PHOSPHORUS RECOVERY AT THE STICKNEY WATER RECLAMATION PLANT

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AGENDA

1. Introduction
2. Process Evaluation
3. Design Summary
   • P Recovery Facilities
   • WASSTRIPL
4. Construction Status
5. Q&A
INTRODUCTION

1. Project background and overview
2. Technology review
3. Project timeline/delivery mode
PROJECT PARTICIPANTS

- **Owner: Metropolitan Water Reclamation District of Greater Chicago**
  - Provides wastewater service to 883 sq mi of Cook County IL, including City of Chicago and 125 suburban communities

- **Design Builder: Black & Veatch Construction**
  - Overland Park KS HQ; Chicago regional office
  - #7 ENR Top 100 Design Build Firms

- **Technology Provider and Offtaker: Ostara Nutrient Technologies**
  - Proprietary Pearl® and WASSTRIP® technologies to recover nutrients from wastewater
  - Crystal Green® slow release fertilizer marketed and sold through established channels

- **Subconsultants, Subcontractors, and Suppliers**
STICKNEY WATER RECLAMATION PLANT

- **Design capacity**: 1,400 mgd
- **Existing TP Effluent**: 1-2 mg/L
- **New TP Effluent Limit** of 1.0 mg/L
  - Optimizing biological phosphorus removal
  - Minimizing phosphorus return loads (24%) from recycle streams
TOWARD A SUSTAINABLE PHOSPHORUS CYCLE

Phosphorus need (finite resource):
- Population growth increases the need for phosphorus fertilizers

Phosphorus removal:
- Point sources: more stringent phosphorus limits at WWTP’s
- Recovery = resource and revenue source
BIOLOGICAL NUTRIENT REMOVAL EFFICIENTLY AND EFFECTIVELY REDUCES EFFLUENT PHOSPHORUS CONCENTRATION

Primary → Anaerobic/Anoxic → Aerobic → Clarifiers

Dewatering → Anaerobic Digestion → Thickening

Biosolids
BIOLOGICAL NUTRIENT REMOVAL COMBINED WITH ANAEROBIC DIGESTION CREATES TREATMENT CHALLENGES

- Primary
- Anaerobic/Anoxic
- Aerobic
- Clarifiers
- Centrate (High PO4 and NH3)
- Dewatering
- Anaerobic Digestion
- Thickening
- Biosolids
- WAS (P, Mg, N)
UNINTENDED STRUVITE FORMATION
THE PEARL® PROCESS INTERCEPTS RECYCLE TO RECOVER PHOSPHORUS AND AMMONIA

Primary → Anaerobic/Anoxic → Aerobic → Clarifiers

Pearl Process → Crystal Green® → WAS (P, Mg, N)

Dewatering → Anaerobic Digestion → Thickening

Biosolids
WASSTIP INCREASES PHOSPHORUS RECOVERY WHILE PROTECTING DIGESTERS FROM STRUVITE FORMATION
OPERATING FACILITIES:

- Durham, OR
- Saskatoon, Saskatchewan
- HRSD, VA
- Edmonton, Alberta
- York, PA
- Rock Creek, OR
- Madison, WI
- Slough, United Kingdom

TECHNOLOGY SCALED UP:

Reactor size for Stickney WRP
- Contract substantial completion: February 25, 2016
- Contract final completion: September 12, 2016
PROCESS EVALUATION

1. Study phase evaluation
2. Offtake agreement
STUDY PHASE COLLABORATION

- Initial study phase to define best implementation of the technology
- Focused process sampling and analysis program in support of process modeling
  - Developed by Ostara and B&V
  - Executed by MWRDGC, with initial coordination assistance by Ostara and B&V
- Plant process modeling for evaluation of options
- Process workshop for decision facilitation
SOLIDS HANDLING AT STICKNEY WRP

- **O'Brien WRP Sludge (PS & WAS)**
- **WAS (Batteries A,B,C,D)**
- **Sludge Screens**
- **Sludge Concentration Tanks**
- **Pre Digestion Centrifuges**
- **Sludge Holding**
- **Post Digestion Centrifuges**
- **Dryers (MBM)**
- **Lagoons**
- **Imhoff Sludge**
- **Centrate**
- **Railcars**
- **To Salt Creek Interceptor**
- **Overflow**
- **To Southwest Interceptor**
- **To Argo Interceptor**
- **Supernatant**
- **Centrate**
- **Dewatered Biosolids**
- **To Argo Interceptor**
BASELINE MODEL LAYOUT
BASELINE VARIANT...

- **Baseline Model:**
  - Baseline Model: represents the current configuration and plant influent characteristics in the plant

- **Modified Baseline Model:**
  - Dedicated WAS centrifuges,
  - New WS primary tanks,
  - New gravity thickening tanks instead of sludge concentration tanks

On-going or planned plant modifications
Current and planned projects

MODIFIED BASELINE MODEL LAYOUT
P-RECOVERY OPTIONS

- Option 1: P recovery from centrifuge centrate post digestion
- Option 2: P recovery using WASSTrip to release phosphate pre-digestion (includes post-digestion centrate as ammonia source)
- Option 3: P recovery from LASMA returns
- Option 4: Combination of Options 2 and 3, recovering P from all 3 sidestreams
Struvite model instability issues
Simplified Approach, Removes P as Ferric Salt, Dose Adjusted to Give ~80% Ortho-P Removal
OPTION 2 MODEL LAYOUT

WASSTTRIP, with pre- and post-digestion centrate
OPTION 3 MODEL LAYOUT

P recovery at LASMA
STUDY PHASE RESULTS

<table>
<thead>
<tr>
<th>Task A Scenario</th>
<th>Ostara Pearl Reactors</th>
<th>PO4-P Recovered/Fertilizer Product Produced</th>
<th>Other Process Units</th>
<th>Model Effluent TP</th>
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<tbody>
<tr>
<td>Description</td>
<td>No.</td>
<td>Size</td>
<td>Type</td>
<td>mg/L</td>
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<tr>
<td>1 Post Digestion</td>
<td>1</td>
<td>Pearl 10,000</td>
<td>1,550 / 2,200</td>
<td>NA</td>
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<tr>
<td>2 WASSTRIP and Post Digestion</td>
<td>3</td>
<td>Pearl 10,000</td>
<td>5,350 / 7,700</td>
<td>Fermenter WAS Thickener WASSTRIP Reactor</td>
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<tr>
<td>3 P recovery from LASMA</td>
<td>$1^1$</td>
<td>Pearl 10,000</td>
<td>1,800 / 2,500</td>
<td>NA</td>
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<tr>
<td>4 Options 2 and 3 Combined</td>
<td>3$^2$</td>
<td>Pearl 10,000</td>
<td>6,200 / 8,900</td>
<td>As Option 2</td>
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- Owner to self-implement WASSTRIP
OFFTAKE AGREEMENT

- Ostara pays Owner for every ton of fertilizer recovered
  - 20 year term
  - $400 per ton of fertilizer
  - Quality standards

- Offtake contract negotiated concurrent with construction contract

- Establishes basis for long term partnership between Ostara and MWRDGC
DESIGN SUMMARY
FACILITY LOCATION ON SITE
P RECOVERY FACILITY LAYOUT
WASSTRIPT INTEGRATION

1. Updated concept
2. Schedule/status
WASSTRIP OPTION

- **Principle of Operation**
  - Engineered P release of waste activated sludge (WAS).
  - Carbon for release can come from primary sludge fermentate, external source, or endogenously.
  - Liquid portion from reactor (high in P & Mg) blended with centrate (high in NH3) before entering P recovery reactor.

- **Benefits**
  - Increases P recovery
  - Reduces struvite formation in digesters
  - Reduces P content in biosolids
  - Less Mg addition to P recovery process

- **Disadvantages**
  - Addition of sizable reactor for process
SWRP WASSTRIP Trials

- Average release ~ 20%
  - Typical release for WASSTRIP tanks ~ 30%
- Average [orthoP] after 6 hours with external carbon ~ 60-70 mg/L
- Release most closely correlated with initial [TP] in WAS
- Addition of carbon sped up orthoP release, but did not yield higher orthoP/TP values
  - Most tests run overdosed the carbon
  - Lower carbon additions tested yielded lower releases
CONSTRUCTION PROGRESS

Progress Photos and Current Status
SITE PRIOR TO START OF WORK
DEMOLITION WORK
WORK TENT ERECTION
WORK TENT
REACTORS IN FABRICATION
WINTER CONDITIONS
REACTOR SEGMENTS BEING DELIVERED
CHEMICAL TANK DELIVERY
REACTOR CONES ON SITE
ASSEMBLY OF FIRST OSTARA REACTOR
CONTINUED REACTOR FIT-UP
PIPE BRIDGE ERECTION
BUILDING FRAME ERECTION
REACTORS ALMOST READY FOR “LIFT AND FLIP”
CONTINUED BUILDING CONSTRUCTION
RECENT VIEW OF SITE
QUESTIONS & ANSWERS

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Building a world of difference.

Together

BLACK & VEATCH

www.bv.com
PEARL® PROCESS PROVIDES FAVORABLE ECONOMICS TO MANAGE PHOSPHORUS RECYCLE
THE CAPITAL COST IS RECOVERED THROUGH OPERATING SAVINGS

- Struvite Maintenance
- Metal Salt Addition
- Sludge Disposal
- Reduced Gas Production
- Nitrification
- Alkalinity
- Carbon
- CO2 Credits

Installed Cost

$
THE OPERATING COSTS ARE RECOVERED THROUGH CRYSTAL GREEN REVENUE

- Struvite Maintenance
- Metal Salt Addition
- Sludge Disposal
- Reduced Gas Production
- Nitrification
- Alkalinity
- Carbon
- CO2 Credits

- MgCl2 Addition
- NaOH Addition
- Power
- Labor
- Maintenance

Installed Cost

Capital Cost

Operating Cost

$
PAYBACK PERIOD IS TYPICALLY 3 TO 10 YEARS

- Installed Cost
  - Struvite Maintenance
  - Metal Salt Addition
  - Sludge Disposal
  - Reduced Gas Production
  - Nitrification
  - Alkalinity
  - Carbon
  - CO2 Credits

- Operating Cost
  - MgCl2 Addition
  - NaOH Addition
  - Power
  - Labor
  - Maintenance

- Crystal Green Revenue Sharing
## STICKNEY RECYCLE STREAMS
### WHERE IS RELEASE OCCURRING?

<table>
<thead>
<tr>
<th>Source</th>
<th>Flow (MGD)</th>
<th>TKN (mg/L)</th>
<th>Sol TKN (mg/L)</th>
<th>NH3-N (mg/L)</th>
<th>Tot P (mg/L)</th>
<th>Ortho P (mg/L)</th>
<th>Fe (mg/L)</th>
<th>Mg (mg/L)</th>
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<td>Gravity Concentration Tank Overflow</td>
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<td>45.1</td>
<td>10.6</td>
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<td>17.9</td>
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<tr>
<td>Pre-Digester Centrate</td>
<td>10.9</td>
<td>37.6</td>
<td>36.7</td>
<td>11.3</td>
<td>14.4</td>
<td>4.6</td>
<td>13.4</td>
<td>17.6</td>
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<tr>
<td>Post-Digester Centrate</td>
<td>2.8</td>
<td>672.7</td>
<td>689.8</td>
<td>604.8</td>
<td>98.2</td>
<td>74.2</td>
<td>1.7</td>
<td>44.5</td>
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</table>
WASSTRIP OPTION W/ NEW WS ONLINE

Primary → Anoxic/Aerobic → Aerobic → Clarifiers

Fermentation/Thickening

Pearl Process: (High P and Mg, low NH₃)

Dewatering → Anaerobic Digestion → WASSTRIP → Thickening → OB
INITIAL TP/SS RATIOS COMPARED TO WASSTRIP ORTHOP CONCENTRATIONS AND RELEASE RATES

Both max orthoP concentrations and release rates in WASSTRIP trials and correlated with initial TP/SS in WAS → successful EBPR will drive WASSTRIP