR -> AER -> SCL -> CCT

Cl₂

RAS

GBT

WAS

AD

BFP

Drying Bed

Effluent
Optimization Options

- Grit Removal
- PCL
- ANX
- AER
- SCL
- Cl2
- CCT
- Influent
- Effluent
- WAS
- RAS
- 100% RAS to return NOx
- Ferric to trim P load
- Alum for P rem

GBT

AD

BFP

Drying Bed

CCT
Optimization
(A) Chemical to Primary
(C) Raise SRT, Operated ANX/AER
(E) Chemical to dewatering
Level 2 – Increase Flow and Load

- **Screen**: Grit Removal
- **PCL**: SND, SNL
- **SCL**: Cl₂
- **CCT**: Influent, Effluent
- **WAS**: BFP
- **Cl₂**: Drying Bed
- **Cl₂**: 100% RAS to return NOx
- **Cl₂**: Anammox
- **Flow Equalize**: Alum to trim P
- **Raise SRT**: Expand Basin to existing
- **100% RAS**: Drying Bed
- **Deammonification**: using old digester
- **Alum to trim P load**: Drying Bed

Flow Path:
- Influent → Screen → Grit Removal → PCL → SND → SNL → SCL → Cl₂ → CCT
Level 2
(A) Chemical to Primary
(B) Deammonication
(C) Raise SRT, Extend Aeration Tank, Operated SNDN
(E) Chemical to dewatering
Flow equalization
Level 3 – 4 stage Bardenpho, filter, MeOH

- Screen
- Grit Removal
- PCL
- SND
- Post Denit & MeOH
- Cloth Filter & Chem

Fluent

Alum to trim P

Flow Equalize

Deammonification using old digester

Anammox

AD

BFP

Drying Bed

100% RAS to return NOx

Cl₂

Alum

Cloth Filter

CCT

WAS

RAS

SND

P load

Alum to trim P load

GBT
Level 3:
(A) CEPT
(B) Anoxic Zone
(C) Fine Bubble Aeration
(D) Secondary Clarifier Conversion
(E) New Aeration Basins
(F) Tertiary Chemical Addition
(G) Filtration
(H) Deammonification
(J) Flow Equalization
Delta Diablo
Optimization Options

- CEPT
- Recirculation to wet
- Bypass to AS
- Anox/shut aeration in front 25%
Level 2 Process Flow Diagram

- BNR MBR complete
- MeOH
- Anox
- WAS
- Reuse

Split 50/50
Peak to TF
ALL reuse to TF/AS no need to remove N ??
Level 3 Process Flow Diagram

- MeOH and more volume
- BNR MBR complete
- Anox
- WAS
- Blowdown to BAF
- Denit & P Filter
- MeOH
- Reuse

Split 50/50 Peak to TF
ALL reuse to TF/AS no need to remove N ??

MeOH

Alum

34
Level 2
Summer
Level 3
Winter
Cost Calculation

- Estimate Capital and O&M Costs
  - Summer and Winter Season
  - N&P, N, and P removal
- Calculate life cycle cost
- Compare results by plant for unit cost for nutrient removal
  - $/gpd capital
  - $/lb N removed
  - $/lb P removed
Group Annual Report Update
Approach

- Data Sources
  - 13267 Letter Data
  - CIWQS
- Parameters of Interest
  - Flow
  - Total Ammonia
  - TKN
  - NOx
- Total Nitrogen
- Orthophosphate
- Total Phosphorus
- Data Confirmation
- Seasonality
  - Dry Season: May 1 – Sept 30
  - Wet Season: Oct 1 – April 30
- Trend Analysis
  - Method of Least Squares
  - Only Dry Season Considered for Trends
Results - Flows

- Total AA discharge ranged from 421 mgd to just over 450 mgd
  - ADW flows ranged 365 mgd to 399 mgd
- South Bay and Lower South Bay contribute highest flows, >60 %
- Largest dischargers: San Jose, SFPUC Southeast, EBDA and EBMUD
- Flows are either flat or trending downward
  - Water conservation, the drought, and increased diversion for recycled water. San Pablo Bay has the largest portion of recycled water diversion during the dry season, when several plants actually divert all flow and have a zero dry season discharge.

Dry Season Average Flows (mgd)

<table>
<thead>
<tr>
<th>Subembayment</th>
<th>Permitted Capacity</th>
<th>2012/13</th>
<th>2013/14</th>
<th>2014/15</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suisun Bay</td>
<td>100</td>
<td>53</td>
<td>52</td>
<td>47</td>
<td>Decreasing</td>
</tr>
<tr>
<td>San Pablo Bay</td>
<td>63</td>
<td>16</td>
<td>17</td>
<td>15</td>
<td>None</td>
</tr>
<tr>
<td>Central Bay</td>
<td>167</td>
<td>68</td>
<td>65</td>
<td>60</td>
<td>Decreasing</td>
</tr>
<tr>
<td>South Bay</td>
<td>261</td>
<td>145</td>
<td>144</td>
<td>139</td>
<td>Decreasing</td>
</tr>
<tr>
<td>Lower South Bay</td>
<td>235</td>
<td>117</td>
<td>109</td>
<td>104</td>
<td>Decreasing</td>
</tr>
<tr>
<td><strong>Total Discharge to Bay</strong></td>
<td><strong>826</strong></td>
<td><strong>399</strong></td>
<td><strong>387</strong></td>
<td><strong>365</strong></td>
<td>Decreasing</td>
</tr>
</tbody>
</table>
Results - Ammonia

- Total AA ammonia ranged from 33,800 kg N/d to 36,900 kg N/d
  - ADW loads ranged from 32,700 kg N/d to 36,600 kg N/d
- Central Bay and South Bay contribute the loads, > 80 %
- Largest contributors SFPUC Southeast, EBMUD, EBDA
- Dry season ammonia loads are flat or increasing
- LSB loads are an order of magnitude lower than other Subembayments, since the dischargers nitrify

Dry Season Average Ammonia (kg N/d)

<table>
<thead>
<tr>
<th>Subembayment</th>
<th>2012/13</th>
<th>2013/14</th>
<th>2014/15</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suisun Bay</td>
<td>4,107</td>
<td>4,159</td>
<td>3,967</td>
<td>None</td>
</tr>
<tr>
<td>San Pablo Bay</td>
<td>834</td>
<td>895</td>
<td>1,181</td>
<td>Increasing</td>
</tr>
<tr>
<td>Central Bay</td>
<td>9,200</td>
<td>10,029</td>
<td>10,154</td>
<td>Increasing</td>
</tr>
<tr>
<td>South Bay</td>
<td>18,315</td>
<td>20,281</td>
<td>21,047</td>
<td>Increasing</td>
</tr>
<tr>
<td>Lower South Bay</td>
<td>262</td>
<td>177</td>
<td>211</td>
<td>None</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32,718</strong></td>
<td><strong>35,541</strong></td>
<td><strong>36,560</strong></td>
<td>Increasing</td>
</tr>
</tbody>
</table>
Total Nitrogen

- Total AA TN ranged from 49,900 kg N/d to 51,600 kg N/d
  - ADW TN ranged from 49,800 kg N/d to 51,400 kg N/d
- Central and South Bay contribute the highest TN loads, >65 percent
- Largest contributor of TN is EBMUD, followed by SFPUC Southeast and EBDA
- Appears to be an upward trend
  - Attributed to increasing loads in the South Bay

### Dry Season Average TN (kg N/d)

<table>
<thead>
<tr>
<th>Subembayment</th>
<th>2012/13</th>
<th>2013/14</th>
<th>2014/15</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suisun Bay</td>
<td>6,928</td>
<td>6,760</td>
<td>6,177</td>
<td>None</td>
</tr>
<tr>
<td>San Pablo Bay</td>
<td>1,549</td>
<td>1,696</td>
<td>1,771</td>
<td>None</td>
</tr>
<tr>
<td>Central Bay</td>
<td>11,963</td>
<td>12,510</td>
<td>12,289</td>
<td>None</td>
</tr>
<tr>
<td>South Bay</td>
<td>21,706</td>
<td>23,439</td>
<td>24,259</td>
<td>Increasing</td>
</tr>
<tr>
<td>Lower South Bay</td>
<td>7,652</td>
<td>7,006</td>
<td>8,044</td>
<td>None</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49,798</strong></td>
<td><strong>51,411</strong></td>
<td><strong>52,540</strong></td>
<td>Increasing</td>
</tr>
</tbody>
</table>
Total Phosphorus

- Total AA TP discharge ranged from 3,500 kg P/d to 3,900 kg P/d
  - ADW TP ranged from 3,200 kg P/d to 3,600 kg P/d
- South Bay contributed the highest TP load
- Largest contributors: EBMUD, followed by EBDA, Palo Alto and San Jose
- Trend is either flat or increasing

Dry Season Average TP (kg P/d)

<table>
<thead>
<tr>
<th>Subembayment</th>
<th>2012/13</th>
<th>2013/14</th>
<th>2014/15</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suisun Bay</td>
<td>393</td>
<td>360</td>
<td>322</td>
<td>None</td>
</tr>
<tr>
<td>San Pablo Bay</td>
<td>233</td>
<td>233</td>
<td>194</td>
<td>None</td>
</tr>
<tr>
<td>Central Bay</td>
<td>1,105</td>
<td>825</td>
<td>890</td>
<td>None</td>
</tr>
<tr>
<td>South Bay</td>
<td>1,146</td>
<td>1,225</td>
<td>1,214</td>
<td>None</td>
</tr>
<tr>
<td>Lower South Bay</td>
<td>717</td>
<td>743</td>
<td>836</td>
<td>Increasing</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3,594</td>
<td>3,386</td>
<td>3,456</td>
<td>None</td>
</tr>
</tbody>
</table>
Lower South Bay

Flow, mgd

Ammonia, kg N/d

Palo Alto  San Jose  Sunnyvale
Separate Appendix for Each Discharger

- Brief overview of subembayment, capacity, and treatment
- Observations of data and trends with explanations if known / available
- Nitrogen loads and concentrations
- Phosphorus loads and concentrations
## Summary of Total Effluent Loads and Concentrations

### Load

<table>
<thead>
<tr>
<th>Constituent</th>
<th>2012/13</th>
<th>2013/14</th>
<th>2014/15</th>
<th>Trend</th>
<th>3 Year Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow, mgd</td>
<td>453</td>
<td>434</td>
<td>421</td>
<td>Decreasing</td>
<td>436</td>
</tr>
<tr>
<td>Ammonia, kg N/d</td>
<td>33,769</td>
<td>36,629</td>
<td>36,887</td>
<td>Increasing</td>
<td>35,762</td>
</tr>
<tr>
<td>TKN, kg N/d</td>
<td>38,212</td>
<td>40,518</td>
<td>41,581</td>
<td>Increasing</td>
<td>40,104</td>
</tr>
<tr>
<td>NOx, kg N/d</td>
<td>14,857</td>
<td>14,470</td>
<td>14,169</td>
<td>Decreasing</td>
<td>14,499</td>
</tr>
<tr>
<td>TN, kg N/d</td>
<td>53,038</td>
<td>54,928</td>
<td>55,798</td>
<td>Increasing</td>
<td>54,588</td>
</tr>
<tr>
<td>Orthophosphate, kg P/d</td>
<td>4,720</td>
<td>4,595</td>
<td>3,074</td>
<td>Decreasing</td>
<td>4,130</td>
</tr>
<tr>
<td>TP, kg P/d</td>
<td>3,946</td>
<td>3,761</td>
<td>3,721</td>
<td>None</td>
<td>3,809</td>
</tr>
</tbody>
</table>

### Concentration

<table>
<thead>
<tr>
<th>Constituent</th>
<th>2012/13</th>
<th>2013/14</th>
<th>2014/15</th>
<th>Trend</th>
<th>3 Year Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow, mgd</td>
<td>453</td>
<td>434</td>
<td>421</td>
<td>Decreasing</td>
<td>436</td>
</tr>
<tr>
<td>Ammonia, mg N/L</td>
<td>20</td>
<td>22</td>
<td>23</td>
<td>Increasing</td>
<td>22</td>
</tr>
<tr>
<td>TKN, mg N/L</td>
<td>22</td>
<td>25</td>
<td>26</td>
<td>Increasing</td>
<td>24</td>
</tr>
<tr>
<td>NOx, mg N/L</td>
<td>8.7</td>
<td>8.8</td>
<td>8.9</td>
<td>None</td>
<td>8.8</td>
</tr>
<tr>
<td>TN, mg N/L</td>
<td>31</td>
<td>33</td>
<td>35</td>
<td>Increasing</td>
<td>33</td>
</tr>
<tr>
<td>Orthophosphate, mg P/L</td>
<td>2.8</td>
<td>2.8</td>
<td>1.9</td>
<td>Decreasing</td>
<td>2.5</td>
</tr>
<tr>
<td>TP, mg P/L</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
<td>None</td>
<td>2.3</td>
</tr>
</tbody>
</table>
2015 Group Annual Report

- Submitted to Water Board in November
- Provided Input:
  - SRP Terminology / Data Reporting
    - Dissolved orthophosphate
  - Recycled Water Data Collection
- Preparing a template to streamline future data collection
- For further consideration: whether to include raw influent trending to avoid misinterpretation of flow and load data
Next Steps

- 2016 Group Annual Report Data Request
- Recycled Water Data Request
- CIP Data Request
- Prepare Draft Optimization and Upgrades Study Report