High Value Resources from High Strength Wastes: Leveraging Food Production Byproducts to Reduce BNR Costs

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Today’s Presentation discusses an innovative approach to procuring alternative carbon resources

- Nutrient Reduction Program at City of Richmond WWTP
  - Treatment requirements
  - Inherent nitrogen removal flexibility

- Opportunities presented by industrial products
  - Public Utilities as a catalyst for economic development
  - Screening of potential brewery byproducts of value

- The current process:
  - Product receiving and feeding implementation
  - Understanding holistic product value
  - Turning assigned value into a commodity product
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Richmond WWTP Service Area

Legend
- Separate Sewer System Tributary to Richmond WWTP
- Separate Sewer System Tributary to Counties
- Combined Sewer System Tributary to Richmond WWTP
Pre-Upgrade Process Diagram
45 MGD Dry / 75 MGD Wet Weather Capacity

Interceptors (Combined Sewer System)

Primary Screening and Grit Chamber
Main Pump Station

Secondary Screening

Primary Sed Tanks
Aeration Tanks
Final Sed Tanks
Storage Tank
Effluent Filters

WWF = 75 MGD
DWF = 45 MGD
**Nutrient Reduction Program**  
**Reliably Meet TN/TP Discharge Requirements**

**Note from General Permit Registration List Regarding Reporting:**  
"Waste load allocations for localities served by combined sewers are based on dry weather design flow capacity. Reported discharge loads for the Richmond WWTP shall include the loads associated with the first 45 MGD of flow on each day."

<table>
<thead>
<tr>
<th>Dry Weather Flow Capacity (MGD)</th>
<th>Total Nitrogen WLA</th>
<th>Total Phosphorus WLA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WLA Based on Conc mg/L</td>
<td>Yearly Load lbs/yr</td>
</tr>
<tr>
<td>45</td>
<td>8.0</td>
<td>1,096,402</td>
</tr>
</tbody>
</table>

New Water Quality Standards are in effect as of January 1, 2011
Post-Nutrient Upgrade Process Diagram

- **Interceptors** (Combined Sewer System)
- **Primary Screen**
- **Main Pump Station**
- **Centrate Sidestream Treatment**
- **Class B Land App**
- **Anaerobic Digestion**
- **Primary Sedimentation Tanks**
- **Aeration Tanks**
- **Final Sedimentation Tanks**
- **Storage Tank**
- **Effluent Filters**
- **Methanol**
- **UV Disinfection**
- **Denitrification Filters**
- **Sidestream Treatment (TN Management)**
- **Chemical Phosphorus Removal**
- **Secondary Treatment Reliability Upgrades**
- **Primary Solids Fermentation (Carbon Recovery)**

**Waste Water Flow Rates**
- **WWF = 75 MGD**
- **DWF = 45 MGD**
Influent ammonia loading had been relatively stable from 1992 to 2005.
Since 2005, influent ammonia loading has increased significantly - by more than 100%

More Nitrogen Loading = More Methanol Demand ($1.6M in 2014)
Three Flexible Nitrogen Removal Facilities

- **Aeration Tanks and Sidestream Treatment are Flexible to use Alternative Carbon**
- **Filters Require Methanol**
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• The current process:
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• Richmond, VA competitively selected
  – 40 cities, 3 finalists
• 500,000 barrel per year production
• Destination Restaurant
• 288 Jobs
• $74M Capital Investment
• $1.2M/year tax revenue
Inherent flexibility facilitated opportunities for the WWTP and the City

- Initial primary sludge fermentation design adaptable to future high strength wastes
- Identification of brewery waste product – leveraged value to WWTP to attract industry to the City

Mixing evaluation of high-rate fermenter

Brewery selected Richmond VA, in part because of partnership opportunity with public utilities
Three waste streams were screened for their applicability as products at WWTP

- City reviewed value of 3 by-products of large scale beer production:
  - Brewery Process Wastewater (low strength, sewered)
  - ‘LT DRIP’ Lauter Tun drainage (high strength, trucked)
  - Spent Yeast (very high strength, trucked)
The brewing process creates several distinct waste streams that were evaluated.
Rapid screening of brewery products revealed the value proposition of each product

HSW Character
Sludge Character
Process Stoichiometry
Energy/Commodity Data

Carbon Product Recovery
Economic/Process Model

Energy Product
Commodity Product
Biosolids Impacts
BNR Impacts

Descriptive life cycle economics and external fee requirements

\[ \Sigma = \]
Background of brewery product evaluation for use at Richmond WWTP

- City reviewed value of 3 by-products of large scale beer production:
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  - ‘LT DRIP’ Lauter Tun waste (high strength, trucked)
  - Spent Yeast (very high strength, trucked)

- Outcomes of product screening, City will...
  - Receive brewery process wastewater
    - Industrial discharge to sewer, received with raw influent
    - Subject to high strength waste surcharges
  - Not accept spent yeast
    - Too high pCOD
    - Impacted biosolids more than corresponding value
  - Procure lauter tun drainage based on net methanol offset value
    - Focus for remainder of presentation
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Variable characteristics of Lauter Tun Drainage; consistently high sCOD content

<table>
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<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Individual Grab Sample Analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Barley Wine</td>
<td>IPA</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen</td>
<td>mg N/L</td>
<td>1,000</td>
</tr>
<tr>
<td>Phosphorus, Total</td>
<td>mg P/L</td>
<td>300</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>mg TSS/L</td>
<td>44,000</td>
</tr>
<tr>
<td>Volatile Suspended Solids</td>
<td>mg VSS/L</td>
<td>-</td>
</tr>
<tr>
<td>Chemical Oxygen Demand</td>
<td>mg COD/L</td>
<td>140,000</td>
</tr>
<tr>
<td>Soluble Chemical Oxygen Demand</td>
<td>mg COD/L</td>
<td>-</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand</td>
<td>mg BOD/L</td>
<td>47,000</td>
</tr>
<tr>
<td>Soluble Biochemical Oxygen Demand</td>
<td>mg BOD/L</td>
<td>43,000</td>
</tr>
<tr>
<td>pH</td>
<td>NA</td>
<td>5.40</td>
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</tbody>
</table>
Soluble and Particulate COD will behave differently in the WWTP & have differing values

- **Soluble Sugars**
  - Readily fermentable
  - Directly elutriated if not fermented

- **Soluble Complex**
  - Fermentable
  - Directly elutriated if not fermented

- **Particulate Solids**
  - Limited conversion in fermenter
  - Mostly degraded in anaerobic digester
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Elutriation is the primary mode of recovery for soluble COD.

Assumed 85% recovery of sCOD based on overflow/underflow ratio of gravity thickeners

12% conversion to sCOD in fermenter, remainder (up to VSR limit) degraded in digester
Operational decisions can greatly impact the gross value of recovered resources.

![Gross Value of Recovered Resources ($US/year)](chart)

- **All Biogas - No HSW**
- **Fermentation - No HSW**
- **All Biogas - w/HSW**
- **Fermentation - w/HSW (12% pCOD conversion)**
- **Fermentation - w/HSW (20% pCOD conversion)**

- **Supplemental Carbon Value**
- **Biogas Energy Value**
Example: Conventional Co-digestion
Spent Brewers Yeast Assessment

$0.099/gallon  $0.059/gallon  $0.049/gallon

Required Gate Fee to Break Even (assuming 2-3% TS)

Remember: Richmond’s goal is to develop net value from brewery product receipt to justify purchasing as commodity chemical
Example: Co-fermentation to recover rbCOD
Lauter Tun Drainage Evaluation

Value to be leveraged (gain share) to purchase as commodity chemical

- Increased Methanol Recovery
- Increased Digester Gas Energy
- Increased Ammonia in Side Stream
- Increased Biosolids Production
- Facility Improvements
- Net Value (No gate fee)

Example: 80% HSW VSR in digester
Product value tied to MeOH

Annual Product Value

$0.49/gallon

7.207128457
In summary, recovery of high value products enhances resource recovery opportunities

- The Conceptual Utility of the Future considers the holistic value of resources and waste streams
  - Identification of holistic value allowed Richmond to justify purchase of waste product
  - Partial cost reduction for supplemental carbon
  - Contributed to large economic win for the City by attracting large industrial facility
In summary, recovery of high value products enhances resource recovery opportunities

- The intrinsic flexibility of the WWTP allowed the City to take advantage of the highest value opportunity
  - Multiple ways to remove nitrogen
  - No sunk cost in energy recovery actually helped justify recovery of higher value (per BTU) products, e.g. VFA

- If we believe in recovering and reusing resources contained in environmental waste streams then seeking and developing strategies to extracted higher value products is critical
  - Entrepreneurialism that benefits served communities is a key aspect of the Utility of the Future!!!
THANK YOU

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